GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India Department

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1886-87.

PREPARED UNDER THE DIRECTION OF

COLONEL H. R. THUILLIER, R.E.,
SURVEYOR GENERAL OF INDIA.

CALCUTTA:
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GENERAL REPORT

ON THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1886-87.

PART I.

INTRODUCTORY.

The operations of the Department that are now reported on are for the year ending 30th September 1887.

2. The administration of the Department and the superintendence of the Topographical Branch have continued in the hands of Colonel H. R. Thuillier, R.E., throughout the year, and he was confirmed in the post of Surveyor General from the 19th February 1887, *vice* Colonel G. C. DePrée, deceased. The direct supervision of the Revenue Branch and of the Trigonometrical Branch have been carried out as before by Colonel J. Sconce, S.C., and Colonel C. T. Haig, R.E., respectively; and the latter officer was confirmed in the post of Deputy Surveyor General from 19th February 1887. The only change in the superintendence of the cartographic offices at the Head Quarters has been owing to the departure on furlough of Lieutenant-Colonel Beavan, S.C., in June 1887, when Major Baird, R.E., was appointed temporarily as Assistant Surveyor General and retained the post for the remainder of the year.

3. Hitherto the Survey parties have been distinguished chiefly by geographical designations taken from the name of the district or locality in which each party was employed; the nomenclature had therefore frequently to be changed. As this system was found to be inconvenient and confusing, the parties now have all been serially numbered and each party is known by its number, which will be permanently retained. The identity of a party can thus be readily traced whereever it may be employed.

4. The operations which have been carried out during the year under review are shown below: the arrangement of the parties in this list has necessarily been made to conform to the nature of the operations in which they were employed and therefore they do not appear in serial order:—

Statement of Field Parties and Survey Operations.

Number of Party.	Nature and *locale* of Operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Trigonometrical Survey.				
24	Coast, Madras	11	Mr. E. C. Ryall	......	D. S. G. Trig.
	Topographical Surveys.				
10	South Maratha Country	12	Lieutenant W. H. Pollen, R.E. Mr. A. M. Lawson	2″=1 mile for reduction to half scale, and 8″=1 mile, skeleton forest survey.	Ditto Rev.

Statement of Field Parties and Survey Operations—continued.

Number of Party.	Nature and *locale* of Operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
14	Mirzapur . . .	14	Mr. W. H. Patterson . .	2″=1 mile for reproduction and reduction to half scale, and 16″=1 mile (skeleton plots).	D. S. G. Trig.
15	Baluchistan . . .	15	Captain F. B. Longe, R.E. .	¼″=1 mile for reproduction.	Ditto Topo.
16	Ditto . . .	17	Captain R. A. Wahab, R.E. .	6″=1 mile, 2″=1 „, ¼″=1 „ } for reproduction.	Ditto ditto.
17	Gujarát and Thana .	19	Colonel A. Pullan, S.C. .	2″=1 mile for reduction to half scale, and 8″=1 mile, forest survey, for reproduction.	Ditto ditto.
18	Himalayas . . .	21	Colonel H. C. B. Tanner, Bo. S.C.	4″=1 mile for reproduction and reduction to half scale, 2″=1 mile for reproduction.	Ditto Trig.
19	Madura and Tinnevelly.	22	Colonel W. F. Badgley, S.C.	1″=1 mile for reproduction.	Ditto Topo.
21	Nicobar Islands . .	24	Lieutenant-Colonel G. Strahan, R.E.	4″=1 mile, ¼″=1 „ } for reproduction.	Ditto Trig.
	Forest Surveys.				
20	Lower Burma . .	27	Mr. H. Hörst . . .	4″=1 mile for reproduction.	Ditto Topo.
	Cadastral Surveys.				
2	Bilaspur and Raipur .	29	Mr. G. B. Scott . . .	16″=1 mile for reproduction.	Ditto Rev.
4	Basti	32	Lieutenant-Colonel S. H. Cowan, S.C.	Ditto . .	Ditto ditto.
5	Gorakhpur . . .	34	Lieutenant-Colonel J. E. Sandeman, S.C.	Ditto . .	Ditto ditto.
6	Darrang and Nowgong .	39	Mr. E. C. Barrett . .	Ditto . .	Ditto ditto.
7	Akyab, Bassein and Thongwa.	41	Lieutenant-Colonel H. S. Hutchinson, S.C.	16″=1 mile and 2″=1 mile for reproduction.	Ditto ditto.
8	Bengal and Orissa .	44	Lieutenant-Colonel W. Barron, S.C. Mr. F. W. Kelly . .	16″=1 mile for reproduction, and 50 feet = 1 inch, city survey.	Ditto ditto.
	Traverse Surveys.				
1	Punjab. . . .	49	Colonel F. Coddington, S.C.	2″=1 mile, compilation for reduction to half scale.	Ditto ditto.
3	Raipur . . .	52	Colonel W. H. Wilkins, S.C.	16″=1 mile (skeleton plots).	Ditto ditto.
9	Jubbulpore and Damoh .	53	Mr. G. H. Cooke . .	Ditto . .	Ditto ditto.
11	Seoni and Chhindwára .	54	Lieutenant-Colonel D. C. Andrew.	Ditto . .	Ditto ditto.
12	Saugor and Narsinghpur	55	Mr. E. J. Jackson . .	Ditto . .	Ditto ditto.
13	Sambalpur . . .	57	Mr. A. D'Souza . . .	Ditto . .	Ditto ditto.
	Geodetic.				
22	Central India . .	58	Lieutenant S. G. Burrard, R.E.	......	Ditto Trig.
23	Ditto . .	*ib.*	Ditto . . .	......	Ditto ditto.
	Tidal and Levelling Operations.				
25	India	62	Major J. Hill, R.E. . .	......	Ditto ditto.

Statement of Field Parties and Survey Operations—concluded.

Number of Party.	Nature and *locale* of Operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Geographical Surveys.				
Det.	Upper Burma . .	65	Bt. Major J. R. Hobday, S.C.	¼″=1 mile . .	D. S. G. Topo.
Det.	Ditto . .	67	Colonel R. G. Woodthorpe, C.B., R.E.	½″ and ¼″=1 mile . .	Ditto ditto.
	Trans-Himalayan Explorations.				
	Bhutan and Tibet .	68	R. N. and K. P. . . .	......	Ditto Trig.

These operations are described in detail in Part II of this Report, in the order in which they are given above, and the following is a summary thereof.

TRIGONOMETRICAL SURVEYS.

5. These operations have been confined, as in the previous year, to one small party, which was employed on secondary triangulation along the Madras coast. The triangulation has been extended 170 miles in length, *viz.* from Madras northwards to a distance of 45 miles beyond Nellore. A gap of about 80 miles has been left between this point and that where the previous season's operations, which were carried southwards from Cocanada, closed near Masulipatam, which could not be completed owing to the prevalence of bad weather and to sickness during the latter part of the season. It is expected that this portion will be completed during the current season and the series carried southwards from Madras as far as Point Calimere. The object of this triangulation is to furnish points as a basis for the future operations of the Marine Survey Department, and is part of a general scheme to complete the triangulation of the parts of the coasts of India and Burma where the principal triangulation has not been carried.

TOPOGRAPHICAL SURVEYS.

6. To meet the demands for remunerative surveys in the Central Provinces, it was found necessary to still further contract the topographical programme during the year under report. During the preceding year, ten parties had been employed exclusively on this class of operations, and they yielded an aggregate out-turn of 19,162 square miles of topography on various scales of survey. The Cutch Party which had completed its work in that province, and the party employed on the Deccan surveys which have had to be postponed, were diverted to Revenue operations. Thus, excluding No. 20 Party, the operations of which are confined to forest surveys in Lower Burma, the topographical parties have been reduced to eight in number, and in two of these half the establishments have been employed on special surveys for the Forest Department in the Bombay Presidency. On the other hand, a topographical section was added to the cadastral party employed in the Akyab district, Burma, so as to complete the topography of some parts of the hill ranges situated between the valleys to which the cadastral survey had been restricted. In the Punjab, the party engaged in compiling topographical maps from the village maps of the settlement surveys has made original surveys of small detached portions of Native States, intermingled with British districts, but for the larger portions of the Native States, the topography of the old maps, though admitted to be imperfect, has been accepted for the new compilations, an extensive re-survey at the present time being considered to be inadvisable.

7. Out of the eight topographical parties, five have been employed in continuation of the preceding year's work: *viz.*, two in the Bombay Presidency, one in Gujarát, another in the Southern Marátha Country (with half their establishments only); one in Baluchistan, which is at the disposal of the Military Department; one in the Mirzapur district, and one in the Himalayas.

8. Of the remaining parties, one which had hitherto been employed in Rajputana was withdrawn therefrom, and the survey thereof postponed in order to make a second party available for the Military programme. This party was transferred to Baluchistan and has been engaged chiefly on special surveys on the frontier required by the Military authorities, but it has also added to the extension of the general survey of Baluchistan in conjunction with the party previously engaged thereon. The completion of the survey of the Mysore State during the preceding year rendered a party available for new work, and the Government of Madras having accepted the proposal of the Government of India for the transfer of the topographical work remaining to be completed in that Presidency from the local Survey Department to the Imperial Department, this party was selected on account of its local experience to undertake the operations in Madras, and it has been employed thereon in the districts of Madura and Tinnevelly. The work, however, has been necessarily almost confined during this first season to triangulation, and but little has been added to the general out-turn of topography. The eighth party has been engaged, in continuation of the survey of the Andaman Islands, in making a survey of the Nicobar Islands, the main object of which was to meet the requirements of navigation. The coasts have been accurately surveyed and as much topographical detail in the interiors of the islands secured as the limited time available permitted, as it was considered desirable to restrict the operations to one season.

9. The aggregate results of the topographical surveys during the year amount to 17,510 square miles, which is exclusive of forest surveys and of the standard mapping in the Punjab, compiled from the village maps of the settlement surveys. The out-turn is composed as follows:—

11,786	square miles	surveyed	on the	½-inch	scale.
257	,,	,,	,,	1-inch	,,
5,041	,,	,,	,,	2-inch	,,
354	,,	,,	,,	4-inch	,,
72	,,	,,	,,	6-inch	,,

FOREST SURVEYS.

10. The special skeleton survey of forest boundaries in the Belgaum district has been continued and completed for the forest tract to which the operations were required to be extended. The maps are on the 8-inch scale and show boundaries only, except in a few cases where large streams or made roads pass through the tract. For general purposes, the topography of the tract will be surveyed on the 2-inch scale in the course of the topographical operations in the Southern Maratha Country; and for forest requirements, the Forest Officers will add such topography to the 8-inch skeleton maps as they may consider to be necessary. The above procedure applies to the forests in the Southern Circle of the Bombay Presidency.

In the Northern Circle, however, more elaborate operations have been demanded by the Bombay Government. Here a complete survey in full detail on the 8-inch scale is required of such of the forest reserves where surveys do not exist on the 4-inch scale, and a commencement has been made in the forests of the Thána district. Two half parties have been employed on these forest surveys in the Bombay Presidency.

11. Two small forests in the Gorakhpur district have been surveyed on the 8-inch scale by the cadastral survey party working in that district.

12. The survey of the forests in Lower Burma has been continued on the 4-inch scale by No. 20 Party; but, owing to the unsettled state of the country and the impossibility of providing police guards for all the scattered detachments in the Prome district, the Native section of the party employed there became quite demoralized, and it was found necessary to suspend the work in Prome and to remove the detachment therefrom. The operations, therefore, had to be confined to new ground in the Pegu district in which preliminary triangulation and traversing constituted the chief work of the party, and the out-turn of final survey has thus been very small. The failure here, however, enabled the party employed in Upper Burma to be materially strengthened by the withdrawals from Prome, and thus a considerable increase in the out-turn of new

geography has been obtained. The areas of the forest surveys above referred to are as follows:—

296 square miles surveyed on the 8-inch scale.
46 „ „ 4-inch „

CADASTRAL SURVEYS.

13. Six parties have been engaged on cadastral surveys during the year. Of these, the operations of five parties have been continued with little change from those on which they were engaged during the previous season: (1) The party employed in Basti has extended its work northward, exclusively in its own district; and the only thing to be specially mentioned in connection with the work of this party is the very minute sub-division of property that has been met with, the average size of the separate plots in which the cultivators have occupancy rights being 0·27 of an acre, which is quite unprecedented for smallness, and is about one-third of the average size of the cultivators' plots in the adjoining district of Gorakhpur. Close upon two million plots have been surveyed, areas calculated, and rights recorded in Basti, while in Gorakhpur, in a considerably larger area the number is less than one million. (2) The party engaged in Gorakhpur has been specially strengthened for the purpose of its accomplishing a larger out-turn, so that the remaining area of the district may be completed in two seasons, that is, before November 1888, as required under the conditions of the expiring settlement. The out-turn has thus been raised to 1,048 square miles, being 228 square miles more than was surveyed last year. This party has also sent a detachment to resume cadastral survey operations in the Tarai district for certain selected villages where the extension of cultivation has rendered such operations advisable. A new departure has been taken in the cadastral work of this detachment by the employment of the village *patwáris* as surveyors in place of professional *amins*, and although some difficulty was at first experienced in training the men, the plan eventually proved quite successful and excellent work was obtained. (3) In Assam, the party having completed the area required to be cadastrally surveyed in the Kámrúp district, has moved into district Darrang, where it has finished the entire area set apart for cadastral survey, the operations being confined, as in Kámrúp, to the villages in which the cultivation is permanent, that is, where the same lands are cultivated year by year, in contradistinction to the villages where the cultivated lands are changed after successive periods. (4) In Burma, the party has been employed partly in the Akyab district, where the area for cadastral survey has been completed, and partly in the Bassein district, in which several circles which had been omitted from the cadastral survey of 1879—83 have now been assigned for survey. The Thongwa district, which adjoins Bassein, has also been assigned to this party for cadastral survey, and preliminary traversing has been undertaken there. Besides completing the cadastral area remaining in Akyab, the party, having been specially strengthened with a staff of topographers, has carried out a topographical survey of parts of hill-ranges lying between the villages to which the cadastral survey was restricted, and thus has provided for the completion of several topographical sheets. (5) In the Central Provinces, the party which had hitherto been employed in the Bilaspur district could not be wholly re-employed therein on account of a partial famine through failure of the autumn crop of 1886, and one section was diverted to the adjoining district of Raipur, where a tract intended for settlement survey by *patwáris* was assigned to it. The total area surveyed in the two districts is 1,022 square miles, showing an increase of 259 square miles on the out-turn of the previous season, and the cost-rate has been reduced from R169-11 to R132-14 per square mile.

14. The last of the six parties which had been employed on cadastral surveys during the previous year is the party which had carried out experimental operations in District Mozufferpore of Bengal, and which, on the stoppage of the Mozufferpore survey, was available for transfer elsewhere. Any large operation sufficient for the employment of the whole party in one locality was not forthcoming, and three separate operations have been assigned, each suitable for a section representing a third of the party.

(*a*) The first section was sent to Calcutta for the survey of the town, the operations of which will be referred to hereafter.

(*b*) The second section was despatched to the Dinagepore district for the cadastral survey of the Sankarpur Estate at present under the Court of Wards. The survey of this estate has presented unusual difficulties on account of the lands composing it being much scattered; not only are many villages in which the estate is exclusively interested detached singly, but in villages in which the estate is only partially interested the lands are found lying in single fields or in groups of fields with the lands of other estates intermingled with them.

(*c*) The third section was despatched to Orissa for the cadastral survey of the Government Estate of Angul, formerly a Tributary State, which was confiscated in 1847, and which is now for the first time being brought under survey for settlement purposes. The main part of the work which has been effected has been village boundary traversing, but an area of 61 square miles has also been surveyed cadastrally, and some of the *sarbarákárs* (village headmen) have been trained for cadastral survey work to be undertaken next season.

The areas surveyed cadastrally are—

	Square miles.
North-West Provinces	1,898
Assam	547
Burma	546
Central Provinces	1,022
Bengal	260
TOTAL	4,273

TOWN SURVEY.

15. The survey of Calcutta has been undertaken in accordance with the representation of the Municipal Commissioners to the Government of Bengal, that the maps of the survey of 1847—49 had become out of date on account of the numerous changes that had occurred, and, moreover, that the maps had been drawn on too small a scale to show the details of the town with sufficient accuracy. The present survey is being effected on the scale of 50 feet to an inch, which is double the scale of the former survey, and all details are being represented with every possible minuteness. Besides the ordinary particulars concerning streets and houses, the boundaries of the separate properties which pay revenue to Government are being shown, and information is being collected to enable a new Register of properties to be prepared for the Calcutta Collectorate, if found to be necessary.

TRAVERSE SURVEYS.

16. The party employed in the Punjab has continued the same operations in British districts as formerly, its field work mainly consisting of the construction of a traverse framework on which topographical maps are drawn in office by reduction from the village maps of the settlement surveys. Besides this, during the present season, small outlying portions of the territories of the Sikh States have been surveyed, so as to render the topographical maps complete, and where extensive tracts of these States have been met with, the survey of which forms no part of the programme of the present operations, the portions of the old maps of the States, surveyed in 1847—50, have been redrawn so that the new series of standard-sized sheets may be published without blanks.

17. The traverse surveys of the Central Provinces, designed to furnish a skeleton basis for settlement surveys by village *patwáris*, have been continued in the districts of Raipur, Sambalpur, Jubbulpore and Damoh where the operations had been begun during the previous season, and Districts Sambalpur and Damoh have been completed. Four other districts, *viz*. Saugor, Narsinghpur, Seoni and Chhindwára, have been entered upon during the season by two new parties, which have been brought up from the Bombay Presidency, where they had been employed on topographical surveys. In the traverse surveys in the Central Provinces, there is besides the village boundary traverses, a complete system of interior sub-traverses, so as to furnish conveniently-sized blocks, for the surveys of the fields by *patwáris*, and every theodolite station is marked with a substantial stone.

The areas which have been traversed are—

	Square miles.
Punjab	6,085
Central Provinces	10,576
TOTAL .	16,661

SPECIAL OPERATIONS.

18. As only one officer could be spared for astronomical work, the telegraphic longitude operations were suspended, and latitude observations resumed. These have been extended south of Jubbulpore on the meridian of 80,° in continuation of the operations of 1884-85, and observations have been completed at five stations. The operations were brought to a close somewhat early, in order to carry out a further series of experiments with the two transit instruments at Dehra Dún for the purpose of elucidating the curious anomalies in the result obtained with those instruments in the determination of differential longitudes which were referred to in the Report for 1885-86.

19. The tidal operations have been continued as usual. Observations for registration of tides were taken at 17 ports in India, Burma, the Andamans, Ceylon and Aden. One new observatory has been established, while that at Dublat was swept away by the cyclone of 29th September 1886, but fortunately not until the 5 years' registration had been completed.

GEOGRAPHICAL SURVEYS AND EXPLORATIONS.

20. In addition to the regular operations of the topographical parties, two detachments, one under Captain (now Major) Hobday, which was raised to the strength of an ordinary field party, and another under Colonel Woodthorpe, R.E., have been employed on geographical surveys in Upper Burma, and considerable additions have thus been made to our imperfect knowledge of that province. The various military expeditions for pacifying the country have afforded the means of obtaining this additional geographical information, and every opportunity, as far as the strength of the establishment permitted, has been availed of to send surveyors with the various columns to acquire new geography. The area that has been thus reconnoitred amounts to 15,284 square miles, chiefly on the $\frac{1}{4}$-inch scale, and the work is all based on triangulation. Besides this, various reconnaissances executed by military officers and soldiers attached to the force, have been utilised and incorporated into the maps issued by this Department, so that every means of adding to our knowledge of the geography of the country has been taken advantage of. To Major Hobday, who has been engaged on these operations since the first occupation of Upper Burma, the successful work that has been accomplished is mainly due ; and it is also by his efforts, in conjunction with Captain Dun, Deputy Assistant Quarter Master General, that the satisfactory results of the association of the Survey Department with the Intelligence Branch of the Quarter Master General's Department have been obtained. His Excellency the Commander-in-Chief has been pleased to express his approval of Major Hobday's services, and of those serving under him. Colonel Woodthorpe accompanied the force that proceeded from Manipur into the Chindwin Valley, and has furnished, in conjunction with Mr. Ogle, his assistant in this as well as in previous explorations on the Assam frontier, a valuable addition to our maps. He succeeded also in carrying the triangulation from Manipur, which is in connection with the main triangulation of India, to the neighbourhood of Mandalay, and effected a junction with that executed by Major Hobday, which was previously unconnected. It will be remembered that Colonel Woodthorpe has been engaged from the field season of 1884-85 on incessant exploration work ;—firstly, to the Bor Khámpti country, in the valley of the western branch of the Irrawaddy, on return from which, after much exposure and hardship, he was selected to accompany the Gilgit Mission. He had no sooner returned from this arduous expedition than he volunteered for this service in Burma. It is gratifying to record that the services of this officer have been recognized by the award of the Companionship of the Military Order of the Bath.

21. Of Trans-Himalayan work the report of the explorations in Nepal and Tibet by M—H, which was mentioned at page 54 of the Annual Report

for 1885-86, has been separately published, with a sketch map illustrating his routes. The detailed report of explorer R. N.'s work in Eastern Tibet is still incomplete, but a summary thereof by Colonel Tanner will be found in the appendix, accompanied by a sketch map of Bhutan, which embodies all the information available up to date regarding that country.

22. In 1880, a native of Sikhim, K. P., was sent in company with a Chinese *láma*, by the late Captain Harman, to Tibet for the purpose of exploring the course of the Sangpo river below Gyala Sindong, the point which had been reached by explorer G. M. N., to the plains of India; or, failing this, to throw marked logs of timber into the stream at the lowest point reached, in order to solve the question of its identity with the Dihang. K. P. has returned to India after many adventures and has given a narrative of his travels, which shows that, owing to the delinquency of the *láma*, the arrangement for casting logs into the Sangpo was not carried out. K. P. was sold as a slave in the Pemakoi country, from which he eventually managed to escape. He succeeded in penetrating to a place called Onlet, on the Sangpo, which he states is not much more than 40 miles from the plains of India; and his account, combined with information derived from a Mongolian *láma*, who had lived for many years near Gyala Sindong, has enabled Colonel Tanner to construct an amended chart of the course of the Sangpo between Gyala Sindong and the point to which our knowledge of the Dihang river extended, which will be found in the appendix. It is intended to publish the itineraries of both K. P. and R. N., together with the information obtained from the *lámas* in a separate report. Meanwhile, a short account is given in Part II, and in Colonel Tanner's note in the appendix, which also contains a résumé of the work done up to date, both in Bhutan and on the Lower Sangpo.

HEAD-QUARTERS OFFICES.

23. The account of the work done in the various offices at the head quarters is given in Part III of this Report. The number of maps published during the year, including new editions of old maps, amounted to 315. This is exclusive of cadastral maps, of which 3,843 have been published. The total number of maps issued amounted to 178,398, valued at R1,36,344. The income from map sales amounted to R9,254.

24. The vast amount of mapping that has been thrown on the drawing offices by the surveys and reconnaissances executed by the officers attached to the Afghan Boundary Commission has caused great pressure on these sections. Considerable progress has been made in the completion of these maps without interference with the ordinary work, which was further increased by the urgent demands for maps of Burma and Baluchistan In the Lithographic Office a series of statistical maps has been commenced, showing the area percentage of the principal crops grown in different districts throughout India. The Military and Railway map, which was noticed in last year's Report, has made steady progress. This map is in 12 sheets and will be printed in four colours. It is hoped that it will be ready for publication during the current year. Among the maps published by the photo-zincographic process may be mentioned a preliminary map of Upper Burma on the 16-mile scale, compiled from the sheets on the $\frac{1}{4}$-inch scale, which were prepared by Major Hobday from all available sources. These maps are necessarily very imperfect, as the acquisition of geographical information in Upper Burma and its accuracy must for some years be gradual and progressive. It is hoped that new editions of the above maps, giving further details, will shortly be published.

25. The processes of heliogravure have made great progress during the year: two quarter-sheets of the Atlas of India have been engraved directly by the aid of photography from manuscript drawings. The results that have been obtained show that for the reproduction of line work the process is well adapted to take the place of hand engraving for temporary purposes, such as for maps in which the geographical information is imperfect and which are likely to be superseded by more reliable materials. For the reproduction of maps, however, in half tone, the process requires further development. The heliogravure processes have also been utilised largely for the reproduction of drawings for the Archæological Survey, in which some beautiful specimens have been produced, and for a Technical Art Series for educational purposes. A medallion portrait of

Her Majesty the Queen-Empress of India, reproduced by the photo-etching process, is appended as a frontispiece. The use of electrotyping for duplicating engraved copper-plates has also been largely extended during the year. The collotype process has also made some advance and specimens of reproduction of a water-colour drawing, printed by this process, will be found in the appendix. These specimens also illustrate the advantages of orthochromatic photography to which some attention has been devoted.

ESTABLISHMENT.

26. During the year the Department has sustained the loss of the services of two officers who have been associated with it for many years. First, by the lamented death of Colonel G. C. DePrée, S.C., late Surveyor General of India. In February 1886, Colonel DePrée was forced by illness to take furlough to Europe, with the intention of returning to complete his full period of service. His health, however, prevented him from carrying out his desire, in which he was actuated solely by loyal motives and by his devotion to the department. Deriving no benefit from his residence in England, Colonel DePrée went to Jersey, where he died on the 18th February 1887, a few months before he would have had to retire from the Department, under the superannuation rules. He had spent 36 years in the service of the Indian Government, of which over 32 years had been passed in the Survey Department. In January 1883, after 28 years' service in executive duties of the Topographical Branch, Colonel DePrée was appointed Deputy Surveyor General in charge of Topographical Surveys, on the occasion of the separation of the duties of that office from those of the Surveyor General; and, subsequently, on the retirement of General J. T. Walker, C.B., R.E., he became Surveyor General of India. Lieutenant-Colonel T. T. Carter, R.E., Deputy Superintendent, 1st grade, retired on the 9th January 1887, owing to ill health, after a service of 29 years under the Indian Government, of which nearly 25 years had been spent in the Trigonometrical and Topographical Branches of the Survey Department.

27. The resources of the Department have been severely taxed in providing officers to superintend the various field operations and in meeting all the demands that have been made upon it. The existing strength of the Senior Division is unquestionably insufficient to continue to bear the strain under which the Department has been working during the past three years. The contraction of the Topographical programme, which is a matter of much regret in view of the completion of the entire first survey of India and of the pressing need of surveys in Upper Burma, has afforded no relief, as the parties employed thereon have been merely diverted to other work to meet the demands for re-settlements. The trained agency available is so limited as to cause much anxiety for the efficient execution of the surveys now in progress; this is due partly to appointments to fill existing vacancies having been withheld, partly to the expansion of the military programme, and to the extra demands that are now made for officers to accompany military and political expeditions. It is essential therefore for the proper prosecution of the work that may be required from the Department, and for the due administration thereof, that a fixed programme should be decided on for a series of years, and that the establishments should be maintained at an adequate strength.

28. It is gratifying to record that the labours of the officers of the Survey Department in Afghanistan and Upper Burma have been appreciated and rewarded.

In recognition of services with the Afghan Boundary Commission, Lieutenant-Colonel Holdich, Majors Gore and the Hon'ble M. G. Talbot have each received a step of brevet rank; Sub-Surveyors Yusuf Sharif and Imam Sharif have obtained the personal distinction of Khan Bahadur and Sub-Surveyor Hira Sing that of Rai Bahadur. Colonel Holdich has further been awarded the Founder's medal of the Royal Geographical Society in London for the services he has rendered to geographical science.

In recognition of their services in Burma, Colonel Woodthorpe, R.E., has been appointed to be a Companion of the Order of the Bath and Major Hobday has received a step of brevet rank.

PART II.

THE OPERATIONS OF THE SEVERAL FIELD PARTIES.

TRIGONOMETRICAL SURVEYS.

COAST TRIANGULATION.

CHINGLEPUT AND NELLORE DISTRICTS, MADRAS.

No. 24 PARTY.

Personnel.

Mr. E. C. Ryall, Officiating Deputy Superintendent, 4th grade, in charge.
Mr. J. Bond, Surveyor, 4th grade.

29. These operations were continued during the season under the executive charge of Mr. Ryall, their object being to fix points of reference for the Marine Survey, at intervals of from 5 to 15 miles along the east coast of India. Light-houses and other permanent marks are utilized for the purpose where such are available, and in their absence beacons are constructed in conspicuous places, their positions being fixed by triangulation or traverse.

30. The party left recess quarters at Mussooree on the 25th November and proceeding to Masulipatam where the stores and instruments had been deposited, went thence by Buckingham Canal to Madras. Owing to the protraction of the north-east monsoon, work could not be commenced until the 26th December and then much delay was caused by the illness of both Messrs. Ryall and Bond. The observations were further retarded by delay in obtaining the sanction of the Conservator of Forests for felling trees for the purpose of clearing the rays between stations required to fix the Ennur beacon.

31. The triangulation this season was arranged in three separate sections, each originating from sides of the principal triangulation of the Madras Coast Series :—

(1) A series of 22 triangles, from St. Thomas' Mount to Ennur, over a direct distance of 22 miles.
(2) From Armugham light-house, Oudali H. S., and Narsimkonda h. s. to the coast, comprising 17 triangles, in length 45 miles.
(3) From Narsimkonda h. s. and Kistama H. S. to Ramapatnam, 41 triangles, in length 61 miles.

In all, the triangulation was extended over 170 miles of coast line northward from Madras, by which nine beacons and other points on the coast were fixed in addition to three light-houses.

32. Two traverses $7\frac{1}{2}$ and 4 miles in length respectively, were also run from stations of the main series to fix beacons and marks which could not be advantageously connected by triangulation.

33. A distance of about 80 miles of coast line remains between the most northern point reached this season and the most southern point of the last season's work; this interval will be completed during the next season. During the recess all computations and charts of the season's work were completed and brought up to date.*

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*Mr. Ryall speaks favourably of Mr. Bond's work and his endeavours to make up for the time lost through sickness.

TOPOGRAPHICAL SURVEYS.

SOUTH MARATHA COUNTRY, BOMBAY PRESIDENCY.

No. 10 Party.

34. This party, which during the previous season had been under the charge of Lieutenant F. B. Longe, was at the beginning of the field season, on the transfer of Lieutenant Longe to a party in Baluchistan, placed under the charge of Lieutenant W. H. Pollen, who supervised the operations in the field, and who on the return of the party to its recess station, when he was about to proceed on leave to Europe, was relieved of the charge by Mr. A. M. Lawson.

Personnel.

Lieutenant-Colonel T. T. Carter, R.E., Deputy Superintendent, 1st grade, in charge from 9th to 31st December 1886.
Lieutenant F. B. Longe, R.E., Officiating Deputy Superintendent, 4th grade, in charge up to 19th October 1886.
Lieutenant W. H. Pollen, R.E., Officiating Deputy Superintendent, 4th grade, in charge from 20th October to 8th December 1886, and from 1st January to 6th June 1887.
Mr. A. M. Lawson, Surveyor, 2nd grade, in temporary charge from 7th June 1887.
Mr. W. M. Kelly, Assistant Surveyor, 1st grade.
Mr. R. R. Dickinson, Assistant Surveyor, 1st grade.
Mr. O. D. Smart, Assistant Surveyor, 2nd grade.
25 Sub-Surveyors and others.

Mr. Lawson held charge until 21st October 1887, on which date Lieutenant-Colonel H. S. Hutchinson, who had been appointed to the party, joined and took charge.

The short incumbency of Lieutenant-Colonel T. T. Carter, *viz.*, from 9th to 31st December, should also be mentioned, although he was unable to take any share in the field operations, having joined the party on return from furlough in bad health which soon compelled him to retire from the service.

The field season extended from 16th November 1886 to 27th May 1887.

35. The party, divided into two sections, has been employed on two distinct operations. One of these is a topographical survey on the 2-inch scale, showing village boundaries, similar to the survey which has been carried on in other parts of the Bombay Presidency; the other is a partial survey of forests on the 8-inch scale, exhibiting, according to the specification of the Forest Department, only the boundaries of the forests, and such details (where existing) as perennial streams or made-roads, all other details and the delineation of the hill features being entirely omitted. The forest survey was carried on in a tract which had not been included in the topographical survey, and the features which have been omitted will hereafter be surveyed on the 2-inch scale.

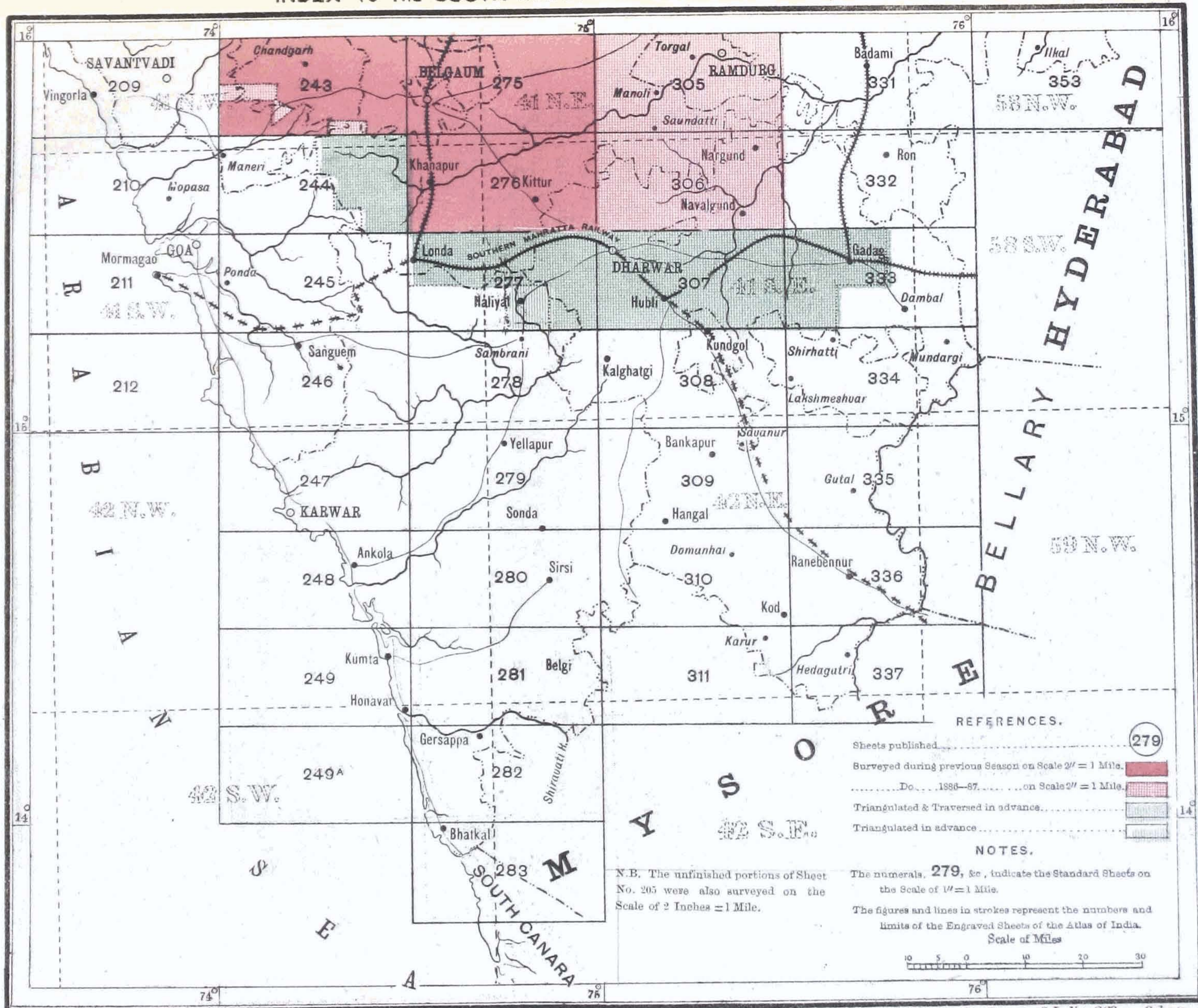
36. The topographical section has undertaken the completion of Sheet 205, which had been partially surveyed by No. 11 Party during the previous season; also, it has completed Sheet 243, which had been left undone the same season; and it has commenced and finished the topography of Sheets 305 and 306. The portions of Sheets 205 and 243 consisted of difficult mountainous country forming parts of the Western Ghâts; Sheet 305, crossed by ranges of flat-topped hills covered with thorny jungle, was also somewhat difficult for the topographers; but Sheet 306 was all open easy country. A few descriptive notes furnished by Mr. Lawson with the aid of the official gazetteer, are printed in the appendix, page ii.

37. The areas surveyed on the 2-inch scale in the several districts and States are shown in the following statement:—

	Square miles.
Kalâdgi District	39
Belgaum „	425
Dhârwâr „	474
Ratnâgiri „	32
Kolhâpur State	206
Sângli „	13
Sâvantvâdi „	53
Râmdurg „	113
Torgal „	57
Total	1,412

INDEX TO THE SOUTH MARATHA TOPOGRAPHICAL SURVEY.

No. 10 PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Lieut: Colonel H. R. Thuillier, R.E., *Surveyor General of India.*

Survey of India Offices. Calcutta, October.

1887

The area triangulated is 1,570 square miles of open country, which has been accomplished by means of observations at 150 stations. The area traversed is 1,527 square miles, of which 1,300 square miles are in advance for next season's detail survey. During both operations of triangulation and traversing, the heights of 190 points have been determined.

38. The topography was surveyed as closely as the scale admits of and it has been tested by 76·5 linear miles of check lines, but these checks are not considered to be sufficient and several sections remain to be tested. Village boundaries in British districts were surveyed according to the marks found on the ground and were afterwards compared with the Revenue Survey maps. In the case of Native States, only the State boundaries have been surveyed. During the recess, the mapping of the 2-inch sections of Sheets 243, 305 and 306 has been done, but the new sections of Sheet 205 consisting of intricate hill features are still unfinished.

39. The Forest survey section has been employed in the Khánapur forests of the Belgaum district; and on account of the forest and village lands being so much intermingled, the survey has necessarily comprised the cultivated lands situated within the forests but still remaining with the villages, as well as the forest reserves which have been exscinded. As required by the Forest Department, the village unit has been upheld, the village boundaries being first surveyed and then the boundaries of the included forests, and the forest boundaries being traced from the Revenue Survey maps according to the field "numbers" which had been transferred by Gazette Notification to Forest jurisdiction. The number of villages falling within the tract that has been surveyed is 83, from 76 of which lands have been exscinded for forests, and while the total area of the tract is 215 square miles, the aggregate area of the portions reserved for forests is 154 square miles. The aggregate of the traversing of the village and forest boundaries is 862 linear miles, fixing 8,623 theodolite stations mostly on boundary stones and a few on stones specially embedded.

40. In the construction of the maps, the village unit has also been retained, separate maps having been projected for each of the villages, showing both the forest lands and the lands left for village assessment. It will be understood from what has already been mentioned regarding the nature of the survey applied for by the Forest Department, that the maps, which are on the 8-inch scale, are mere skeletons showing the boundaries to which in some cases surveys of large streams or made-roads have been added where existing, but there has been no representation of the hill features or of the minor drainage. Copies of the maps have been drawn for the use of the Forest Department.

41. The total cost of the party for twelve months ending 30th September is R50,843, half of which is payable by the Government of Bombay (Forest Department); and the cost-rates per square mile thus deducible are shown in the table at page 72.

42. The party suffered a good deal from fever both in the forest tracts and open country during the early part of the season, two cases proving fatal. Guinea-worm was also common all over the district.

43. The recess office of the party at Poona was inspected during September by the Deputy Surveyor General in charge of the Revenue Branch, who was satisfied with the character of the field work and with the progress made as regards the computations and drawing in office.*

* Mr. A. M. Lawson, who has prepared the annual report, reports favourably of Messrs. Kelly, Dickinson and Smart, and states that the undermentioned Sub-Surveyors have done excellent work, *viz.*, Fyzullah Khan, Damodar Gopal, Govind Janardhan, Ramrao Yadho, Vitoba Nagaji and Babaji Ram Chunder.

MIRZAPUR DISTRICT, NORTH-WESTERN PROVINCES.

No. 14 Party.

Personnel.

Mr. W. H. Patterson, Officiating Deputy Superintendent, 4th grade, in charge.
Mr. L. J. Pocock, Surveyor, 3rd grade.
" C. F. Hamer, " 4th "
" C. D. Potter, " 4th "
" W. J. Cornelius, Assistant Surveyor, 1st grade.
Mr. H. T. Kitchen, Assistant Surveyor, 1st grade.
Mr. E. F. Berkeley, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

Azim Khan, | Barkat Ali,
Prem Raj, | Gurdutt Sing,
and 6 others.

44. This party resumed field operations in the Mirzapur district on the 17th November 1886 under the superintendence of Mr. W. H. Patterson who has held charge during the entire year. Field work was continued till the end of April, when the party started for recess quarters at Mussooree.

45. The out-turn of work consisted of (*a*) the triangulation of 525 square miles in sheets 198, 199 and 212; (*b*) the detail survey on the 2-inch scale of 454 square miles in the same sheets; (*c*) the completion of the boundary survey of seven villages in Pargana Bijaigarh left incomplete by the Revenue Survey Party previously employed in the district owing to the hilly nature of the country; (*d*) the mapping of details taken from the village plans of the Settlement Survey executed in 1864—68, and based on the traverse survey of last season of 1,223 villages in sheets 168, 169, 181 and 182, comprising an area of 391 square miles; (*e*) the traverse survey of 536 villages in Parganas Khera Mangraur and Naugarh, sheets 197 and 198, forming the Chakia Estate of the Maharaja of Benares, of which a cadastral survey will be undertaken during the present season.

46. The operations under head (*a*) complete the triangulation required for the 2-inch detailed survey in District Mirzapur; under head (*b*), the accuracy of the topography has been carefully tested by the examination of the field sections from positions *in situ* by the executive officer and the European assistants; under class (*c*) the work involved the setting up of the theodolite at 4,105 stations and the measuring of 860 linear miles of chain traverse. Azimuths were observed at 13 stations to check the bearings of the traverse lines.

47. Three native soldiers were attached to the party during the field season for training, and after being instructed in the use of the plane-table they conjointly contributed an area of 57 square miles of 2-inch survey to the season's out-turn.

48. The country topographically surveyed is of the same intricate and hilly nature as that met with in previous seasons. Most of the precipitous slopes of the Kaimur range of hills fall within the season's work, and the survey of these, in addition to the intricate jungle-clad ground met with elsewhere, rendered the work difficult and laborious. Further delay was incurred by the health of the establishment which was bad during the entire season; the detachments working in the Kaimur hills were attacked with a malarious type of fever which prostrated the surveyors for a considerable time and caused serious interruptions in the work. The out-turn therefore is not so large as was anticipated and the cost-rates have thus been somewhat enhanced.

49. During the recess the following maps have been completed on the 2-inch scale:—8 sections of the standard size comprised in sheets Nos. 168, 181, 184, 185 and 200 for reproduction to scale; and 5 sections of sheets Nos. 200 and 201 for reduction to 1-inch. The fair drawing of sheets Nos. 184, 198, 199 and 212 will be completed in the Drawing Office at Calcutta.

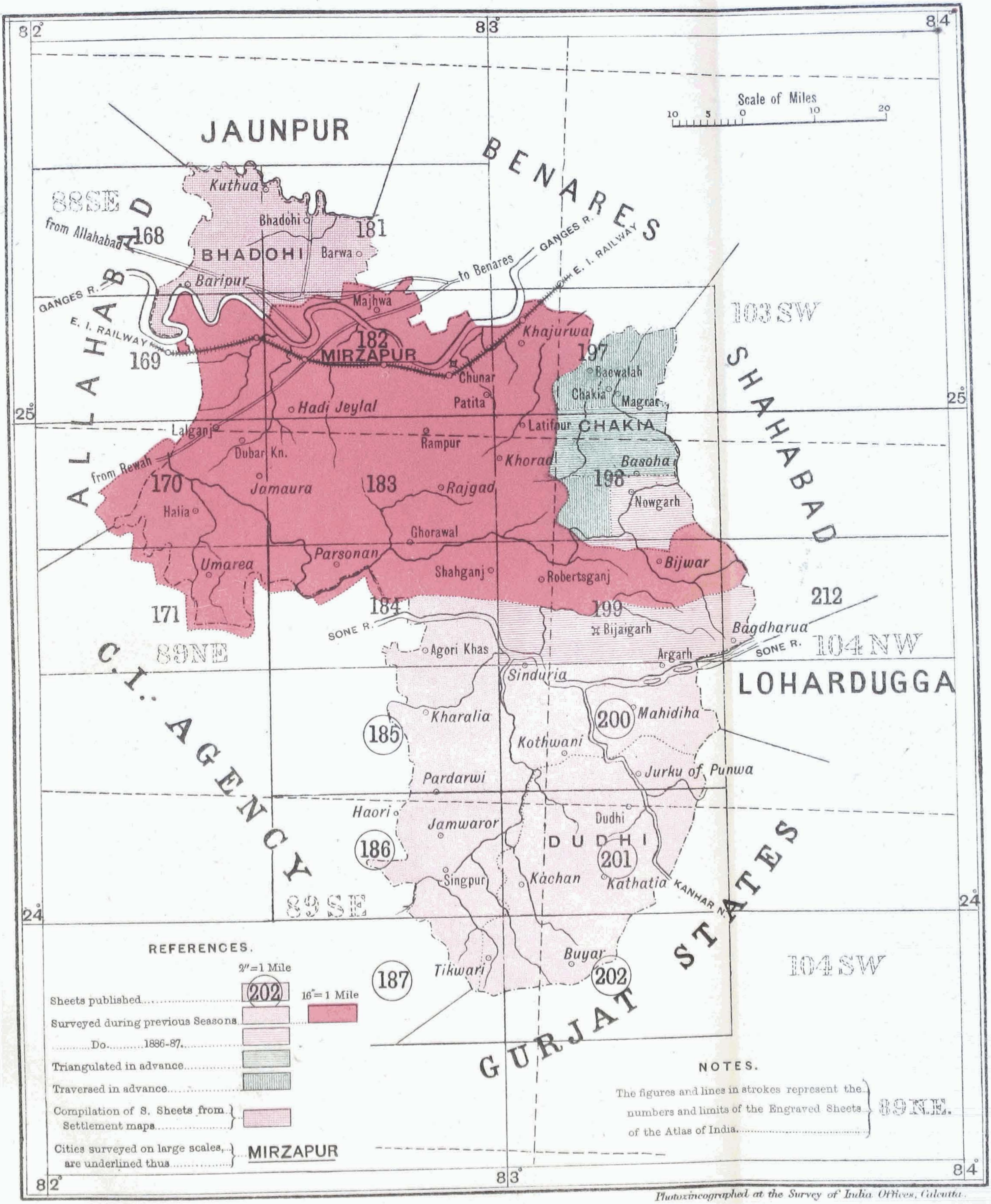
In addition to the above the plotting of the polygons of the villages in the Chakia Estate and the records connected with the traverses thereof were completed. The computations of the season's triangulation were finished and a chart of triangulation for the whole district of Mirzapur prepared on the ¼-inch scale. The arrears of the general reports and records of the Khándesh and Bombay Native States and of the Bhopal and Malwa surveys which had been entrusted to Mr. Patterson's supervision, have now been completed in the office of this party.

50. The area that now remains for survey in the Mirzapur district amounts to about 350 square miles, of which 175 square miles, comprising the Maharaja of

NORTH WEST PPOVINCES SURVEY.

INDEX TO THE SURVEY OF DISTRICT MIRZAPUR.

No. 14 PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

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Survey of India Offices, Calcutta, March.

1888

to be triangulated therefore devolved on Mr. Barckley. Observations were prevented in a certain tract by the unsettled state of the tribes which necessitated the avoidance of that neighbourhood, and the complete programme was, therefore, not accomplished, but this portion will be finished in the ensuing season.

This triangulation was connected on the north with that executed by Captains Talbot and Wahab in 1882-83. The result, however, is not very satisfactory, which is owing in a great measure to the dense haze which spreads over the country during the months of May and June and to the fact that the cairns erected as marks for observation were often knocked down by the Brahuis as soon as erected, so that on occasions the top of the hill only could be observed to. A few observations next season will, it is expected, perfect the work.

55. The country topographically surveyed comprises portions of the Bugti and Marri hills, the Khetráni hills, the Kachi near Sibi, the Bori valley and the Luni Pathán country in the north and the juniper forests about Ziárat. Captain Longe reports that the Marri, Bugti and Khetráni countries are extremely intricate and that great difficulties were met with in obtaining water and supplies. To the north however the country is much less complicated, the valleys are wider and comparatively well inhabited, and the hill ranges which run approximately east and west, are well marked and easily surveyed.

56. The four native soldiers who had been attached to this party during the previous year were sent back to military duty after a two years' course of instruction. They were replaced by three other native soldiers who have been with the party throughout the year under report. They have shown considerable aptitude and intelligence and are capable of performing independent surveys on the ½-inch scale. During the recess season they have been instructed in drawing, in which they have made considerable progress and during the ensuing season they will be taught geographical and route surveys.

57. The health of the party during the field season was on the whole good; though owing to the extremes of heat and cold always met with in this country the season was a trying one. Captain Longe reports that during the latter part of April and in May the heat in tents in the Marri and Bugti hills was almost unbearable.

58. A small detachment comprising one European Surveyor and one Sub-Surveyor from this party and the same from No. 16 Party recessed at Quetta, to carry out any special work that might be urgently required by the military authorities. They were employed in working out the computations of the triangulation done by Captain Longe's party during the field season.

59. During the year the drawing of the fair sheets of the 2-inch survey of the Khwája Amrán range was completed, two Sub-Surveyors having been employed on it throughout the year. This survey was executed during the previous season, but owing to the shortness of the recess that year the fair-drawing could not be finished. During this recess season all the fair maps of the sheets surveyed this year on the ½-inch scale were drawn, except those of which the survey was executed during the recess by the detachment which remained at Quetta. The fair maps have been drawn with much care and skill. The computations of the season's triangulation were completed and the charts and general reports of Degree sheets brought up to date. A long report on the explorations of two Sub-Surveyors in the Registán, mentioned in paragraph 60, Part II, of last year's Report, was translated by the office writer and epitomised by Mr. Claudius. Captain Longe has written an interesting account of the country topographically surveyed, and Mr. Barckley has submitted a comprehensive report of the routes, &c., in the area which came under triangulation. These reports have been separately printed.

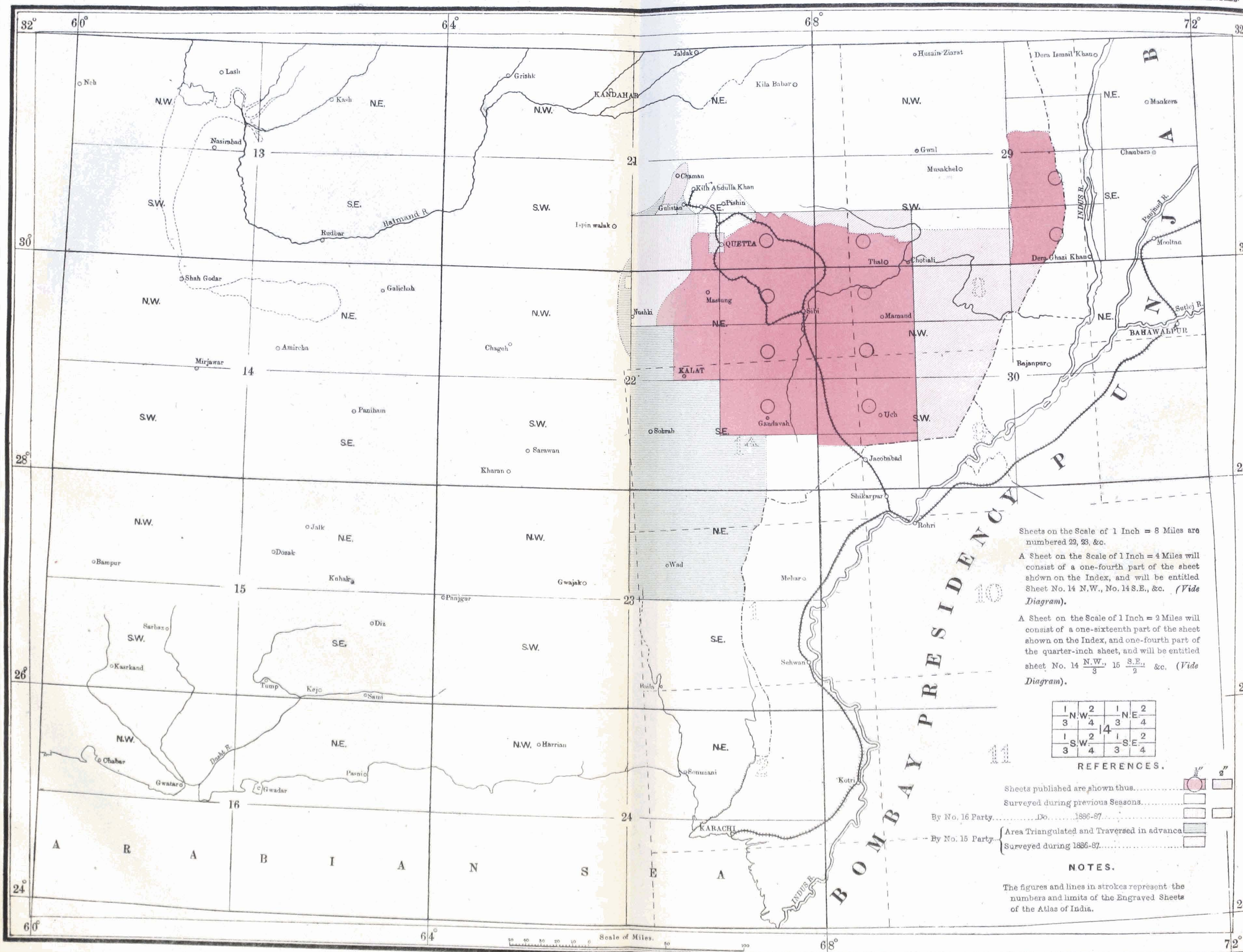
60. The cost-rates of this party will be found at page 72 of the appendix. The expenditure on these trans-frontier surveys is necessarily high, as explained in paragraph 59, Part II, of the last Annual Report, owing to the heavy charges for tribal escorts for the protection of the surveyors. The amount incurred on this account alone during the year under report was R23,759 or more than one quarter of the whole cost of the party. The cost of carriage also is exceedingly high.

During the ensuing season sheet 23 N. W. will be triangulated and if time admits, part of sheet 23 S. E. A series of first-class triangles will be carried from Kalát to the Great Indus Series. The topography will be taken up of

NORTH WESTERN TRANS-FRONTIER SURVEY.

INDEX TO THE SURVEY OPERATIONS IN BALUCHISTAN.

Nos. 15 & 16 PARTIES.



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Photozincographed at the Survey of India Offices, Calcutta sheets 22 $\frac{S.E.}{3\,\&\,4}$, 23 $\frac{N.E.}{1,2,3\,\&\,4}$, 30 $\frac{S.W.}{3}$, and if possible of portions of sheets 22 S. W. and 23 N. W.*

BALUCHISTAN.

No. 16 Party.

Personnel.

Captain R. A. Wahab, R.E., Offg. Deputy Superintendent, 4th grade, in charge.
Mr. W. Todd, Surveyor, 2nd grade.
„ W. W. McNair, Surveyor, 3rd grade.
„ E. Graham, Assistant Surveyor, 1st grade.
„ G. P. Tate, Assistant Surveyor, 2nd grade.
„ B. R. Hughes, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

Abdul Ghafar.	Asgar Ali Beg.
Ghulam Mahomed.	Jafar Ali.
Mahomed Husen.	Imam Bakhsh.

61. Owing to the demands of the military authorities for special surveys on the frontier, the party that had been employed for some years past in Rajputana and Central India was transferred to Baluchistan, and Captain Wahab, R.E., who had been temporarily attached to the Himalaya Party during the absence of Colonel Tanner with the Tibet Mission, was placed in charge a short time prior to the party taking the field. Lieutenant Pollen, to whom the conduct of the party had been entrusted during the recess season of 1885-86, was transferred to the charge of the S. Maratha, or No. 10 Party.

62. The strength of the party on taking the field is shown in the margin above. Leaving Mussooree early in October, Sibi was reached on the 22nd, and by the courtesy of the Manager of the North-Western Railway (Pishin Section) the party was enabled to travel with all its equipment over the then unopened Bolán line to Quetta, and thus the expense and loss of time which would have been incurred in the trying march through the Bolán pass was saved.

63. The original programme of work for the party was the extension of the general survey of Baluchistan on the ½-inch scale in conjunction with No. 15 Party; but shortly after the arrival of the party at Quetta, when all preparations had been made for carrying on the ½-inch work in the neighbourhood of Kalát, a requisition was received from the military authorities for certain special surveys which were to take precedence of all regular work, and a few days were, therefore, lost in making arrangements for the new programme. This included a detail survey, on the 6-inch scale, of about 27 square miles of country in the neighbourhood of Quetta; a 2-inch survey of the eastern portion of the Pishín plain and the Surkháb, Gwal and Kach valleys with the intervening hill ranges, also the extension southwards of the 2-inch survey of the Khwája Amrán range to include the Wach Dara, the southern branch of the Gwázha pass.

64. All this ground had to be triangulated and the computations worked out before the party could commence the detail survey, and as the whole establishment was not required for these preliminary operations, a certain number of the efficient plane-tablers were employed on the ½-inch survey in Shorárud and Shorávak, a part of the original programme, and this was carried out without interfering with the progress of the special surveys.

65. The out-turn of topography executed during the season is as follows :—

27	square miles	surveyed on the	6-inch	scale.
760	„	„	2-inch	„
2,276	„	„	½-inch	„

The 6-inch area has been surveyed in great detail, with water-levelled contours at vertical intervals of 50 feet in the low ground and 100 feet in the higher hills, while the other areas have been as minutely surveyed as the scales would admit. The necessary examinations of the field sections were made to test the accuracy of the work.

* Captain Longe reports as follows on his Assistants :—" Mr. Claudius is a very valuable assistant; his knowledge of the country, the people and the work of the party generally has been of great help. Mr. Wainwright has worked very steadily and well throughout the year. Mr. Barckley had a very long and trying season and worked very energetically. Mr. Kitchen is a very accurate and careful surveyor."

The Sub-Surveyors are generally favourably reported on, and the following are specially brought to notice :—Ahmed Ali Khan, Hussein Baksh and Kadar Sharif. The services of the writer Fateh Mahomed are also prominently mentioned in having translated a long report on the Nushkí exploration out of office hours.

66. The triangulation for the 6-inch and 2-inch work was based on the side Mashelak—Usda of the Baluchistan Series, both of which stations were satisfactorily identified. From this base, triangulation was extended to the crests of the hills north of Pishin, and every opportunity was taken of fixing prominent points considerably beyond the limits of the detail survey to the north and east.

The triangulation for the 6-inch survey was completed during November and the computation and plotting of plane-tables by the 15th December, when the detail survey was commenced. In addition to the triangulated points, a number of points were fixed (and their heights determined) by traversing, which were of great assistance in the contouring.

The triangulation for the 2-inch work was completed by the same date and the computations and plotting by the middle of January. The area triangulated was about 910 square miles. Some difficulties were experienced owing to wet and cloudy weather in the high hills near Kach, but the observations were fortunately complèted before the worst of the cold weather with its fogs and snow had set in.

67. Captain Wahab has submitted an interesting report descriptive of the country surveyed, which has been separately printed.

68. The party remained at work throughout the winter months without interruption, and though the operations were occasionally delayed by snow and intense cold in January and February, the health of the party did not in any way suffer. The main body of the party returned to recess quarters at Mussooree on 25th May, but three Sub-Surveyors remained in the field until the middle of June to complete the work in the higher mountains, which could not be entered during the winter months owing to the extreme cold. They were supervised by Mr. Graham, who remained with the detachment that recessed at Quetta.

69. Three native soldiers were attached to this party also, for instruction in surveying. They were taught plane-tabling during the first few months, and were eventually able to take a share in the operations, each surveying about 40 square miles of easy ground.

70. During the recess the fair maps of the whole of the 2-inch and 6-inch work have been drawn—the former in 9 sections of the standard size, the latter in 3 sections, all of which have been reproduced. The 6-inch sheets show only the instrumental contours traced in the field, and interpolated contours based on the hill sketching of the field sections, where, owing to the steepness of the ground, regular contouring was impossible. In the field sections the hills have been represented with the addition of eye contours at 10 feet vertical intervals, but owing to the shortness of the recess, time did not permit of these eye contours being drawn on the fair maps. These can be added if required at any future time, but the maps in their present state are for many purposes clearer and more useful than they would be with complete hill shading.

71. The large out-turn and excellent character of the work that has been accomplished by Captain Wahab and his assistants is highly creditable, more especially as this was the first year the party had been employed in the country, and most of the members were inexperienced in frontier work.

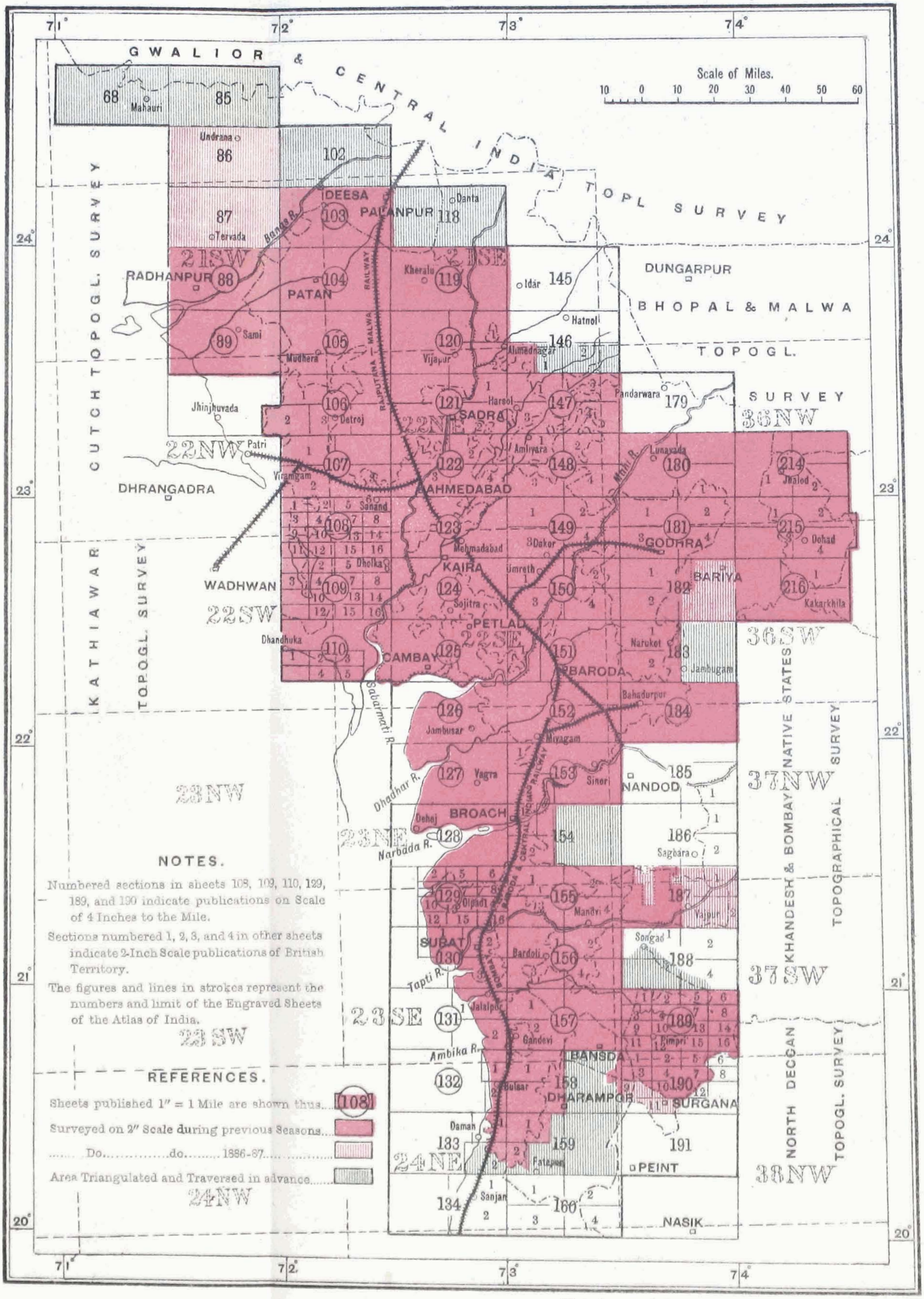
72. During the ensuing season the party will continue the general survey of Baluchistan on the ½-inch scale as far as any special requisitions that may be made on it will admit. A first-class series of triangulation will also be carried along the 30th parallel between Dera Ghâzi Khan and Pishín, which, in conjunction with a meridional series, to be run by No. 15 Party, southward, to join the Great Indus Series near the 27th parallel, is intended to link the stations on the Pishín frontier with the great triangulation of India and form a final basis for extensions that may be required in Southern Afghanistan and Baluchistan.*

* Captain Wahab reports that all his Assistants worked zealously and well. Messrs. McNair and Graham did specially good work both in triangulation and detail survey; and to the excellent services of these two officers Captain Wahab attributes in a great degree the successful completion of the programme. Of the Sub-Surveyors, Abdul Ghafar and Jafar Ali worked particularly well.

BOMBAY SURVEY.

INDEX TO THE SURVEY OPERATIONS IN GUJARAT.

No. 17 PARTY.



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1887.

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45	185
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50	190
51	191
52	214
53	215
54	216

Nos. 68 & 85 are 43 & 85 of Rajputana Survey.

GUJARAT AND THANA DISTRICT, BOMBAY.

No. 17 Party.

Personnel.

Colonel A. Pullan, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. J. Newland, Surveyor, 4th grade.
" G. A. Knight, Assistant Surveyor, 1st grade.
Mr. S. F. Norman, Assistant Surveyor, 1st grade.
Mr. C. Norman, Assistant Surveyor, 1st grade.
" P. J. Serrao, Assistant Surveyor, 3rd grade.

Sub-Surveyors.

Gopal Vishnu,	Balkrishna Babaji,
G. R. Bhopatkar,	Govind Gopal,
Bhau Gobind,	and 19 others.

73. This party, which had been under the charge of Mr. J. Newland during the greater part of the previous year, owing to the paucity of available officers of the Senior Division, was at the commencement of the field season placed under the charge of Colonel Pullan, whose services became available on the completion of the Cutch Topographical Survey, and the operations during the year under report have been supervised by that officer.

74. The party was divided into two sections for employment on two distinct operations, and left recess quarters at Poona on 18th November 1886, one section proceeding to Surat and Pálanpur to carry on the topographical survey of Gujarát on the 2-inch scale; and the second to the Kalyán *taluka* to commence the surveys, on the scale of 8 inches to a mile, in full detail, of the Forest Reserves in the Thána district required by the Bombay Government.

75. The topographical section has completed the detail survey of 1,841 square miles on the 2-inch scale, included in sheets 86, 87, and portions of sheets 182, 187 and 190. The whole of sheets 85 and 86 consist of open sandy plains offering no obstacles to the surveyor; the portions of sheets 182, 187 and 190 that were surveyed comprise low undulating hills thickly wooded and difficult to delineate, and consequently the progress of the work was much slower.

76. In addition to the above, the triangulation of sheets 102 and 118 has been executed, comprising an area of 1,085 square miles, in advance for next season's detail survey. The boundaries between different States and *talukas* in Baroda were also traversed, aggregating 236 linear miles.

77. The topography has been surveyed as minutely as the scale would admit and its accuracy has been tested in part by 197 linear miles of check traverses, and elsewhere by *in situ* examinations made by the executive officer and his senior assistants.

78. The Forest Survey section was exclusively employed in the Thána Forests under the immediate supervision of Mr. Newland. As this was the first season of the field operations, the work was at first necessarily confined to the preliminary triangulation and traversing and the detail survey was not commenced in consequence till the 15th December, when a small squad of 6 plane-tablers was started and the remainder early in January. The character of the survey required was a topographical survey, on the scale of 8 inches to a mile, showing all details that the scale will admit. The work has proved to be one of considerable labour and necessarily of slow progress.

79. The area topographically surveyed on this scale is 53 square miles comprising the forest reserves of 43 villages of Karjat *taluka*, 18 villages of Sálsette, and 7 villages of Kalyán, including the Khairna-Pati Reserve on the Parsik range of hills. The work lies in 7 detached blocks and is confined to the hills. The range varies in height from 500 to 1,300 feet above sea-level, and though in parts it is sparsely wooded and bears but little valuable timber, still great obstruction was met with on account of the thickness of the scrub jungle which is mainly composed of *khair* and cactus. The boundaries of the forests which run round the bases of the hills, encircling each block of forests separately, have been surveyed by chain and theodolite traverse with offset measurements to boundary-pillars where necessary. The survey included the determination of contours by the water-level, differences of height having been taken at vertical intervals of 12½ feet down the spurs of the hills or at suitable distances along the hill sides, the contour lines between the water-level marks being sketched in. The water-level operations are based on the heights obtained by the triangulation; the measurements add considerably to the cost of the work, but without them the

survey would be of an inferior character, and not suitable to the requirements of the Forest Department or of the prescribed scale.

80. The accuracy of the topography of each field section was tested by *in situ* examinations, and with one exception, which required a partial re-survey, was found to be highly satisfactory.

81. The triangulation for these Forest surveys covered an area of 107 square miles by means of observations at 145 stations, the total number of points fixed being 548, the heights of which were determined. This number of heights was supplemented by the boundary traverses, the aggregate length of which is 159 linear miles, and further determinations were obtained with the clinometer to provide an efficient basis for the water-levelling operations. The area that has been prepared in advance for detail survey next season is 28 square miles.

82. The section employed on these Forest surveys suffered very considerably from fever. It is locally recognized that survey operations cannot be effectively carried out in the Thána forests between November and January, both months inclusive, owing to the prevalence of malarious fever at that time, yet to meet the requirements of the local Government, it had to be attempted, and the progress of the work was in consequence much retarded by sickness. During the current season it has been arranged to prosecute the preliminary operations of triangulation and traversing only during these unhealthy months, and to employ all the detail surveyors in Gujarát until the end of February, when the major part of them will be moved into the Thána forests, and in the three remaining months of the field season, with the stronger force that will be employed, it is expected that a larger out-turn will be obtained.

83. The field operations were continued till 31st May, when the party returned to its recess quarters at Poona. During the recess season all the fair maps of the general survey on the 2-inch scale were prepared and those of the forest survey on the 8-inch scale have been drawn in 21 sections, according to the geographical lines which are ordinarily used for limiting standard sheets, and dividing the forests into sections. In addition to the details within the forests which were surveyed, these maps show the principal topographical features in the immediate neighbourhood of the forests, which have been added by enlargement from the maps of previous surveys. They are excellent specimens of work and show that the survey has been carried out with much care and skill.

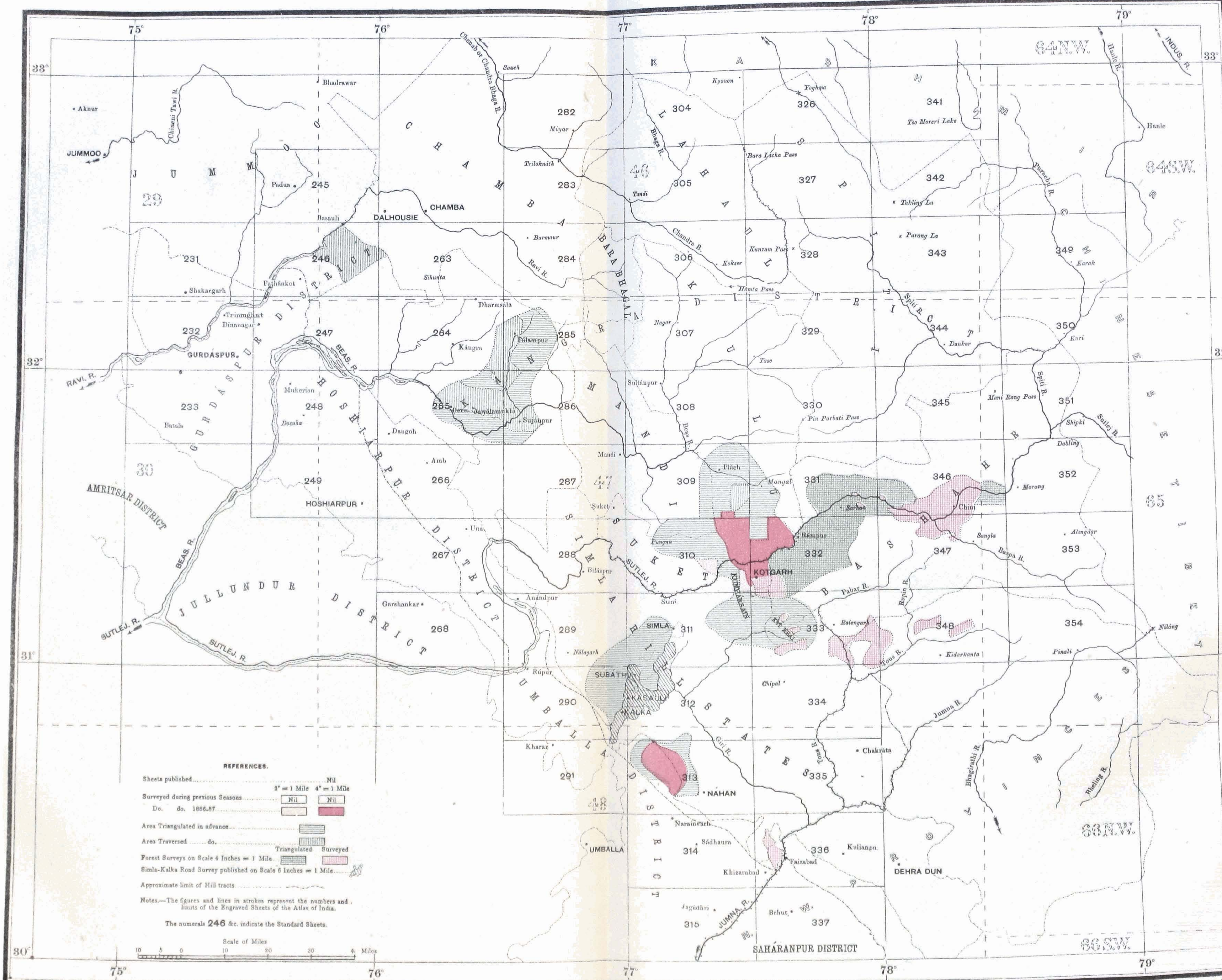
84. The costs of the different operations will be found at page 72. That of the 8-inch survey is excessive, but this is due to the operations having only recently been undertaken and to the circumstance that the proper re-organisation of the establishment for forest work, which is being carried out by training additional plane-tablers, has not yet been developed. These drawbacks, which are inseparable from new operations, are being overcome. The limited period of four months in which field operations can be carried on in the Thána forests owing to the unhealthiness of the country, also militates greatly against a large out-turn of forest work. This difficulty has been met by extending the forest survey operations over the whole of the Northern Division, instead of confining them to the Thána district, and arrangements have been made to commence, during the ensuing season, the survey of the forests of Málegaum where the country is healthy, *pari passu* with the Thána forests, whereby the field establishments can be satisfactorily employed on the survey of forests during seven or eight months each year. By this means, and with the experience that has now been obtained by the field surveyors of the work necessary for this large scale, a considerable increase of out-turn of forest surveys is expected with the corresponding result of a much cheaper cost-rate.

85. The programme for the ensuing season is for the topographical section to continue the general survey of Gujarát, on the 2-inch scale, in the northern portion of the Province, and to survey the cantonment and environs of Deesa on the 8-inch scale to meet the requirements of the Bombay military authorities; the forest section will continue the survey of the forest reserves, on the 8-inch scale, in the Kalyán and Karjat *talukas* of the Thána collectorate; and will commence the survey of those in Málegaum. A detachment comprising one European and two native surveyors will be deputed to the Rajputana Agency for employment on the disputed boundary between Meywar and Marwar in the Aravalli Hills.

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE HIMALAYAS.

No. 18 PARTY.



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Survey of India Offices, Calcutta, March.

1888

86. The recess office of this party was inspected by the Deputy Surveyor General in charge Revenue Branch, who had proceeded to Poona for the purpose of inspecting the parties under his charge which recess there. He reports that Colonel Pullan is to be commended for the style of the topographical maps that have been produced, and that credit is also due to Mr. Newland for the excellent forest maps turned out under his immediate supervision.*

HIMALAYAS, PUNJAB.

No. 18 Party.

87. This party has continued throughout the year under the charge of Colonel Tanner. Field work was commenced on various dates during October and November 1886, in continuation of the previous season's operations, the nature and scope of which were described in paragraph 249, Part II of the Administration Report for 1885-86. The party remained in the field till July 6th 1887.

Personnel.

Colonel H. C. B. Tanner, Deputy Superintendent, 2nd grade, in charge.
Lieutenant J. M. Fleming, S.C., Offg. Assistant Superintendent, 1st grade.
Mr. H. E. T. Keelan, Surveyor, 1st grade.
„ E. S. P. Atkinson, Surveyor, 2nd grade, joined 12th February 1887.
Mr. W. Robert, Assistant Surveyor, 1st grade.
„ P. F. Prunty, Assistant Surveyor, 1st grade.
Mr. F. E. Warde, Assistant Surveyor, 3rd grade, up to 1st May 1887.
Mr. G. H. Powell, Assistant Surveyor, 3rd grade.

Sub-Surveyors.

Shah Nasiruddin, | Janki Dass,
Sheikh Omar, | Atma Sing,
and 14 others.

88. The exaggerated 2-inch detailed survey, *i.e.*, a survey on the 4-inch scale in open style, showing only the details required for a 2-inch map, was completed in the Morni State in the Kotáha *taluka* of the Umballa district and was also conducted in the Outer Seoraj *pargana* of Kulu, and in the Kotgarh *tahsil* of the Simla district. The Morni State, the Sháhpur Kandi *taluka* and a portion of the Pálampur *tahsil* of Kangra were traversed. Triangulation was carried on in Morni, Shahpur Kandi, Pálampur, Outer Seoraj and the Kotkhai *taluka* of the Simla district. The separate areas completed in the different localities and on the different scales are shewn below:—

District or locality.	Description and Scale of Survey.	Area in square miles.
Umballa: Morni State, Kotáha *taluka*	Topography, 4-inch	102
	Triangulation	157
	Traversing	102
Kángra: Kulu and Outer Seoraj Subdivisions.	Topography, 4-inch	146
	Triangulation	40 exclusive of 200 square miles partially triangulated from Principal Stations.
Gurdáspur: Shahpur Kandi *taluka*	Triangulation	100
	Traversing	100
Kángra: Pálampur *tahsil*	Triangulation	216
	Traversing	70
Simla Hill States	Topography, 2-inch	35
	Triangulation	50
Simla districts: Kotgarh, Kotkhai and neighbourhood.	Triangulation	120
	Topography, 4-inch	24 inclusive of 8 square miles overlap into Hill States.
TOTALS	Topography, 4-inch	272
	Ditto, 2-inch	35
	Triangulation	683
	Traversing	272

* Colonel Pullan reports that Mr. Newland's work is excellent and his industry untiring. Messrs. S. and C. Norman have given great satisfaction both in the field and in recess. Of the Sub-Surveyors, Gopal Vishnu, G. Bhopatkar and W. Ganesh have done very good work both with the plane-table and theodolite, and in recess.

89. The bar-subtense method of traversing, which was explained in the foot-notes of page 51 of the last Annual Report, was followed, and by this means all the trijunction points of *bhojas* * and *mauzas* † in Morni, and to a great extent those of *mauzas* and *tikkas* ‡ in Pálampur were fixed in order to furnish a frame-work for the survey of the fields by *patwáris*. It has now been arranged with the Financial Commissioner of the Punjab that the Survey Department shall, in future, fix the trijunctions of these boundaries only in such parts of the country which are open and cultivated and where the hills are of moderate altitude, omitting those which are situated in high mountainous tracts, where the cultivation is much scattered, and where the *patwáris* could not be expected to make their village maps fit on to the fixed points.

90. The 4-inch topographical sheets shew the following items:—(1) boundaries of *kothis* * and *bhojas* without the boundary cairns, but including all contained trijunctions; (2) all forest boundaries with their cairns; (3) limits of cultivation and of unreserved forest tracts; (4) main lines of communication; (5) contour lines measured at vertical intervals of 500 feet in the lower hills and 1,000 feet in the higher mountains; (6) hill features, shown by lines at vertical intervals of 50 feet.

91. The contours, of which 900 linear miles were executed, have been laid down with the clinometer; this instrument was used in preference to the water-level, as it was found that owing to broken ground and to clumps of forest on the hill slopes, continuous lines could not be carried. Owing to the absence in some cases, and to the inferior quality in others, of the forest *shajra* § maps, the surveyors have had difficulty in finding all the forest boundary marks on the ground; arrangements have, however, now been made by the Financial Commissioner to ensure prompt and correct information being given to the surveyors in future.

92. The cost-rates of the work during the year under report are unduly high. This is in a great measure due to the scattered nature of the operations and partly to alterations in the previously arranged programme, but principally to failure in the work of three of the European Assistants caused by sickness, whereby the total out-turn fell far short of expectation.

93. Three soldier surveyors have been attached to the party for training, and during the year they have learnt plane-tabling and the use of the theodolite, and have executed route surveys from which they have constructed a map of the country travelled over.

94. The Director of Settlements has attached pupils to the party for plotting the 161 sheets of Morni on the 40-*kadam* scale (27·68 inches = 1 mile). They have also traced the Morni sheets, as an index to the operations of the Settlement Department in that *taluka*.‖

MADURA AND TINNEVELLY DISTRICTS, MADRAS.

No. 19 Party.

95. The Government of Madras having accepted the proposal of the Government of India, for the transfer of the topographical work remaining to be completed in the Madras Presidency from the local Survey Department to the Survey of India Department, this party, which had just completed the survey of the

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* A *kothi*, or in the Morni State a *bhoja* is a collection of several village lands under a single *mukia* or head man, who is responsible to Government for the revenue of the *kothi*; it is therefore somewhat similar to an *iláka* in other parts of India.

† A *mauza* includes an area within convenient and generally natural limits and all the habitations therein.

‡ A *tikka* is a subdivision of a *mauza*.

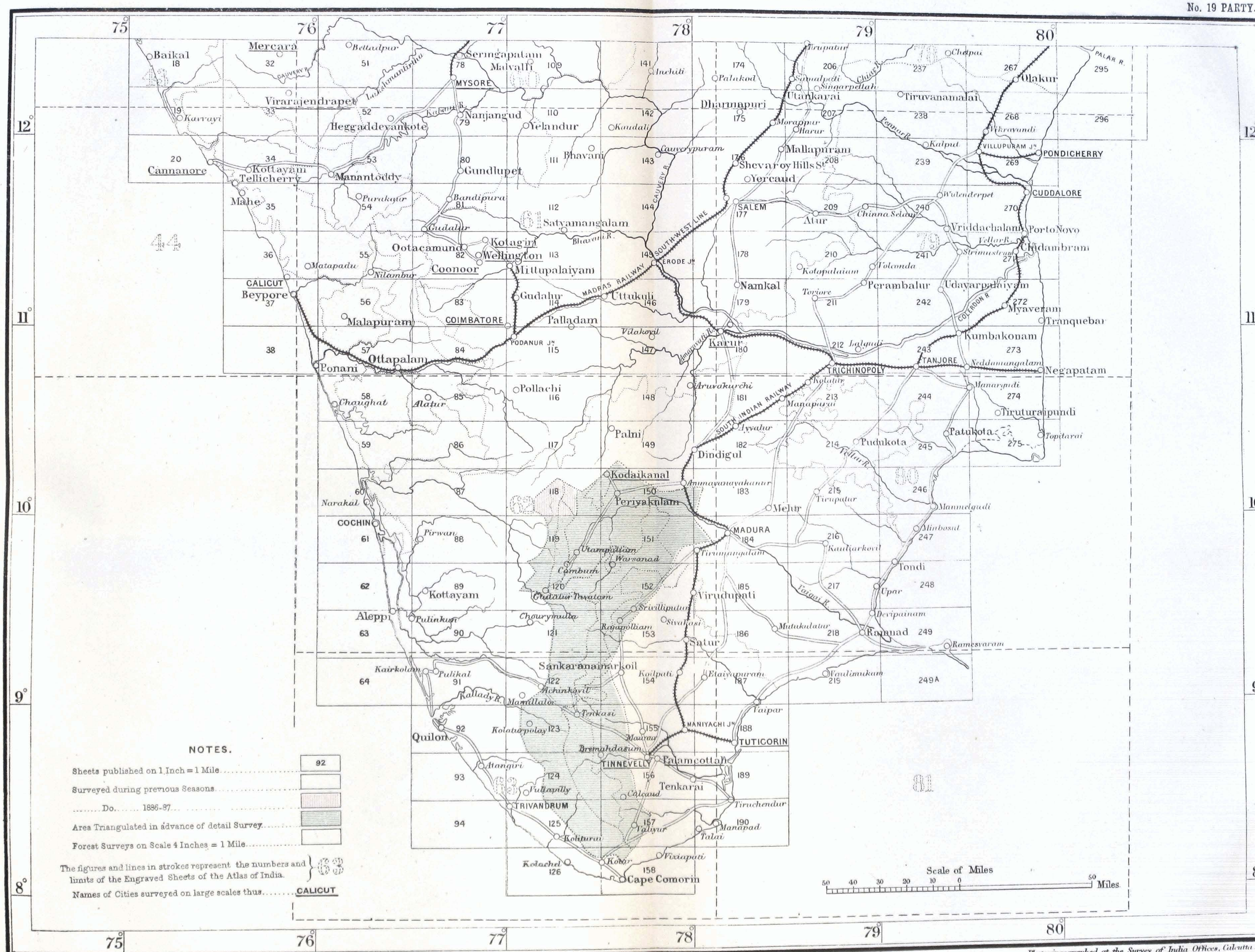
§ A *shajra* is a village map on which is recorded every individual holding of land in the village.

‖ Colonel Tanner reports favourably on Messrs. Robert, Prunty and Powell.

MADRAS SURVEY.

INDEX TO THE SURVEY OPERATIONS IN MADRAS.

No. 19 PARTY.



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Survey of India Offices, Calcutta, January.
1888

State of Mysore, was selected to undertake the work. The following are the districts in which the incompleted portions, aggregating about 12,400 square miles, will be surveyed on the 1-inch scale:—Ganjam, Vizagapatam, Tinnevelly, Madura, South Canara and Malabar. The survey of the forests in the last four districts is also to be undertaken on the scale of 4 inches to the mile.

96. The districts of Madura and Tinnevelly having been selected for the operations to be commenced in, the party proceeded thereto under the charge of Lieutenant Jackson, R.E., from the recess quarters at Bangalore. The whole of the computations, mapping, records, &c., connected with the survey of Mysore, had been completed early in October, but as the country to be operated in could not be entered with safety to health till towards the end of November, the party marched down from Bangalore, arriving at Karúr to the north of the Madura district, on the 4th November and on the 18th field operations were commenced. In the meantime Lieutenant Jackson was transferred to the Upper Burma detachment at Mandalay and Colonel Badgley took over the charge of the party from him at Karúr.

Personnel.

Lieutenant-Colonel W. F. Badgley, S.C., Officiating Deputy Superintendent, 2nd grade, in charge from 4th November 1886.
Lieutenant H. M. Jackson, R.E., Officiating Deputy Superintendent, 4th grade, in charge to 4th November 1886.
Mr. A. J. James, Surveyor, 4th grade.
„ H. Todd, „ „ „
„ R. Todd, Assistant Surveyor, 1st grade.
„ T. J. J. Mills, „ „ 2nd „

Sub-Surveyors.

Raghavayengar.	L. Jadow.
Tiruventkatsami.	B. Dhondiba.
A. Dhondiba.	

97. As the country to be surveyed had not been prepared in advance for the detail survey, the operations of the whole party were almost entirely confined to triangulation throughout the season. The triangulated area that has been completed amounts to 4,370 square miles, which is considerably in excess of the area of which topographical survey is required, but it was found necessary to extend the triangulation to this extent in order to overlap the country which had been surveyed by the Madras Revenue Survey, so as to secure a good junction therewith and also to supply heights in parts where they were deficient. The triangulation was based on sides of the Great Arc Series of the Great Trigonometrical Survey and on the triangulation of the Palni hills executed by the Madras Survey. Observations were taken at 57 new stations from which 691 points were fixed and the heights thereof nearly all determined. In the area over which the detail survey is required, this triangulation furnishes on an average, about one point in every three square miles.

The country embraced by the triangulation consists of the Warasnath hills projecting eastward into the Madura district and of a long narrow strip running southwards from the Palni hills nearly to Cape Comorin, being the eastern slope of the range of which the watershed forms the Travancore boundary. Some of this ground was especially difficult, being covered with bamboos or damp forest with dense undergrowth, infested with leeches.

98. In addition to the triangulation executed, a small area of 172 square miles was topographically surveyed by Colonel Badgley in sheet 118 on the 1-inch scale. This was the only portion of unsurveyed country in which it was found that the old triangulation furnished a sufficient basis to admit of the detail survey being undertaken. It was for the most part open but exceedingly rugged and precipitous, which made it most tedious to survey owing to the difficulty in getting from point to point. The country being impracticable for carts except along the foot of the hills, coolies were the only means for transport, and they were not easy to obtain owing to the paucity of inhabitants in the hills, and to their aversion to physical labour. All supplies and the coolies themselves had to be imported generally from the villages in the plains, sometimes at a great distance from the work, which caused a good deal of delay. A description of this part of the country by Colonel Badgley will be found in the appendix at page v.

99. The field operations were closed at the beginning of May owing to rain fall, which rendered the country unhealthy, and the party repaired to recess at Octacamund. During the recess the computations and charts of the triangulation executed during the field season were completed.

100. In addition to the areas in the Madura and Tinnevelly districts that have been assigned to this party aggregating about 1,445 square miles, the survey will embrace the adjoining Native States of Travancore and Cochin, and will be carried out on the 1-inch scale *pari passu* with that of the British districts. The

existing maps of the mountainous tracts of these States, which were surveyed some seventy years ago, are very deficient. The present survey will be confined in the first instance to these tracts, as the village lands are in course of survey by the Government of these States for revenue purposes. From information received from the local Superintendent of Survey, the village maps are prepared on the scale of 16 inches to a mile and embrace all topographical details; and, as the survey is said to be based on a scientific framework, it is possible that the village plans may be utilized for preparing the topographical standard sheets of that part of the country, and endeavours will be made to secure this result, and obviate a re-survey of the portions completed by the States' Government. The programme for the ensuing season will therefore be as follows:—To extend the preliminary triangulation over the required tracts in Cochin and in the northern half of Travancore; to traverse the Travancore-Tinnevelly boundary, and to carry out the detail survey of the country that was triangulated in the last season as far as can be arranged.*

The approximate areas and the scales of survey required that remain in Madura and Tinnevelly are as follows:—

		Square miles.
In Madura	1-inch survey	885
,,	4 ,, ,, (forest reserves)	10
In Tinnevelly	4 ,, ,, (do.)	550

NICOBAR ISLANDS.

No. 21 Party.

Personnel.

Lieutenant-Colonel G. Strahan, R.E., Deputy Superintendent, 1st grade, in charge.
Mr. J. Keating, Assistant Surveyor, 1st grade.
,, D. Campbell, ,, ,, ,,
,, R. W. Senior, ,, ,, 2nd grade.

Sub-Surveyors.

Harlal Sing, Ali Nawaz Khan.

101. This party completed the survey of the Andaman Islands during the previous season and was under orders for Upper Burma, but the Chief Commissioner having decided that the country was still too disturbed to allow of the introduction of regular survey operations, it became available for the survey of the Nicobar Islands as had been originally contemplated.

102. The main body of the party sailed from Calcutta on the 19th November. Port Blair was reached on the 24th November, and after discussing with the Officiating Superintendent, Colonel Wimberley, the requirements of the survey and the best means of carrying them out, Colonel Strahan embarked again and reached Kamorta on the Great Nicobar island on the 26th idem. Two of the Indian Marine steamers, *viz.*, the *Kwangtung* and the *Nankauri*, with all their boats, were placed at Colonel Strahan's disposal as well as a batch of convicts required for manual labour. An Assistant had been sent on nearly a month before to make arrangements for supplies, materials, &c., and to select and prepare a site for a base-line. His work was, however, very much retarded by the rain which fell almost incessantly from the time he landed till the arrival of the party, and indeed throughout the whole field season.

103. As it had been decided that the operations were only to extend over one season, some departures from the usual practice in commencing new surveys were necessary, the most important being that, as no elements on which to base the work were in existence, it became necessary to carry on the detail survey, the triangulation and astronomical work, all simultaneously, arrangements being made for subsequently fitting on the detail work to the stations of the triangulation, after it had been computed out on return to recess quarters.

104. The objects to be attained in the topographical survey of the Nicobar Islands were four in number, *viz.*, 1st, an accurate survey of the coast lines of

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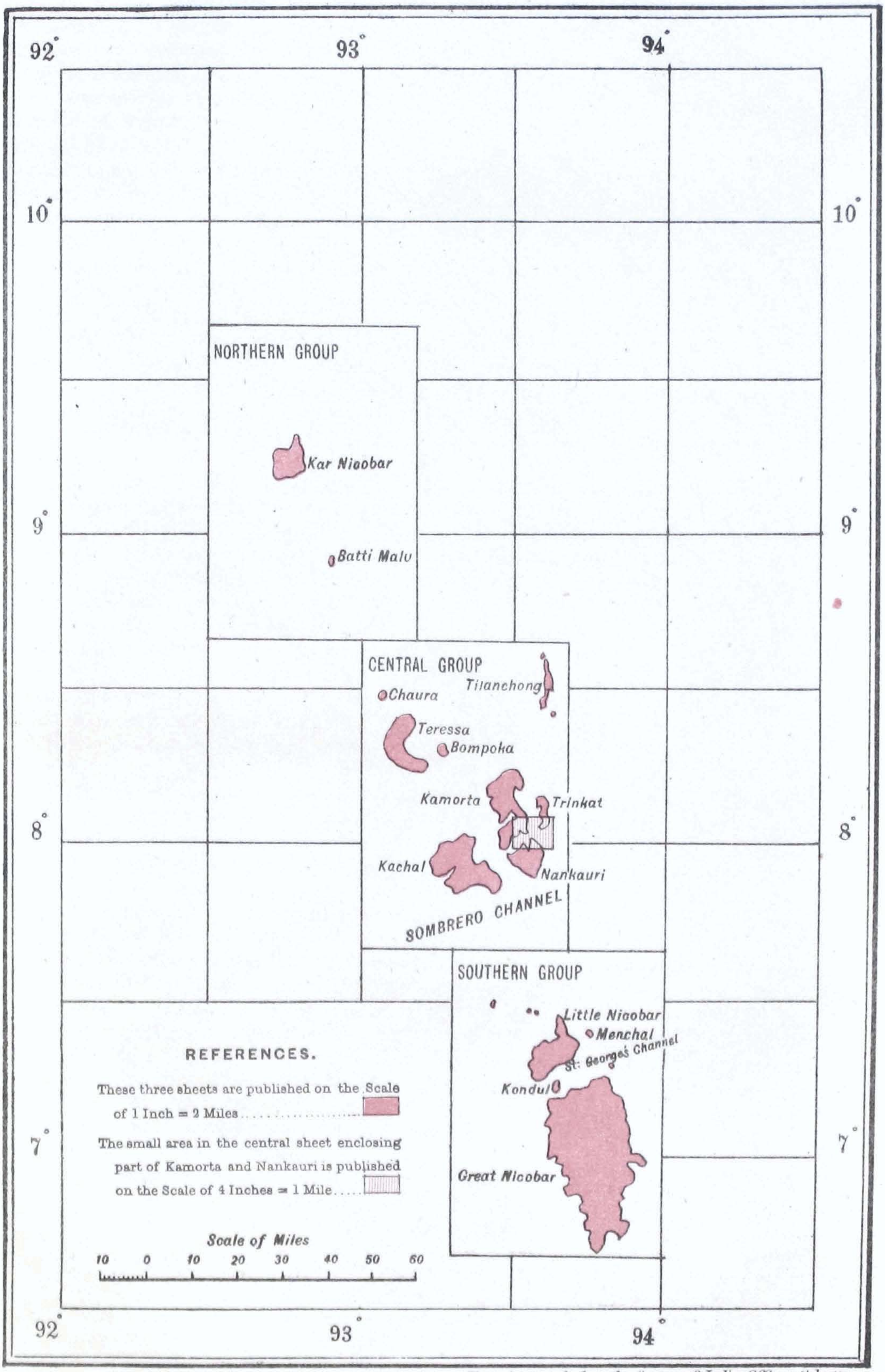
* Colonel Badgley reports favourably of the work executed by all his Assistants.

NICOBAR ISLANDS.

INDEX TO THE TOPOGRAPHICAL SURVEY.

No. 21 PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel H. R. Thuillier, R.E., *Surveyor General of India.*

Survey of India Offices, Calcutta, January.

1888.

each of the principal islands; 2nd, a correct determination of the position of the Nicobar group on the earth's surface, including their relative positions *inter se*; 3rd, as much topographical detail of the interiors of the islands as could be obtained; and 4th, an enlarged plan of the settlement of Kamorta and its environs, contoured at 25 feet vertical intervals, and on a scale sufficiently large to show the various buildings, roads, drainage lines, &c., clearly.

105. Of the four objects specified above, the first two have more special reference to the requirements of navigation. Hitherto the charts of this group of islands have been confessedly very inaccurate; they were chiefly compiled from sextant observations by Danish and Austrian ships, and though not erring very grossly in the position of the islands in latitude and longitude, they are very inaccurate in the details of the coast lines, and contain no topography whatever of the interiors.

106. To meet these requirements it was necessary to arrange (*a*) for the determination of astronomical latitude and longitude at certain points, (*b*) for a network of triangulation, extending over all islands that are mutually visible, including the measurement of a base-line; (*c*) for the delineation of the coast lines; and (*d*) for the contouring and detail surveying of the settlement of Kamorta and its immediate environs, to which was added by a subsequent request of the officer in charge of the Tidal and Levelling Party—a tidal record of the rise and fall of the tide at Kamorta at 15-minute intervals for 33 days and nights.

107. The astronomical observations were undertaken by Lieutenant-Colonel Strahan and consisted firstly of a determination of the difference of longitude between Chatham Island, Port Blair and Kamorta by means of eight chronometers transported three times between the two observatories; and secondly, of the determination of the latitude of the Kamorta observatory. The longitude of Chatham Island had been determined by Mr. Nicolson of the Great Trigonometrical Survey in 1862-63 by a large number of observations of moon-culminating stars and lunar zenith distances; it was therefore deemed advisable to obtain the longitude of Kamorta differentially from Chatham Island rather than to determine it independently by astronomical observations. The method employed is such that twenty-four independent values are obtained, the probable error of their mean being only $\pm 0^{\cdot}11$ of a second of time corresponding to linear uncertainty of about 165 feet.

In the determination of the latitude of the Kamorta observatory there was no novelty, the usual well known methods being employed, giving a probable error of $\pm{}^{\cdot}81$ of a second of arc, equal to a linear distance of about 82 feet. Latitudes were also measured at nine other points, *viz.*, five on the coast of the Great Nicobar, one at Batti Malv, one at Kar Nicobar, and two on the Little Andaman.

108. A network of triangulation resting on a measured base-line about 4 miles to the north of Kamorta was laid out, and the angles observed as usual. The islands of Kar Nicobar and Batti Malv were the only ones not embraced in this network; they therefore depend entirely on observations of latitude and longitude, in contradistinction to all the other islands of the group which are connected together by triangulation. Time did not admit of hill tops in the interior of the islands being cleared of jungle to serve as stations, and consequently clear spots on the beach were the only points available for observing from, and it is obvious that stations on the sea-level are hidden from each other at comparatively short distances, and this difficulty prevented the triangulation from being so extended as it would otherwise have been.

109. Owing to the very limited time available for this survey, it was found impossible to secure much topographical detail in the interiors of the islands. A few conspicuous peaks were fixed during the progress of the coast traverses and some of the chief watersheds and watercourses were estimated with more or less approximation to the truth, but no attempts were made to penetrate the dense forests which cover most of the islands, as other far more important work occupied the attention of the party. The heights of several inland hill peaks were measured trigonometrically; the culminating point of the whole group which stands near the north-east corner of the Great Nicobar was found to be 2,105 feet above the sea. There are also three considerable peaks in the Little Nicobar of 1,417, 1,416 and 1,355 feet respectively, and one in Tilanchong of 1,040 feet; the other islands are of less altitude.

110. The peripheries and areas of the several islands are as follows:—

	Periphery. Linear miles.	Area. Square miles.
Great Nicobar	126·5	375·7
Little "	43·0	56·8
Kamorta	65·0	57·0
Kachal	43·3	61·7
Nankauri	26·3	19·4
Trinkat	14·8	6·7
Teressa	32·1	33·8
Bompoka	7·8	3·8
Chaura	6·1	2·6
Tilanchong	25·5	9·3
Kar Nicobar	30·5	48·5
Kondul, Menchal, Kabra, Trak, Treis, Meroe, Pulo Milu, Isle of Man, and Bati Malv, together	...	2·5
TOTAL AREA .	...	677·8

111. The plan of the settlement of Kamorta was made on the scale of 4 inches = 1 mile, and contoured at 25 feet vertical intervals. It is so constructed as to show the east entrance to the harbour of Nankauri and the anchorage there, as well as the position of the buoys laid down for the convenience of ships coming in there. The coast lines only of the adjacent islands of Trinkat and Nankauri are given, as it was considered unnecessary to extend the contouring to these.

112. The survey of these islands presented exceptional difficulties, and much credit is due to Colonel Strahan for the ability and readiness of resource which he brought to bear on the undertaking, the conditions of which were entirely different from those usually met with in India. Without the aid of the local authorities the difficulties would have been almost insuperable, and Colonel Strahan brings to notice the very cordial assistance rendered by Colonel Cadell and the various officers under his command, which enabled him to bring the operations to a successful completion. A very interesting account of the operations, as well as of the islands and their inhabitants, will be found in the extracts from Colonel Strahan's narrative report given at page vii of the appendix.

113. In addition to the survey of the Nicobar Islands a little extra work was done on the Little Andaman island at the request of Colonel Cadell, the Chief Commissioner of Port Blair. A portion of the coast was surveyed and two astronomical latitudes measured, one on the north point and another on the south point of the island, to supplement the previous survey of that group which had been left slightly incomplete during the previous season owing to want of time. The position of this island on the marine chart was found to be considerably in error; data now exist for correcting this, and its situation will be altered accordingly in future maps.

114. The field operations were brought to a close on the 19th April, and the recess office was opened at Mussooree on the 20th May. The results of the season's observations were then computed and the following fair maps, &c., prepared:—three sheets containing the northern, southern and central groups respectively on the ½-inch scale; one sheet showing all three groups together on the scale of 5 miles to 1 inch, prepared especially for the use of the Indian Marine Department; a chart of triangulation; a contoured plan of the settlement of Kamorta and environs on the scale of 4 inches to a mile; and one sheet containing the Little Andaman island on the ½-inch scale. During the next season the party will be transferred to Captain Hobday's charge in Upper Burma, absorbing the detachment already working there under that officer.

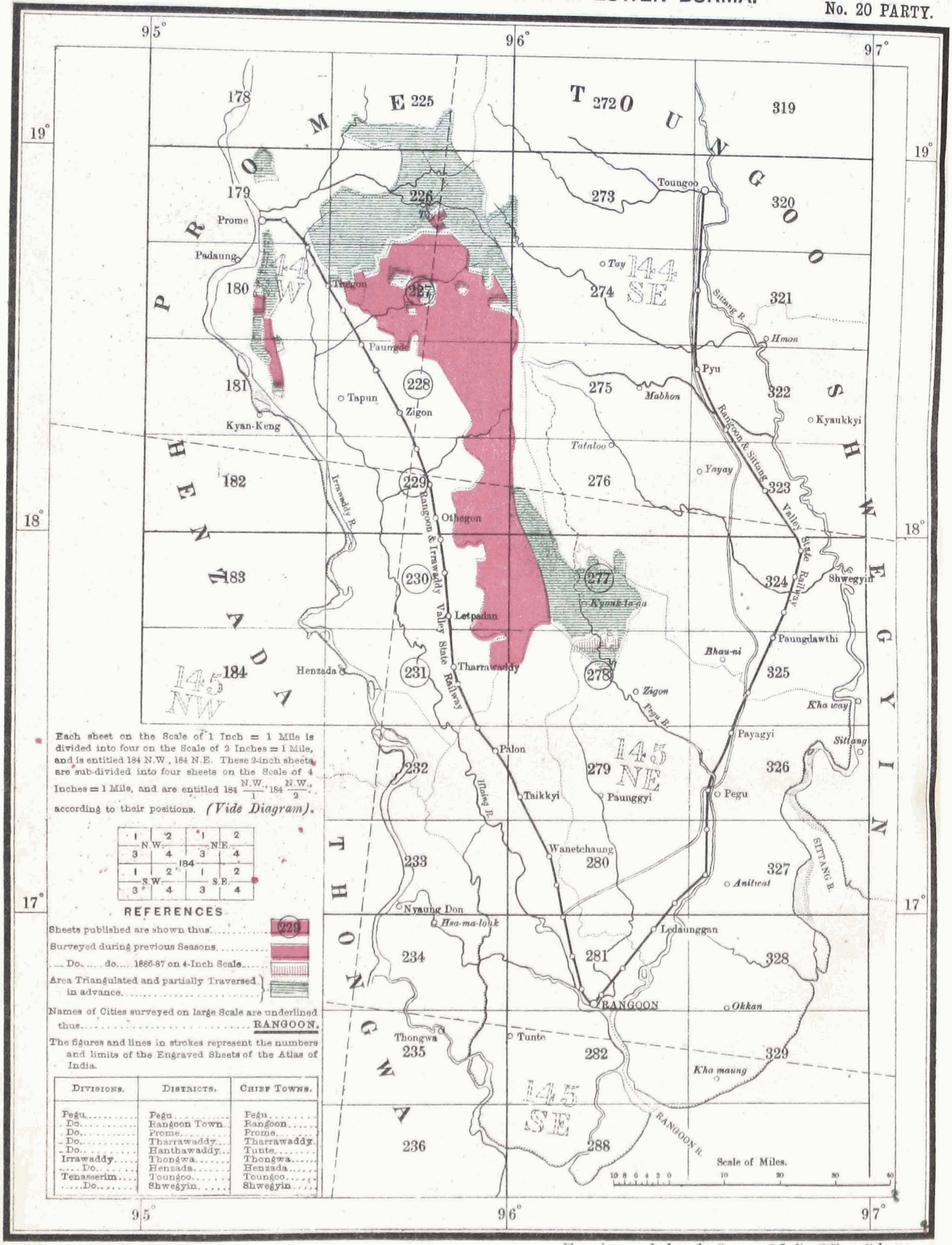
115. Owing to the varied character of the work on which the party was engaged no cost-rates can be deduced; the total cost of the operations, however, amounted to R39,006.*

* Colonel Strahan reports that Messrs. Keating and Campbell and Sub-Surveyor Harlal Singh have done conspicuously good work in spite of difficulties, hardships and sickness, to the effects of which the Sub-Surveyor unfortunately succumbed, having died after his return to recess quarters.

BURMA SURVEY.

INDEX TO THE FOREST SURVEYS IN LOWER BURMA.

No. 20 PARTY.



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Published under the direction of Colonel H. R. Thuillier, R.E., *Surveyor General of India.*

Survey of India Offices, Calcutta, March.

1888

FOREST SURVEYS.

LOWER BURMA.

No. 20 Party.

Personnel.

Mr. H. Hörst, Deputy Superintendent, 3rd grade, in charge.
Mr. A. G. Wyatt, Surveyor, 3rd grade, up to 1st January 1887.
Mr. J. H. Wilson, Assistant Surveyor, 1st grade.
Mr. C. P. Torrens, Assistant Surveyor, 1st grade.
Mr. W. H. Penrose, Assistant Surveyor, 1st grade, from 1st April 1887.
Mr. W. H. D. Ewing, Assistant Surveyor, 2nd grade, up to 1st January 1887.

Sub-Surveyors.

Venkat Swamy, Sher Shah, Durgaia, Sharfuddin, Sumer Sing, and 19 others.

116. This party, of strength as per margin, was divided into two sections—one to continue the detail survey on the 4-inch scale of the forest reserves in the Prome district in which the preliminary operations had been completed, and the other to commence the survey of the Zamayi reserve in the Pegu district with the usual preliminary triangulation and traversing. The former section, under the immediate supervision of the Deputy Superintendent, took the field on the 12th December and the latter on the 20th November 1886. Mr. Hörst reports that the party was efficient and thoroughly organised and equipped for the field, and that a good season's out-turn was expected; but owing to the same cause that led to a shorter out-turn of work last year, namely, the unsettled state of the country and to the timidity of the native establishment, the out-turn this year has not only fallen far short of what was expected but also of that of the preceding season.

117. The Sub-Surveyors told off for the detail survey in Prome were allotted work within 20 miles on either side of the Irrawaddy Valley Railway; those to the east of the line, hearing rumours of dacoits being in the neighbourhood, returned to the head-quarters camp the day after marching out, and refused to go out again unless each squad was provided with a police guard, and a guarantee was given them that Government would provide for their families in case of accidents. The *khalásis* followed the example of the Sub-Surveyors and shortly afterwards the squads of the European Assistants and of the remaining Sub-Surveyors also struck work. The men were reasoned with and every endeavour was made to induce them to return to their work, but to no effect.

118. As it was impossible to provide a police guard for each of the several detachments, it was found under the above circumstances to be futile to attempt to carry out the survey of the forests in that tract. With the concurrence of the Chief Commissioner, it was decided, therefore, to suspend operations in the Prome district and to transfer such members of the establishment for whom work could be found in the Pegu district, and to distribute the remainder among the other parties working in Burma, as reported in paragraph 139 of the last Annual Report. Mr. Wyatt and four Sub-Surveyors were then sent to Upper Burma where there was plenty of scope for the services of surveyors with the military expeditions, and five Sub-Surveyors were transferred to No. 7 Party employed in Akyab.

119. Mr. Hörst then proceeded with the remnant of his detachment to Pegu to join the section employed on the preliminary work in the Zamayi forest. The state of affairs here was almost as bad as in Prome. In the middle of December both the European Assistants fell ill, and were obliged to return to Pegu, one of them having to be sent on leave under medical certificate from 1st January. The Sub-Surveyors had stopped work, some through sickness, and others through fear of meeting dacoits, and the work was almost at a standstill, one Sub-Surveyor only, whose name, therefore, deserves mention, Modin Beg, standing to his ground and carrying on his allotted work. On the arrival of the Deputy Superintendent fresh efforts were made to push on the triangulation and to get some ground ready for detail survey. Mr. Wilson who had accompanied Mr. Hörst from Prome was detailed for this duty; he was the only efficient Assistant remaining with the party and he continued these operations till the end of the field season. The lateness of the season and the consequent haze which then prevails retarded the observations, but Mr. Wilson persevered with his work, although suffering from fever, and the triangulation was completed on the 9th April and the results roughly computed.

120. In the meantime, in order to secure a certain amount of final survey, a few traverse plots were set up and on this basis detail survey was commenced on 12th March. Sickness and bad weather continued to retard these operations which were carried on till the beginning of May when the monsoon set in and prevented further field work. The party then returned to Pegu and arrived at recess-quarters at Rangoon on 23rd May.

121. The out-turn of the season's operations was thus naturally small, comprising the detail survey of 46 square miles on the 4-inch scale, the triangulation in advance of 295 square miles of a difficult and densely forest-clad country in which the means of communication was limited to one foot-path, and the traversing of 191 square miles of which 145 square miles remain to be surveyed in detail.

122. When the advance work of triangulation and traversing has not been previously prepared, and the detail survey has to be done in the same season as the preliminary operations, the out-turn of final topography must necessarily be small, even when climatic and local circumstances are favourable. The failure of the section in Prome and the consequent disorganization of the party rendered it imperative to employ the rest of the party which could not be elsewhere transferred, in the Zamayi forests in Pegu, where the above condition existed, and considering the very adverse circumstances met with, *viz.*, the extreme unhealthiness of the country operated in, the demoralization of the native members from fear of meeting dacoits and the limited establishment employed, the small result obtained is only what could have been expected. A fair cost-rate of the final survey cannot be deduced from such a small area. The failure of the work in Prome however has been partially compensated for by the additional geographical surveys that were executed by the members of this party transferred to Upper Burma and which will be reported on under the operations of the Upper Burma Party.

123. Mr. Hörst reports that the area brought under survey, locally known as the Lower and Upper Zamayi Reserves, is very intricate, being interspersed with low hills covered with extremely dense forest and intersected with deep ravines; the undergrowth and rank vegetation therein causing it to be very unhealthy. Sickness among the members of the party was excessive, and caused much interruption to the progress of the work. The Europeans and Natives suffered equally, chiefly from malarious fever, and scarcely a man escaped it.

124. During the recess the computations connected with the triangulation and traversing were brought up, and one fair sheet was drawn and sent to Calcutta for publication. On the 11th August, at the request of the Chief Commissioner, a detachment consisting of one European Assistant and two Sub-Surveyors was deputed to the Ruby Mines District to undertake a large-scale survey of the Ruby Mines, which cover an area of about 10 square miles. Owing to sickness and bad weather, the survey operations had to be suspended for a time, and the work is not yet completed.

125. Mr. Wilson conducted an examination in surveying of Burmans, who presented themselves as candidates for the posts of *thugyis* or village surveyors.

126. The Chief Commissioner having decided to retain the party in Lower Burma for another season, in order that the survey of the areas in the Prome district should be completed without further delay to prevent the risk of the triangulation and traverse marks disappearing, it has been arranged to employ the party during the coming season entirely in the Prome district, in the first instance to survey the 255 square miles of reserved forests on the 4-inch scale, and subsequently to take up such of the unreserved forest tracts, of which an area of 280 square miles has been prepared in advance, as time will permit.

127. Mr. Hörst having proceeded on furlough, the charge of this party has been placed in the hands of Major the Hon'ble M. G. Talbot, R.E., who will superintend the operations.*

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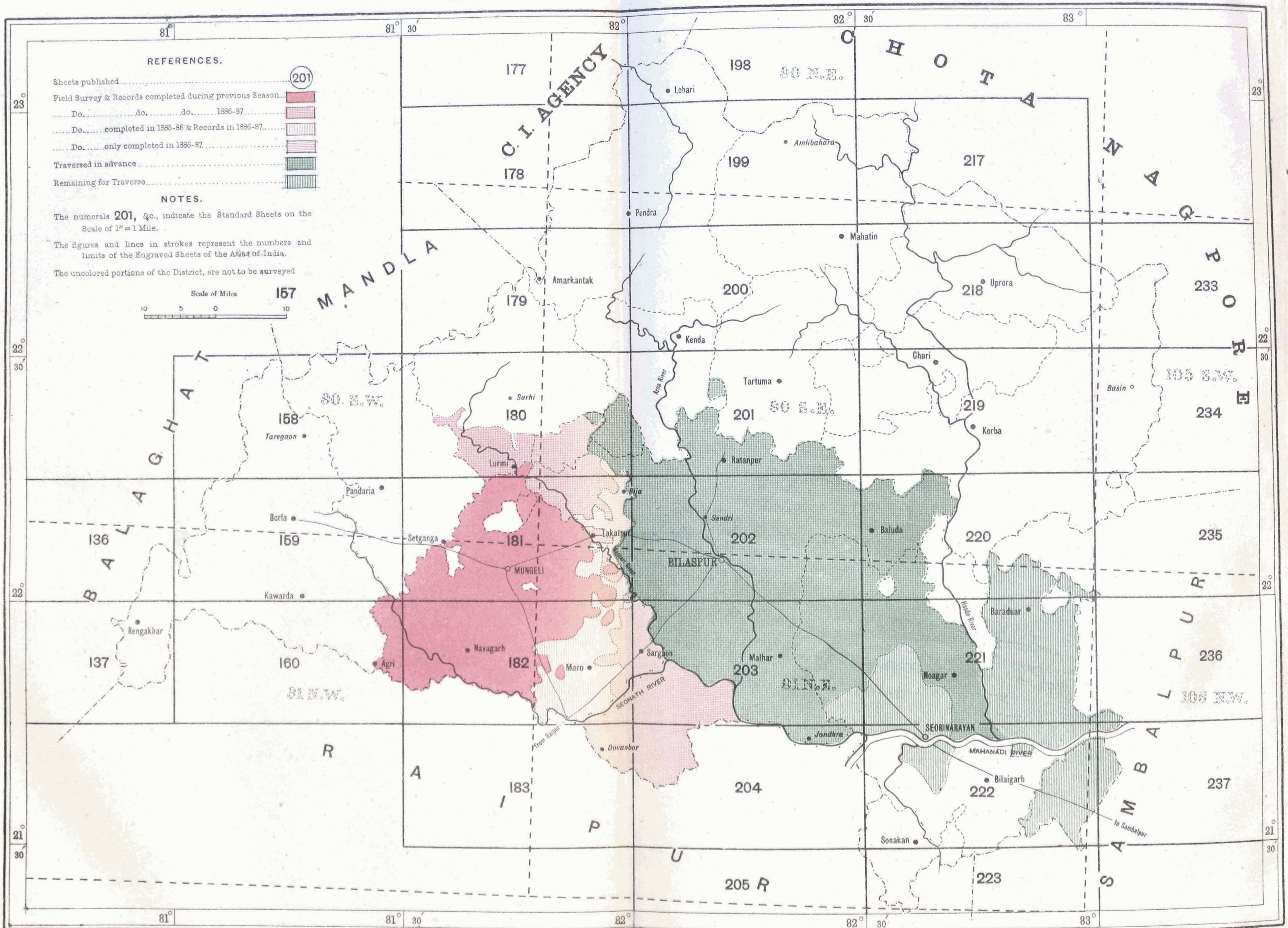
* Of his Assistants Mr. Hörst reports as follows:—Mr. Wilson worked well though he suffered throughout the field season from ill-health; Mr. Torrens was unfit for active duty, but was well employed in the camp office in computing traverses and preparing plots. Of the Sub-Surveyors Sumer Sing and Modin Beg are specially mentioned, and two young Burmans, Hpo Nyeing and Kyan Nyeing, promise to turn out well. Harlal Sing, the writer, and Fazal Haq, in medical charge, also discharged their duties well.

CENTRAL PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. BILASPUR.

No. 2 PARTY



Published under the direction of Lieut: Colonel H.R.Thuillier, R.E., Surveyor General of India.

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Survey of India Offices, Calcutta, October 1887

CADASTRAL SURVEYS.

BILASPUR AND RAIPUR DISTRICTS, CENTRAL PROVINCES.

No. 2 Party.

128. A change has occurred in the supervising officer of this party, owing to Colonel Steel having been compelled to take sick leave to Europe through ill health which was largely occasioned from the severe exertions and anxiety he had undergone when training a new establishment and initiating a new system in the Central Provinces. Fortunately, the Assistant Superintendent with the party, Mr. G. B. Scott, is a very able and energetic officer and he had thoroughly mastered under Colonel Steel's guidance all branches of the work required in Bilåspur. The charge therefore was entrusted to Mr. Scott, and the operations have been carried on under the same system as before, except for a few modifications which the experience of a second season has led Mr. Scott to adopt.

Personnel.

Lieutenant-Colonel E. H. Steel, S.C., Officiating Deputy Superintendent, 3rd grade, in charge up to 25th October 1886.
Mr. G. B. Scott, Officiating Assistant Superintendent, 1st grade, in charge from 26th October 1886.
Mr. F. Grant, Surveyor, 1st grade.
" J. R. Scott, Assistant Surveyor, 1st grade.
" J. McHatton, Assistant Surveyor, 1st grade.
" C. S. Kraal, Assistant Surveyor, 1st grade, from 1st May 1887.
Mr. P. C. H. Smart, Assistant Surveyor, 2nd grade.
Mr. F. W. Moore, Assistant Surveyor, 2nd grade.
Mr. J. P. Barker, Assistant Surveyor, 2nd grade.
20 Sub-Surveyors and others.

Temporary Establishment.

334 Field Surveyors and others.

129. A portion of the establishment has been temporarily diverted during the season under review to the Raipur district on account of the scarcity of food-grains which had occurred in parts of the Bilåspur district through a short rainfall. This change of programme was made suddenly when the field establishments were proceeding to re-assemble in the Bilåspur district at the end of the recess season, and at first it was expected that the whole party would have to be withdrawn from Bilåspur; but matters had somewhat improved by the beginning of November, when the surveyors had reached the ground, and the Commissioner of Chhattisgarh was then able to select tracts well-favoured with rain where employment was found for one of the cadastral sections of the establishment, while the second cadastral section had to be passed on to work in a selected part of the Dhamtari *tahsil* of the Raipur district. The traversing section of the party was retained in a part of the Bilåspur district where the rainfall had been plentiful. These final arrangements received the sanction of the Government of India in Revenue and Agricultural Department letter No. 949 S.—157-3, dated 3rd December 1886. It should be mentioned here that the employment in the Raipur district of the cadastral section which could not be retained in Bilåspur was rendered possible without much loss of time through traverse plots which had been prepared by the Raipur Traverse Party for the settlement survey of the district, being available for immediate use.

130. The traversing section was subsequently also sent into the Raipur district, but not on account of the scarcity. A *pargana*—Khalåri—had been named for traverse survey for settlement survey purposes after that part of the Raipur district had been traversed, and its situation made its traversing more convenient for the Bilåspur Party than for the Raipur Party.

131. The various sections of the party had all begun their work by the 25th November, but soon afterwards a very severe outbreak of fever with occasional cases of cholera took place, from which the sections in both the Raipur and Bilåspur districts suffered severely, the total number of sick for some days reaching 120 and several deaths occurring. As a result of this outbreak the return of work was very short during December, though by January the health of the party had become quite restored. Field work was continued up to 5th May, notwithstanding the very great heat which is said to have prevailed during April. A division was then made of the office establishment for the recess, one part to be employed on completing the drawing of the cadastral sheets, calculating field areas, and finishing up the traverse computations, being taken to Mussooree, and the second part to be employed on a small share of the same duties as the first part, but mainly on the completion of all the vernacular village records, being taken to Kamptee. The officer in charge of the party proceeded to Mussooree and the Kamptee office was left in charge of Mr. J. R. Scott, Assistant Surveyor.

132. The peculiar difficulties under which the party had laboured during the previous season, the first season in Bilâspur, through the want of experience of both officers and men in the preparation of village records, had been removed, and the advantage of working with a well-trained establishment, both in the rapidity and character of the work, was soon apparent. It was found possible also to increase the establishment on account of the improved capabilities of the officers for extended supervision, the result both of greater efficiency and increased strength being an additional out-turn over that of the previous season of 259 square miles. To a great extent, the acquaintance the establishment had acquired with the revenue law and village customs of the Bilâspur district, as needed for the preparation of the records, was facilitated by Colonel Steel's Hand-book, specially designed for guidance in record-writing, which had been printed and put in the hands of all. A few alterations had to be made in this Hand-book, chiefly on points of law, on its being reviewed by the Settlement Officers of Bilâspur and Raipur, and by the Commissioner of Settlements, but with these slight exceptions the book as originally drawn up has formed the basis of the record-writing. In the general procedure, there has been one innovation, in that new village proprietory rolls (*khewats*) have been drawn up by the Survey staff from local enquiries, the old rolls of the last settlement which had been used last year having been found to be misleading through the mutations of names not having been kept up. These new rolls will be attested with the other records at the time of settlement.

133. The average size of the fields was much smaller than those met with last year, having been ·77 of an acre in Bilâspur and ·66 in Raipur against 1·03 of last season, which has occurred chiefly through the country surveyed both in the Bilâspur and Raipur districts having included considerable rice-growing tracts, whereas last season mostly wheat-fields had been surveyed; and the rate of survey has been somewhat less rapid in consequence of the increased number of the field plots. In the Dhamtari *tahsil* of Raipur, there was also some delay through the want of demarcation of village boundaries, which caused the survey *amins* to be employed at first in relaying all boundaries in accordance with the old settlement survey maps, but afterwards the orders were changed for them only to relay the boundaries which were disputed, while the other boundaries were accepted as now acknowledged by the villagers.

134. During the first season, it had been found advisable to teach the operation of taking the *khânapuri*, *i.e.*, the register of tenants' rights, to only a certain number of field-surveying *amins*, partly because all the men were not acquainted with Hindi writing and partly because it was believed to be necessary that *patwâris* must assist in making the necessary inquiries; but this season, most of the *amins* having qualified to write Hindi through studying the character during the recess and being found to be competent to conduct the inquiries independently, the taking of the *khânapuri* of each village has been carried out by the same *amin* who has done the field survey. A staff of selected *amins* had however to be employed at the beginning of the season in writing up the *khânapuri* of 102 villages, in area equal to 157·34 square miles, which had been left undone during last season. This season, the *khânapuri* has been written for the entire area surveyed in Raipur, and left undone only for 38 square miles in Bilâspur.

135. The following statement shows the work that has been done in connection with the cadastral survey :—

District.	Records written only (Khanapuri). Surveyed in season 1885-86.		Cadastrally surveyed and records written.		Cadastrally surveyed only.	
	Number of villages.	Square miles.	Number of villages.	Square miles.	Number of villages.	Square miles.
Bilâspur	102	157·34	334	418·58	21	38·38
Raipur	...	...	342	564·72	...	...
Total .	102	157·34	676	983.30	21	38·38

In Biláspur, 3,80,123 fields have been surveyed of an average size, calculated on the entire area, of ·77 of an acre, and in Raipur, the number of fields is 5,56,764 of an average, similarly calculated, of ·66 of an acre. The total number of fields in both districts is 9,36,887, and the average size calculated on the cultivated area is about ·4 of an acre. Of preliminary boundary traversing, 945 square miles have been surveyed in Biláspur; and in Pargana Khalári of Raipur, an area of 288 square miles has been traversed for the Raipur settlement survey.

136. The field survey and the entries in the records have been rigorously checked by the European officers and native *munsarims*, in the same way as last year, the tests on the survey having amounted to 362 linear miles of check survey measured by the European officers and 1,338 miles by the *munsarims;* and the entries of 62,164 fields having been tested by the Europeans and of 2,36,400 fields by the *munsarims*. For the traverse work, observations for azimuth have been taken at 41 stations in Biláspur and at 16 stations in Raipur. Connections with the Great Trigonometrical Survey were made at 3 hill stations in each district.

137. The total expenditure for the Survey year ending 30th September 1887 has been R1,46,546-3-10, from which the following cost-rates per square mile have been obtained after apportionment of the details of the expenditure, *viz.* :—

	R	a.	p.
Traversing (which includes the plotting of the skeleton maps and computation of the areas of the skeletons)	18	12	4
Marking stations	1	7	4
Detail Survey (which includes the fair-drawing of the cadastral map and of two copies, also calculation of areas of fields)	58	5	9
Khánapuri (which includes the completion of an entire set of village papers, *viz.*, *khewat*, *khasra*, *jamabandi*, *milán khasra*, *safawár khasra*, *jinswár*, *jamabandi goshwára*, and of the preparation of a duplicate set of copies of the same)	54	4	2
TOTAL .	132	13	7

138. Owing to the late date on which the requisition for copies of the village papers had been received from the Settlement authorities, the records of season 1885-86 were reported in paragraph 167 of last Annual Report, not to have been ready to hand in at the close of the recess of 1886. They were eventually completed in office at Biláspur, the last papers being furnished to the Settlement Officer by the end of January 1887. This season, the copying of the records has been carried on apace with the calculation of the areas and completion of the original papers, and all the records both of Biláspur and Raipur were furnished to the Settlement Officers of the respective districts by the 6th December 1887.

139. A revised edition of Colonel Steel's Handbook of "Instructions concerning the preparation of the village papers in connection with the Cadastral Survey of District Biláspur" has been drawn up by Mr. G. B. Scott embracing a few changes found to be desirable on the experience of a second season's working and embodying the requirements of the Commissioner of Settlements and Agriculture on certain points of revenue law. A small number of copies of the revised edition have been printed.

140. The detached office of the party at Kamptee was inspected by the Deputy Surveyor General in charge of the Revenue Branch during September, when the nature of the work that was being executed and the progress of the work were found to be quite satisfactory. Mr. G. B. Scott's arrangements for the recess work in both offices at Mussooree and Kamptee, as well as his manner of government of the party in the field, have all been excellent, and do him great credit in this his first charge of a cadastral survey party. He has now to vacate the charge on Colonel Steel's return from furlough.

Mr. Scott states :—

"Before closing this report, I would mention that Mr. Hassan Khan, Assistant Settlement Officer, attached to the camp in Raipur, gave much valuable assistance both in Dhamtari and Khalári by his influence among the *málguzárs* and by his knowledge of the peculiarities and customs of the people, while his assistance and advice on legal points concerning tenures and other questions that arose have, I trust, saved much error in the record-writing in that district."*

BASTI DISTRICT, NORTH-WESTERN PROVINCES.

No. 4 Party.

Personnel.

Lieutenant-Colonel S. H. Cowan, S.C., Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. H T. Hanby, Surveyor, 3rd grade.
" W. J. O'Sullivan, " 3rd "
" W. C. Price, " 3rd "
" L. F. Berkeley, Assistant Surveyor, 2nd grade.
Mr. R. F. Warwick, Assistant Surveyor, 2nd grade.
Mr. W. E. Johnson, Assistant Surveyor, 3rd grade.
21 Sub-Surveyors and others.

Temporary Establishment.

361 Field Surveyors and others.

141. This party resumed operations in the Basti district in continuation of its work of last season. No changes were made in the preparation of the settlement records and statistical statements; but a slight alteration was made in the system of survey, in so much that the village boundaries, besides the stations and lines of the traverse, were plotted on the sheets issued to the *amins*, the village boundaries having been surveyed during the traversing for the purpose of ascertaining the boundaries which were disputed, and thus to provide for the settlement inquiries being instituted in time and to prevent delay in the completion of the village papers. The new system was found to answer well, and the whole of the 893 disputes except 9 were disposed of by the Settlement officials during the season.

142. Field work was commenced on the 25th October 1886, and closed on the 30th April 1887, when the party returned to recess quarters at Naini Tal. An office was at the same time established at Fyzabad where all the vernacular records were taken to be completed and for the tabulated statistical statements to be prepared. Mr. L. F. Berkeley was left in charge of this office which had an establishment of computers and writers averaging in numbers about 300 throughout the season.

143. The following table shows the out-turn of 16-inch cadastral survey :—

District.	Pargana.	Number of villages.	Area in square miles.	Number of fields.
Basti	Maghar East (part)	181	66·99	87,136
	Bánsi East (part)	895	301·97	540,623
	Rasúlpur	724	330·95	943,574
	Bánsi West (part)	156	74·29	276,021
	TOTAL	1,956	774·20	18,47,354

The traversing of the district has been completed, furnishing an area of 491 square miles ready for next season's cadastral survey. The average size of the field is ·268 acres giving 2,386 fields to the square mile. The labour involved in preparing the records and statistics of nearly two millions of fields has been very heavy, but all the *misls* except 44 were completed and despatched to the Settlement office by the 30th of September. A list of papers which constitute a complete *misl* or village record, as furnished by the survey party in District Basti, is given at page xiv of the appendix.

144. The detail survey has been checked by 2,337 linear miles of test survey, of which 306 were surveyed and compared by the European staff and 2,031 by the

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* Mr. Scott reports most satisfactorily on the services of Messrs. F. Grant, J. R. Scott, and J. McHatton, in charge of sections, commending their "hearty co-operation and constant and careful attention to every detail of work."

Mr. Kraal, who joined the office at Mussooree, though much out of health, is said to have worked very well, and Messrs. P. C. H. Smart, F. W. Moore, and J. P. Barker, are all much commended for the excellent work they did in the field.

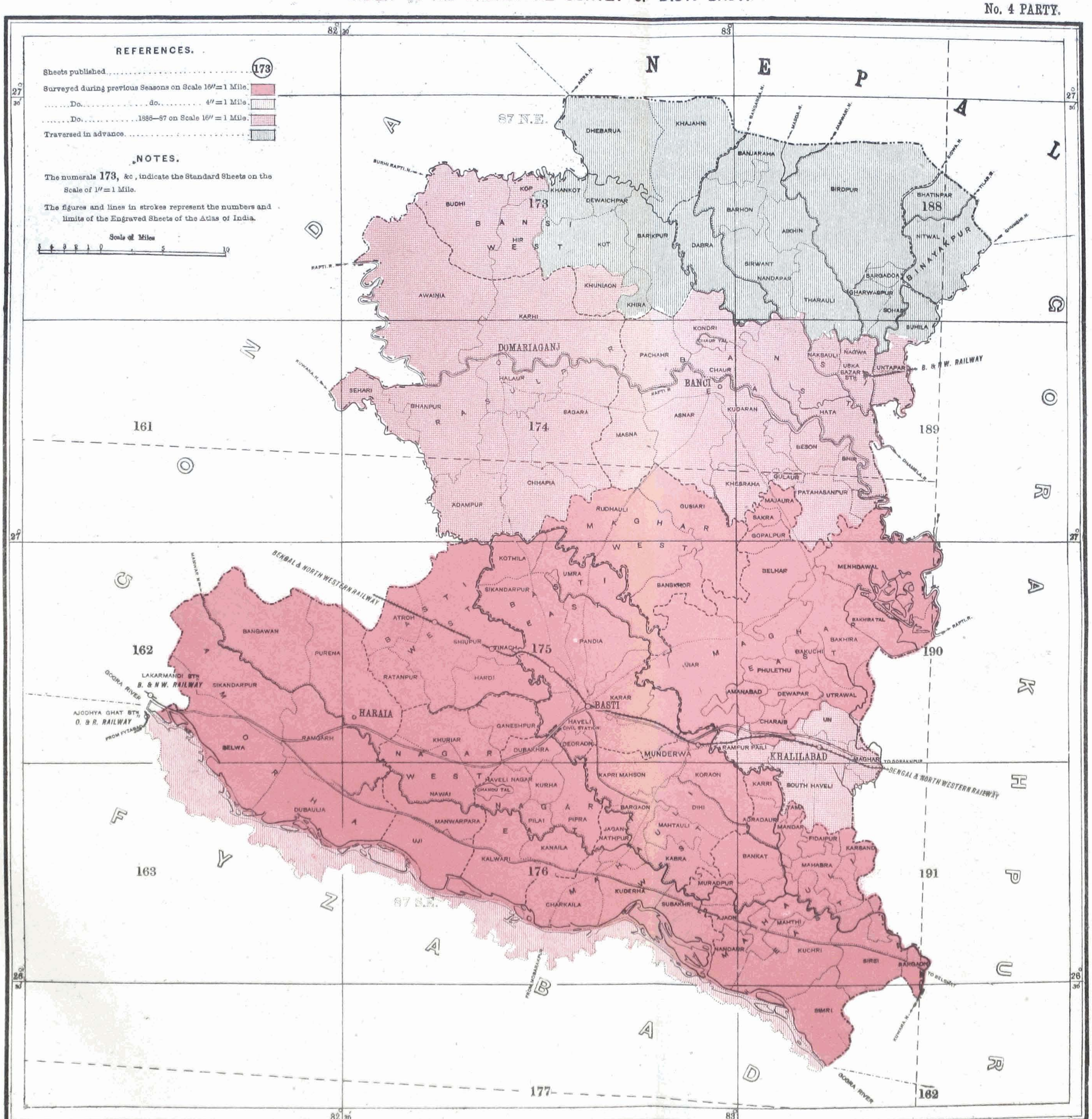
Of the permanent native establishment, the names of the following are creditably mentioned, *viz.*, Latifulah Khan, Hilaludin, Angumothu, Bholanath, Ramji Lal and Hospital Assistant Nanak Pershad.

Of the temporary establishment, the following are the names brought to notice, *viz.*, Mr Berkeley, Mr. McGowan, Makhan Lal, Promothonath, Abdulgofur, Mahomed Idris, Karam Ali Khan, Karm Hussain Ghulam Abas and Mozaffar Beg.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DIST. BASTI.

No. 4 PARTY.



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Survey of India Offices, Calcutta, September.

1887

native Inspectors. The entries in the *khasras*, &c., relating to 37,917 fields, were tested on the spot by Europeans, and 5,20,723 by Natives. To confine the angular error of the traverses, 15 azimuths were observed at an average distance apart on the main circuit of 7 miles, or at intervals of 28 angles. The traverses have been connected on two stations of the Great Trigonometrical Survey, and the average error of the chaining is shown to be 4·19 feet per mile.

145. To give a permanent value to the traversing, 4,009 traverse stations have been marked with stones, giving 6·9 permanently marked points per square mile (in addition to the village trijunctions) at a cost of R6-6 per square mile.

146. The villages surveyed have been mapped on 1,523 sheets, imperial size, suitable for reproduction by photo-zincography. Good progress has been made in the compilation and drawing of the standard 2-inch sheets of the Basti district for reduction by photography and publication on the scale of 1 inch = 1 mile. Of the 30 sections, 19 have been plotted and pentagraphed, and 13 inked up.

147. The rate per square mile for each branch of the work separately is given in the following statement:—

Head of charge.	Per square mile.			Per acre.			Per 100 fields.		
	R	a.	p.	R	a.	p.	R	a.	p.
For permanent marks	6	6	0	0	0	1·9	0	4	3·3
„ Traversing	27	5	7	0	0	8·2	1	2	4·1
„ 16-inch survey	94	13	0	0	2	4·4	3	15	7·0
„ Khánapuri and Urdu khasra	43	6	11	0	1	1·0	1	13	1·5
„ Statistics	65	13	1	0	1	7·7	2	12	1·6
TOTAL	237	12	7	0	5	11·2	9	15	5·5 or 1 anna 7 pies per single field.

Comparing these rates with those of last season, both the rates for survey and for records are found to be considerably higher; but this is fully justified by the extremely minute subdivision of property which is quite unprecedented, the average size of the fields being a little over ¼ of an acre. The rates calculated per 100 fields are less than those of last year.

148. Four junior officers of the Civil Service, Messrs. J. S. Meston, H. D. Griffin, J. M. Wright, and H. C. Ferard were attached to the party for two months to receive instruction in surveying, and were reported to have attained a sufficient knowledge of the various processes of a cadastral survey.

149. All the *kánúngos* of the district received instruction in cadastral surveying and in taking out areas with the talc square. They have all provided themselves with a set of instruments (optical square, compasses, &c.) and, if they are kept up in their work and not allowed to forget what they have learned, should be able to carry out all the survey work that is ever likely to be required in the Basti district. No *patwáris* were available to be taken off duty and placed under instruction until late in the season, when a *patwári* school was established at Bansi.

150. The area remaining for cadastral survey in District Basti is 491 square miles, which will be completed in the coming field season. Besides this, the detail survey of Tahsil Chakia, District Mirzapur, part of the family domains of the Maharaja of Benares (the traversing of which has been done by No. 14 Party) and the completion of the topographical survey of District Mirzapur, together equal in area to about 351 square miles, have been assigned to this party. The traversing section of the party has been transferred to Bengal for employment on the survey of the Srinagar Ward's Estate in Districts Bhágalpur and Monghyr.

151. The Settlement Officer of Basti, Mr. Hooper, continues to give the survey every possible assistance; and his Deputy Collectors, especially Babu Bishan Chandra, also further the work in every way they can.

152. The recess office of the party was inspected at Naini Tal during October by the Deputy Surveyor General in charge of the Revenue Branch, who expresses himself to have been well satisfied with the character of the work that

had been executed and with the manner in which Colonel Cowan maintains the excellent organization of the party.*

GORAKHPUR AND TARAI DISTRICTS, NORTH-WEST PROVINCES.

No. 5 Party.

Personnel.

Lieutenant-Colonel J. E. Sandeman, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. E. G. Little, Surveyor, 3rd grade, in temporary charge from 11th July 1887.
Mr. T. F. Freeman, Asisstant Surveyor, 1st grade.
" J. Murphy, Assistant Surveyor, 1st grade, employed on Tarai District survey from 1st December 1886.
Mr. A. W. Smart, Assistant Surveyor, 1st grade.
" N. Bedford, " " 2nd "
" W. V. Skilling, " " 3rd "
" F. B. Powell, " " 3rd " from 1st November 1886.
24 Sub-Surveyors and others.

Temporary Establishment.

535 Field Surveyors and others.

153. This party returned from its recess quarters at Naini Tal and resumed field operations in the Gorakhpur district on 20th October 1886. Field work was continued up till the end of April, when the main part of the office establishment was taken back to Naini Tal, leaving a suitable establishment in an office at Gorakhpur under Mr. T. F. Freeman to complete the vernacular records and prepare the statistical tables.

154. The chief work has been the continuation in the Gorakhpur district of the cadastral survey and the writing of the village papers, but a small area of forest land has also been surveyed in Gorakhpur, and a survey has been made on the 4-inch scale of certain *diwára* lands in the Sarun district of Bengal where the provincial boundary falls on the Gandak river, and an overlap survey on the 2-inch scale has been made where the boundary with the Sarun district does not fall on the river. The only change of importance in the procedure of this season is that the new classification of soils as "table land," "slope" and "low land" has been abandoned, and the old classes of "clay," "loam" and "sand," which are more readily distinguishable, have been reverted to. An endeavour was made to employ the district *kánúngos* in place of the Survey Department *munsarims*, but the experiment failed as the men were found to be very ignorant. An increased establishment was maintained during the season on the special requisition of the Board of Revenue, so as to furnish a larger area and thus to provide for the completion of the survey of Gorakhpur in two seasons, *i.e.*, by the end of season 1887-88, as required by the conditions of the expiring settlement. An additional area of 227·74 square miles beyond the out-turn of the previous season has thus been secured.

155. The following statement shows the areas of the several descriptions of survey :—

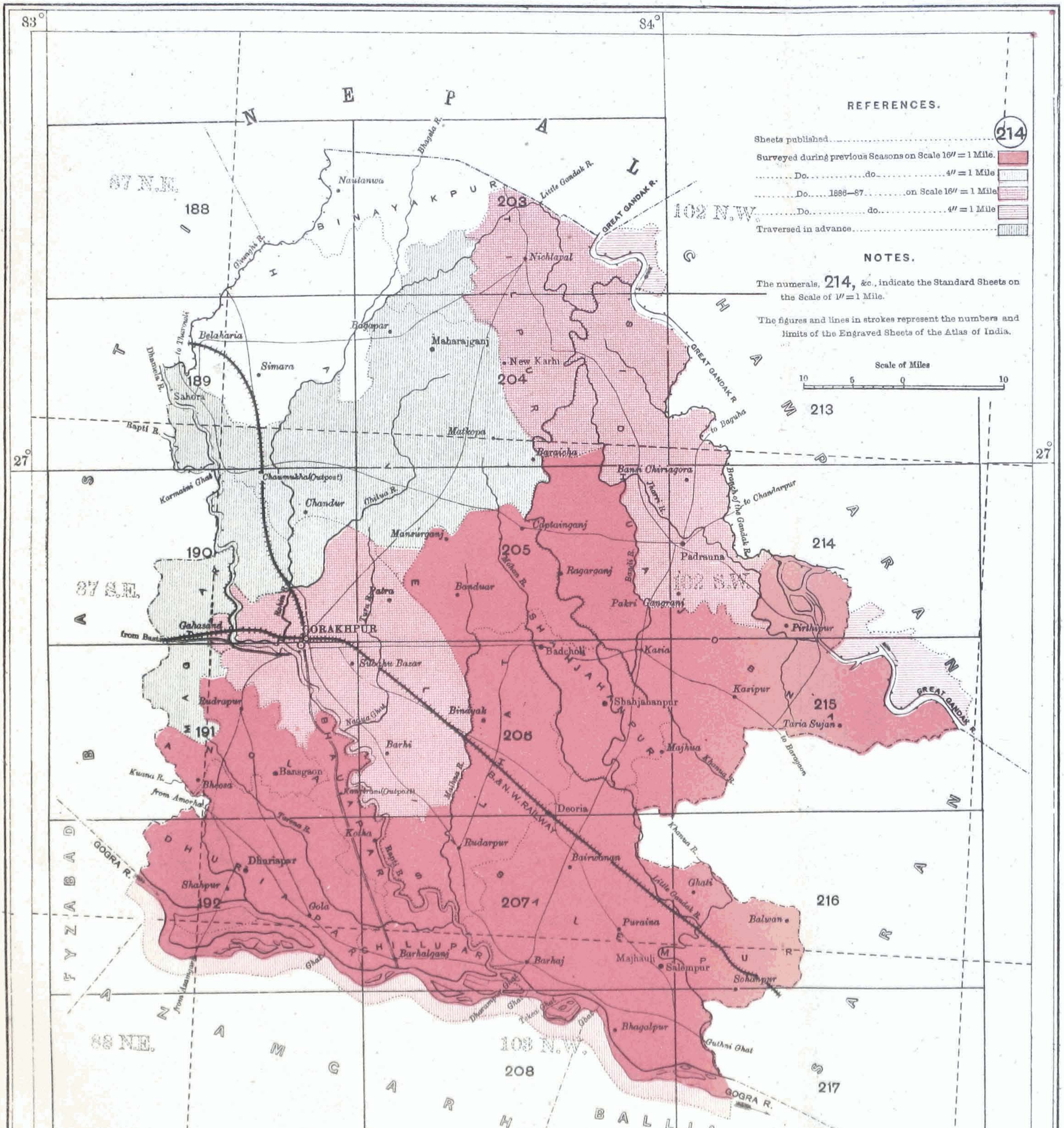
District.	Tahsil.	Description and scale of survey.	No. of villages.	Area in square miles.
Gorakhpur	Padrauna	Cadastral survey, with usual village records ; scale, 16″ to a mile	570	393·77
	Maharajganj	Do. do.	289	203·43
	Gorakhpur	Do. do.	826	450·63
		Total of Cadastral survey	1,685	1047·83
	Maharajganj, Gorakhpur	Forest survey, 8″ to a mile		28·47
Sarun (Bengal)		Diwara lands survey, 4″ to a mile		71·99
		Topographical survey, 2″ to a mile		30·00

* Lieutenant-Colonel Cowan highly commends the excellent service rendered by Mr. H. T. Hanby and by Mr. W. C. Price, who had charge of the two Cadastral sections. The other members of his European staff, *viz.*, Messrs. W. J. O'Sullivan, L. F. Berkeley, R. F. Warwick and W. E. Johnson, are also favourably mentioned. Among the native establishment, Meer Asjad Ali, Ramjus Misr, Ganga Parshad and Rahimudin are mentioned as having distinguished themselves by good work.

N. W. PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. GORAKHPUR.

No. 5 PARTY.



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Survey of India Offices, Calcutta, October.

1887

In addition to the above, preliminary boundary traversing has been executed of 1,171 villages covering an area of 775 square miles in the Maharajganj and Gorakhpur *tahsils*. The cadastral area which was surveyed includes 930,427 fields, of which the average size is ·72 acre.

156. The permanent marking of theodolite traverse stations has been carried out in the usual manner, partly with stones at selected stations chiefly at actual boundary points, and partly with burnt clay cylinders, 8,820 stations having been marked with stones and 5,782 with clay cylinders, giving an average of 7·4 stones and 4·9 cylinders per square mile; and besides these there are the trijunctions of village boundaries permanently marked previous to the survey. A large part of the cost of the stone embedding, which has amounted to R7,953, or 8 annas 9 pie per mark, is recoverable from the *zamindárs* for the stones which form actual boundary marks.

157. There were 924 boundary disputes in the season's area, many of which were adjusted by the relaying of former boundaries from the old 4-inch maps of 1837. The disputes on the Gorakhpur-Sarun boundary, mentioned at paragraph 175 of last year's Report, were disposed of by the Settlement officer acting as a Joint Commissioner with an officer specially deputed from Bengal.

158. The cadastral survey has been tested by 2,771 linear miles of check surveys, of which 1,660 miles were measured by Inspectors of squads during the survey and 1,111 miles by the European officers or by specially deputed Inspectors after the survey. The latter test which is the most stringent is at an average rate of about 1 linear mile per square mile of area. The angular work of the traverses was regulated by observations for azimuth at 130 traverse stations, and the chain measurements were brought into accord with Great Trigonometrical Survey distances by means of connections on eight tower stations. The comparison of chain measurements with triangulation distances showed the chaining to have been in error on an average, + or —, of 1·45 feet per mile.

159. Regarding the writing of the records, Colonel Sandeman reports as follows:—

"The *khánapuri* was submitted to the following checks. European Assistants partalled 9,076 numbers. Native *munsarims* partalled 255,731 numbers. The former is under 1 per cent., but the latter over 26 per cent. The small amount of European check is due to the time of the Assistants being so much occupied listening to disputes and endeavouring to have, *primá facie*, the right entries made in such cases. One great difficulty to be overcome in making a correct record is to eliminate the false entries which exist in the *patwáris*' papers. In former reports specimens of such entries have been given. The *zamindár* is the real master of the *patwári*, and until measures are taken to punish the *kánúngos* very severely for permitting the *patwáris* of their circles to falsify the papers, it is hopeless to expect correct records to be kept up from year to year. I mention the following circumstances as an indication that our severe checks have had some good effect and that we have succeeded in our endeavours to make a correct record."

"The Settlement Officer tells me that about four years ago by the order of Government a return was compiled of occupancy tenants over the Province, and he finds that in the Hata *tahsil*, which he has been settling, our papers contain nearly *twice as many* of these tenants as were returned by the *kánúngos* four years ago. Some of these rights have doubtless accrued in the interval, but they could not have done so to anything like this amount, and the entries are doubtless due to the presence of the European surveyors, whose protection has enabled the tenants to assert their rights more fearlessly than they could have otherwise done. I myself have constantly found the *zamindár* striving to have fields entered in his own name as *khudkásht* on the plea that he was cultivating during the year of survey, whereas the *patwári's* record showed them to be occupancy tenants' fields. As a check against this practice, the following order of the Settlement Officer was circulated :—'The fact that an occupancy tenant does not cultivate his field in any given year, has no effect on his tenancy. He must either be legally ejected or formally resign his holding to enable it to be recorded in any other person's name."

"In the Court of Wards' villages, at the instance of the Manager, we had to adopt special measures to protect the *zamindárs*' rights against the cupidity of the tenants. All rights claimed as 'occupancy' had to be checked with the 12 years ago papers, and care had to be taken that *sáyar* items were not wrongly entered in the names of the tenants against the constitution or custom of the village."

160. The cadastral area has been mapped on 1,976 sheets, all of which were inked up by the *amins* before the village *khasra* was written, instead of the lines of field boundaries and field numbers being left to be inked up afterwards by draftsmen in office. The sheets are thus not quite so neat in appearance, but there has been no uncertainty about the boundaries or the numbers of fields as

F 2

is liable to be the case when the sheets are sent into office in pencil. A series of 8 sheets comprising the *diwára* lands of the Gandak river where the river forms the district boundary are under compilation. The plotting of the 2-inch sheets has been continued, and 12 have been sent down to Calcutta for the topography to be drawn by reduction from the 16-inch maps in the head quarters office.

161. With regard to the sale of printed copies of the 16-inch maps, which in the Gorakhpur district is carried out under special arrangements of keeping a supply of the maps in the head-quarters of the several *tahsils*, Colonel Sandeman reports :—

"Up to date, 1,559 maps have been sold to the *zamindárs* in the Deoria and Bansgaon *tahsils*, and a sum of R584-10, the proceeds of the sales, has been credited to Government. Although the sales have not been so rapid as was expected, still I doubt not that the small number of available maps of each village will be gradually absorbed by the people to whom these must be a great boon as a substitute for the comparatively highly-priced and difficult to obtain hand-made copies they were formerly in the habit of getting from the Collectorate."

162. The total cost of the party during the 12 months of the Survey year has been R1,54,441, and the rates for the season for the various works are shown in the following statement :—

	Per sq. mile.			Per acre.			Per 100 fields.		
	R	*a.*	*p.*	*R*	*a.*	*p.*	*R*	*a.*	*p.*
Stone embedding	6	11	11	0	0	2	0	12	0
Traversing	20	2	8	0	0	6	2	4	0
Field survey	39	13	3	0	1	0	4	8	0
Extraction of areas and completion of maps	20	5	11	0	0	6	2	4	0
Record-writing (Khanapuri) . .	18	7	9	0	0	5½	2	1	0
Completion of records . . .	5	7	5	0	0	1½	0	9	0
Abstract statistics for purposes of assessment, and soil maps . . .	30	9	9	0	0	9	3	6	0
TOTAL .	141	10	8	0	3	6	15	12	0 or 2 as. 6 pies per single field.

Under all heads the cost-rates are lower than last year, the reduction in the total rate per square mile being R39 nearly. This is mainly due to the fixed charges being spread over a larger area.

163. Messrs. Pike, Trethway, Legget, Hope, and Hushmat Ullah of the Civil Service have been instructed in surveying according to the usual course during the field season.

164. A school for *patwáris*, with native Sub-Surveyors as instructors, was established at Gorakhpur from 1st January, and is thus reported on by Colonel Sandeman, *viz.*:—

"Up to date, 19 *kánúngos* and 180 *patwáris* have passed the school tests in field surveying and mensuration. A much larger number could have been put through the school had the attendance been larger, but the monthly attendance has only been from 50 to 60 instead of from 125 to 150 as was intended. Each *patwári* takes on an average 8 weeks to pass through the school. The worst pupils are the *kánúngos*, who are evidently not appointed for their fitness but by interest."

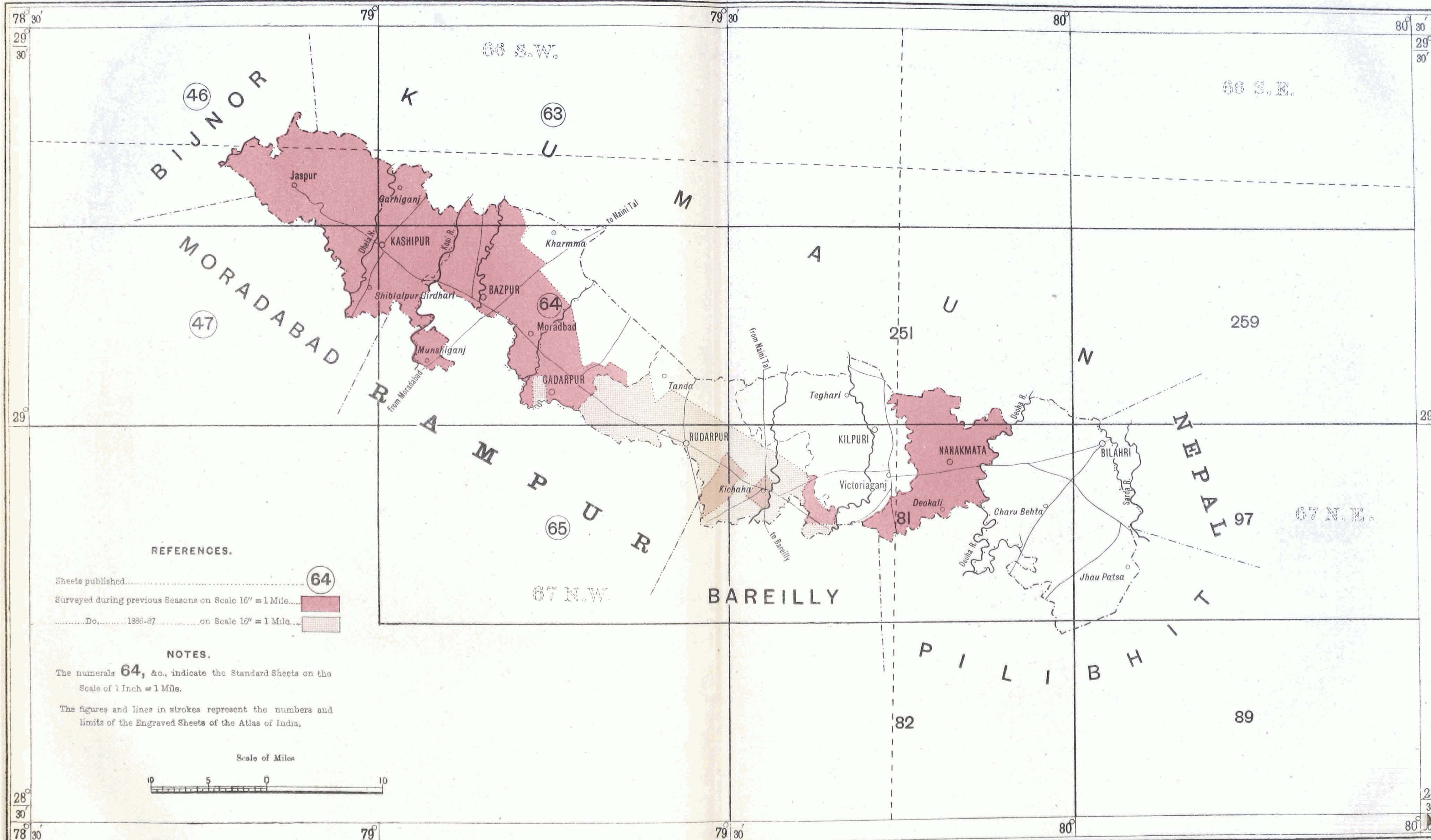
165. Colonel Sandeman writes as follows regarding the Civil officers with whom he has been associated :—

"To the Settlement Officer, Mr. A. W. Cruickshank, to Mr. Mellor, the Collector, and to his successor our best thanks are due for the manner in which they have aided us. We on our side have done what we could to prepare such maps and records as would in every respect meet their requirements, and I trust we have been fairly successful in this."

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT TARAI.

No. 5 PARTY



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Survey of India Offices, Calcutta, October
1887

166. This party has furnished a detachment as per margin for cadastral survey in the Tarai district, in accordance with a requisition from the Board of Revenue, North-Western Provinces, as sanctioned by Government, North-Western Provinces, order No. 1399—I.-8 A., dated 22nd September 1886. The present survey is in continuation of the operations of a detachment of this party during seasons 1880-81, 1881-82, and 1882-83, and of those of a subsequent survey carried out under special arrangements by the Superintendent of the Tarai during season 1883-84, the plan of operations in this district having been for the survey to be undertaken according as cultivation extended and more villages became formed. A list of villages to be first taken up was supplied by the Superintendent.

Personnel.

Mr. J. Murphy, Assistant Surveyor, 1st grade, employed in Tarai District survey from 1st December 1886.
2 Sub-Surveyors.

Temporary Establishment.

8 Boundary Surveyors and others.

167. Colonel Sandeman on receiving orders to undertake this survey at once consulted with the Superintendent as to the possibility of carrying out the work through the agency of the district *patwáris*, so as to give effect to the frequently expressed injunction of the Government for these officials to be instructed in surveying and employed as surveyors whenever practicable. The Superintendent gave his hearty support to the scheme and arranged for a suitable number of *kánúngos* and *patwáris* to be brought together for instruction at the beginning of the field season; but in place of the men so withdrawn, it was necessary, the Superintendent represented, that substitutes should be entertained to carry on the current duties in the district.

168. On being put under instruction, the *patwáris* showed considerable dissatisfaction and at first refused to accept surveying as part of their legitimate duties. They were firmly dealt with by the Superintendent, who also encouraged them to work zealously by holding out the promise of appointments in the higher grades to those who should excel as surveyors, and thus they were brought under proper discipline. But there was also considerable difficulty in bringing the men to understand that their survey work must be strictly accurate, and it was only by persistent partalling on the part of the Assistant Surveyor in charge, and by the rejection of a large number of inferiorly surveyed sheets that good work was at last obtained. *Khasras* were not written during the survey. The Tarai *khasras*, on account of the cultivators having no occupancy rights, are simple documents written twice a year at the time of the spring and autumn harvests; and as the papers for the spring harvest had already been prepared, those to correspond with the maps had to be left to be written by the *patwáris*, each in his own circle, at the autumn harvest in August. The operations were begun about 6th December 1886, and were closed about 15th May 1887, when the detachment went into recess quarters at Naini Tal.

169. The out-turn of the season is shown in the following statement:—

Parganas.	Scale of survey.	No. of fields.	Acres.	Sq. miles.	Remarks.
Bazpur . . Gadarpur . . Rudarpur . .	16″ to a mile.	31,078	48,896·2	76·40	The average size of the fields is 1·57 acre.

The boundary traversing has been done for the above area as well as the field survey. No traversing could be done in advance for next season on account of a very severe outbreak of cholera which put a stop to further field work sooner than was intended. All the traverse stations have been marked either with stones or with burnt clay cylinders, the marks having had mounds of earth raised over them, and being placed under charge of the village *patwáris*.

170. The traverse survey is an extension of what had been done in the Tarai in previous years. It has been checked by observations for azimuth at eight traverse stations, and has been connected with six stations of the Great Trigonometrical Survey. To test the survey of the fields, 1,019 lines of check surveys were measured, averaging 17 lines in each village. In length, these lines aggregated 360 linear miles, or 4·7 miles per square mile.

171. The Assistant Surveyor in charge rendered assistance to the Superintendent of the Tarai in settling eight boundary disputes, including three with the Rampur State, by furnishing maps of the disputed lands with the lines of old boundaries added. A Sub-Surveyor was deputed to accompany the Superintendent to the Nepal boundary on the Sarda river, where a survey was required to determine the sites of old boundary pillars which had been washed away.

172. *Patwáris* have only been employed for part of the recess work, as the Superintendent found he could not spare more than eight men at a time; they have done about three-fourths of the area computations and about one-fourth of the mapping.

173. The 60 villages surveyed during the season have been mapped on 113 sheets, of each of which two tracings have been furnished to the Superintendent. *Khasra* forms with areas entered in acres and *bighas* have also been furnished in readiness for the *khánapuri* when it will be taken. The villages will in due course be mapped on the 4-inch scale by reducing the 16-inch maps, and it is proposed to add to the series of 4-inch maps which were begun during the surveys of the other parts of the Tarai.

174. The total cost of the detachment has been R10,579, of which R862 was paid to *patwári* substitutes according to terms arranged with the Superintendent. Excluding the amount paid to the substitutes, the rates per square mile for the different works are as follows :—

	R	*a.*	*p.*
Stone embedding	4	7	5
Traversing	38	1	5
Field survey, including the computation of areas and entering them in the khasra forms	56	7	0
Khanapuri		*nil.*	
Instruction of patwaris	28	3	1
TOTAL .	127	2	11

175. Sanction (by North-Western Provinces Government order, Revenue Department, No. 738—I.-8 A., dated 4th June 1887, to the Secretary, Board of Revenue) has been given for a continuance of the cadastral survey over Parganas Kilpuri and Bilhari on the same system; and a grant of R11,500 has been allotted for the work for the Revenue year 1887-88.

176. The recess office of the party at Naini Tal was inspected during October by the Deputy Surveyor General in charge of the Revenue Branch, who testifies to the continuance of Colonel Sandeman's excellent arrangements for the organization of his large establishments, and to the maintenance of the same high character in the maps and records as in former years. During Colonel Sandeman's absence on three months' privilege leave, Mr. E. G. Little has carried on the executive duties very efficiently.*

* Colonel Sandeman commends the good work done by Mr. E. G. Little while in charge of the party for three months. Messrs. T. F. Freeman and A. W. Smart in charge of sections are reported to have worked "in their usual zealous and thorough manner," and they are said to have been so well aided by their assistants, Messrs. N. Bedford, W. V. Skilling, F. B. Powell, and J. H. Murphy (Office Assistant), that a very large amount of work was brought up to date and the field would be taken with no arrears.

In connection with the Tarai survey, Colonel Sandeman reports :—

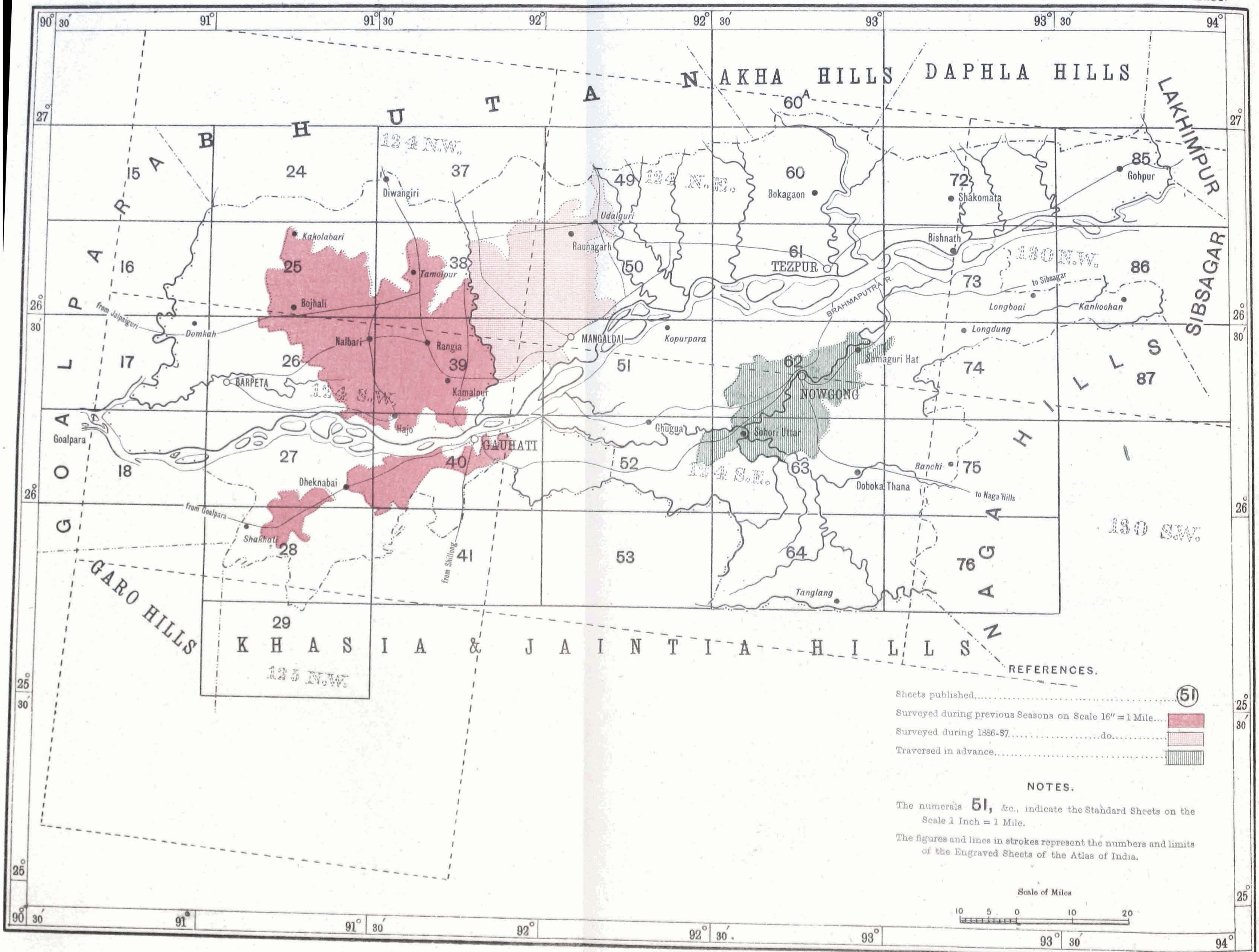
"Mr. J. Murphy, Assistant Surveyor, who has been in immediate charge of these experimental operations, deserves great credit for his management of the *patwáris* and for the manner in which he instructed them, and for his conduct of the entire operations."

Of the native establishment, Colonel Sandeman gives the following names as being deserving of mention, *viz.*, Puran Chand (who helped in the instruction of the junior Civilians), Nidha Lal, Golamgous Khan, Joala Pershad, Hari Singh, Dhanpat Rai, Amanat Hosain, Farhat Ulla, Babu Ram, Har Sahai, Jai Narain, Waris Ali, Bhoj Raj, Maula Bux, and Badri Pershad

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY OF DISTS. KAMRUP, DARRANG, & NOWGONG.

No. 6 PARTY.



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Survey of India Offices, Calcutta, September,
1887

Photozincographed at the Survey of India Offices, Calcutta.

DARRANG AND NOWGONG DISTRICTS, ASSAM.

No. 6 Party.

Personnel.

Mr. E. C. Barrett, Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. J. H. O'Donel, Surveyor, 4th grade.
" D. A. King, Surveyor, 4th grade.
" J. Connor, Surveyor, 4th grade.
" M. Gastaud, Assistant Surveyor, 2nd grade.
" J. Smith, Assistant Surveyor, 3rd grade.
24 Sub-Surveyors and others.

Temporary Establishment.

159 Field Surveyors and others.

177. This party under Mr. Barrett has carried on cadastral operationsin the Darrang district, where the whole area required to be cadastrally surveyed has been completed, and has executed preliminary boundary traversing in the Nowgong district. Both operations were begun on 10th November and were closed together on 10th May, when the office establishment returned to Shillong.

178. The field season was particularly unhealthy. Cholera was prevalent in District Nowgong during the months of November and December, and occasioned three deaths among the Hindustani *khalásis*. In Darrang there was only one death from cholera, but an inspector, 2 *amins*, and 6 measurers (all Hindustanis) died from fever and other complaints; and during the recess, information was received of the deaths at their homes, victims to the unhealthy Assam climate, of 1 inspector, 4 *amins*, and 8 measurers, making a total of 26 deaths in all, or 8 per cent. of the entire up-country field establishment. It is not surprising that service in Assam is not regarded with favour by Hindustanis, and that each year the party has had to work with from 40 to 50 per cent. of new hands. The need for the almost exclusive employment of Hindustani *amins* (Bengalis have only been procured in the proportion of 1 to 4) will, it is hoped, be obviated in future by a plan which is about to be tried of working with the village headmen (*mandals*) as surveyors.

179. The nature of the cadastral operations in Darrang has been the same as previously carried on in Kámrup, *i.e.*, a field survey by *amins* on the 16-inch scale, with a village *khasra*, which in Assam is little more than a simple register of tenants, the tenures of all being almost alike. Separate copies of the *khasras* are written by *amins* and village headmen (*mandals*) simultaneously, each in his own vernacular. The area for cadastral survey in Darrang, which is a very small part of the total area of the district, had been determined by the Provincial authorities with consideration to the main tract where the cultivation is permanent. This tract had been prepared for survey by boundary traversing during the previous season, but this season it has been increased, with the sanction of the Chief Commissioner, by adding a strip of fairly well cultivated country to the north of the original tract and the whole area thus surveyed, which is all that is intended to be surveyed in Darrang, amounts to 547·02 square miles. The entire area includes 29 whole *mauzas* and 7 portions of *mauzas*, which (as mentioned at paragraph 185 of last report) had not, previous to the present survey, been formed into villages and have now been subdivided into 630 villages of an average area of 555 acres.

180. The boundary traverse survey has been executed over an area of 456·45 square miles, of which 70·8 square miles are in Darrang, being the area which was added afterwards to the tract originally selected, and 385·65 square miles are in District Nowgong in preparation for next season's cadastral survey. In Nowgong, as was the case in Darrang, the *mauzas* are being subdivided during the traverse survey into villages of convenient size.

181. For the traverse survey, observations for azimuth have been taken at 27 stations, and connections have been made with two stations of the Great Trigonometrical Survey. The cadastral survey and the village records were carefully tested by the European officers and by native Inspectors who constantly moved about among the *amins* in the field, and on the occasion of each visit being attended by the *ráiyats* interested, examined, plan in hand, the *khasra* entries of not less than 10 per cent. of the fields surveyed since the last visit. The field measurements were also tested in the usual way by check lines measured after the survey, of which an aggregate length of 353 linear miles was executed by European officers and 803 miles by native Inspectors, both together furnishing an average check of 2 linear miles to each square mile of survey. The work

was also examined by *munsarims* and Sub-Deputy Collectors of the Settlement Department, who gave particular attention to the *khasra* entries.

182. All village tri-junctions are marked by stone prisms 3 feet long with 1 foot sides. The intermediate traverse stations are not marked, but the position of all are indicated by *semal* trees, one of which is planted at a distance of 5 feet to the magnetic north of each station point. In District Darrang it was found that 50 per cent. of these indicating trees planted during the previous season had failed to take root and they have been re-planted.

183. The area surveyed is mapped on 718 sheets; tracings from which, together with the original *khasra* books with field areas entered in acres and in local measures, were all furnished to the Settlement Officer by the 24th September.

184. In accordance with established procedure, revision parties were sent out at the beginning of the season to the areas surveyed in District Kámrup during season 1885-86 to investigate the objections raised by the holders of land against the composition of their holdings as determined by the cadastral survey. The operations were completed by the 22nd January, 210 villages out of 319 having been passed without requiring corrections of any kind. As the revision work progressed, the cadastral sheets after correction were sent down to Calcutta to be printed and all had been despatched by the 30th March.

185. A small hand-book, drawn up by Mr. Barrett, embodying the instructions issued from time to time to officers in charge of sections "concerning the methods of preparing the village papers adopted in connection with joint survey and settlement operations in the Assam Valley districts," has been printed and is in use as a book of reference in the party.

186. The cost-rate of the survey for the season is R198-14-3 per square mile, and R1-11-4 for the revision survey, both rates being slightly less than the rates of last season. The rates for the settlement operations have not been ascertained.

187. Regarding the financial advantages which have been derived from the operations of the survey and settlement in District Kámrup, Mr. Barrett furnishes the following particulars, showing that the expenditure on the operations has been amply justified on financial grounds only, and adducing evidence concerning the circumstances of the present assessment in the parts of the district from which the survey has been excluded, which afford good proof of the need for an extension of the operations :—

"The financial results of the three years of survey and settlement in District Kámrup by cadastral survey and *mauzadári* papers are given in the following comparative statement :—

Year.	Total area of assessable cultivation in Acres		Revenue.		Increase.
	By Mauzadár's papers.	By Cadastral papers.	By Mauzadár's papers.	By Cadastral papers.	
			R	R	R
1883-84	1,04,007	1,08,284	1,25,183	1,33,542	8,359
1884-85	1,79,417	1,85,788	2,30,077	2,40,569	10,492
1885-86	1,34,220	1,39,307	2,29,534	2,43,243	13,709
	4,17,644	4,33,379	5,84,794	6,17,354	32,560

"The total expenditure on combined survey and settlement operations in Kámrup, including revision survey, amounted to R3,61,166-12-10, and the increase of revenue, as shewn above, to R32,560, giving 9·01 per cent. on the outlay.

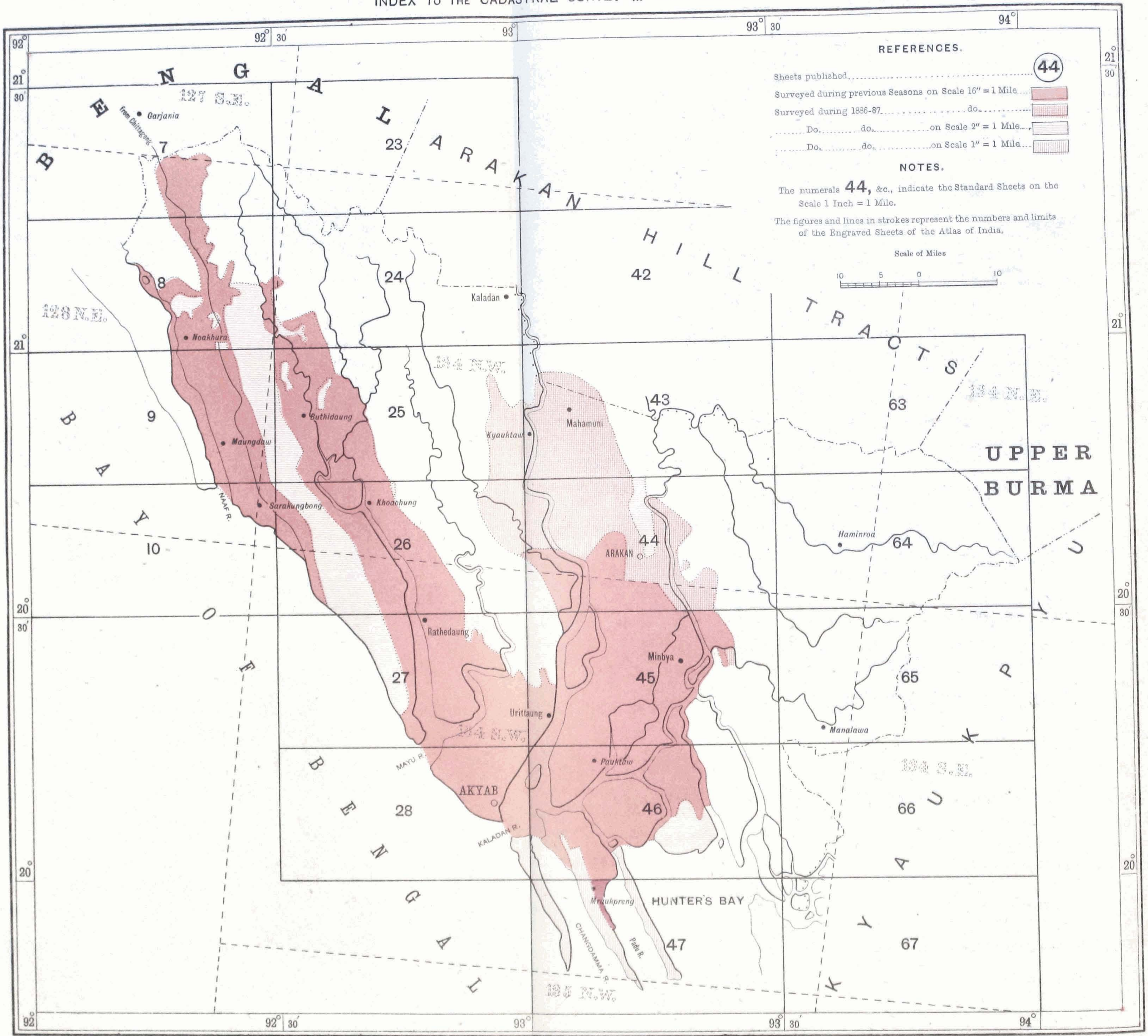
The proportion of the increase of revenue to expenditure during each of the three years of survey was—

For 1883-84 . . . . 8·41 per cent.
" 1884-85 . . . . 7·44 "
" 1885-86 . . . . 11·33 "

LOWER BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. AKYAB.

No. 7 PARTY.



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Published under the direction of Lieut: Colonel H. R. Thuillier, R.E., Surveyor General of India.

Survey of India Offices, Calcutta, November.

1887

The figures prove that the survey has, apart from administrative considerations, paid its way each year.

Survey operations in Kâmrup were, as far as practicable, confined to the closely populated and most frequented tracts where land is valuable and competition for it keen; but it is a noteworthy fact that the largest increases to the revenue have been obtained from the least accessible and sparsely cultivated areas, and more especially from those *mauzas* where the cultivation is *faringhati* or fluctuating. The figures for a few of the jungle and *faringhati mauzas* given in the following table will afford some idea of the extent to which an increase of revenue might fairly be hoped for, if the scope of survey operations were extended to all cultivated tracts :—

Mauzas.	Classification.	Revenue on Khiraj lands		Percentage of increase of revenues.
		By Mauzadâr's papers.	By Cadastral papers.	
		R	R	
Borigog	Faringhati	13,441	19,603	45·8
Dephali	Jungle	1,252	1,465	17·0
Sela Sindurighopa	Do.	6,303	7,157	13·5
Hajo	Faringhati	12,830	14,704	14·6
Jhargaon	Jungle	1,347	1,441	7·0
Bekeli	Faringhati	3,306	3,562	7·8
Bangaon	Do.	2,960	3,494	18·0
Bardnar	Do.	12,306	13,821	12·3

The cost of the survey and settlement of the eight *mauzas* at average rates amounted to R51,178 and the increase of revenue to R11,502, which is equal to 22·47 per cent. on the expenditure.

188. The Chief Commissioner of Assam, Mr. W. Ward, inspected the field offices of the party at Kolaigaon on 14th April 1887

189. Mr. Barrett reports as follows on the assistance he received from the Civil Officers with whom he was associated :—

"Very satisfactory arrangements were made for furthering survey operations in Districts Darrang and Nowgong by their respective Deputy Commissioners, Colonel Campbell, and Mr. Knox Wight. The acknowledgments of the Deputy Superintendent are also due to the Settlement Officer, Rai Sarat Chunder Banerjee, Bahadur, for his cordial and efficient co-operation with the survey throughout the year."*

AKYAB, BASSEIN AND THONGWA DISTRICTS, LOWER BURMA.

No. 7 Party.

190. This party remained under the superintendence of Lieutenant-Colonel H. S. Hutchinson until he proceeded on leave on 28th June, when it was placed under the temporary charge of Mr. H. R. Littlewood, Surveyor, who was relieved on 5th September by Mr. F. W. Kelly, appointed to succeed Colonel Hutchinson (who had been transferred to another party) in the permanent charge.

191. The party during the field season was divided into two main sections, one section being retained in the Akyab district to complete the area required to be surveyed cadastrally, as well as to conduct a topographical survey of portions of hill ranges which stretch into the cadastrally surveyed parts of the district; and the second section being despatched to the Bassein district to resume cadastral opera-

Personnel.

Lieutenant-Colonel H. S. Hutchinson, S.C., Officiating Deputy Superintendent, 3rd grade, in charge up to 28th June 1887.
Mr. F. W. Kelly, Officiating Deputy Superintendent, 4th grade, in charge from 6th September 1887.
Mr. H. R. Littlewood, Surveyor, 2nd grade (in temporary charge from 29th June to 5th September 1887).
Mr. J. A. Barker, Surveyor, 4th grade, from 4th November 1886.
Mr. G. W. Jarbo, Assistant Surveyor, 1st grade.
" J. S. Swiney, Assistant Surveyor, 1st grade.
" P. Beechey, Assistant Surveyor, 2nd grade, from 7th December 1886.
Mr. G. S. Willes, Assistant Surveyor, 3rd grade, up to 31st July 1887.
27 Sub-Surveyors and others

Temporary Establishment.

94 Field Surveyors and others.

* Mr. Barrett specially commends the good services rendered by Mr. J. H. O'Donel, and reports favourably of Messrs. King, Connor, Smith and Gastaud.

Of the native establishment, the following names are given as deserving of mention, *viz*,—Mohan Singh, Tajjudin, Sahkawat Hossein, Khurshed Hossein, Amjad Khan, Janardhan Rao, Saroda Prosad Chuckerbutty, Ganga Ram, Ghulam Hyder, Audur Chunder Ghosh, Jhuni Lall, Harack Narayan, Eusuf Hossein, Mosan Ali, and Anwar Hossein.

tions there in certain circles which have been named for survey since the time of the previous operations in the district, as well as to initiate the cadastral survey of selected circles in the Thóngwa district. The Akyab section moved out into camp from its recess quarters at Akyab on 3rd December, the cadastral part of the section continuing at work up to 8th May and the topographical part up to 30th May. The office portion of the section was then moved to new recess quarters at Rangoon. The Bassein section left Akyab on 4th November for Rangoon where the field establishments were collected, and work was begun in the Bassein district on 17th November.

192. In Akyab, the cadastral survey has comprised the townships of Myohaung and Kaladan, east and west of the Kaladan river, and small portions of Urittaung and Minbya townships, the tract being divided into 134 villages and covering a total area of 349·66 square miles, distributed in about the usual proportion of cultivation and waste-land, as is shown in the following statement of the separate areas, *viz.* :—

	Square miles.
Cultivation	163·96
Jungle and waste	141·60
Rivers	44·10
TOTAL .	349·66

The cultivated area includes 435,198 fields, of an average size of 0·22 of an acre.

193. In addition to the above, the boundaries of 10 Waste Land Grants lying in remote situations in the Naaf township have been revised, in consequence of changes which have been made subsequent to the survey of 1885-86. The maps of adjoining villages had also to be revised through these changes.

194. The topographical survey which has been executed in the Akyab district has been mainly restricted to the Mayu hill ranges in the Naaf and Rathedaung townships lying between cultivated valleys, and has been undertaken for the purpose of filling up gaps in the compiled topographical maps, which had been occasioned through the cadastral survey having been confined to the cultivated tracts. The scale adopted was that of 2 inches to the mile to correspond with the scale of the reduced compilations, and the survey that has been executed has enabled seventeen 2-inch standard size sections to be completed. In the case of the three Boronga islands situated to the extreme south of the district, the 1-inch scale has been adopted, the standard sheet in which they fall—sheet No. 47—comprising so small a portion of cadastral survey that there is no need for 2-inch sections to be projected. A small portion of the Kyaukpyu district, cutting into the Akyab district, was also surveyed topographically on the 2-inch scale to allow of the northern margin of Hunter's Bay being shown in the maps. The greater part of the topographical work is based on the traversing which had been used for the cadastral survey, but a small amount of triangulation has been executed for the survey of the Boronga islands. A special establishment had to be collected, mainly by transfers from parties in India, for this topographical survey. The areas which have been accomplished are as follows:—

	Square miles.
District Akyab, scale, 2 inches to a mile	447
„ „ „ 1 inch to a mile	85
„ Kyaukpyu, scale 2 inches to a mile	60
TOTAL .	592

195. In the Bassein district, three circles were assigned for cadastral survey, *viz.*, Pulu, Myaungmya and Labutkala, of which the two latter have been completed as regards the cadastral area, though a small area of hilly country in the Myaungmya circle remains to be surveyed topographically, while the Pulu circle has only been traversed. The completed area in circles Myaungmya and Labutkala is 228·07 square miles, 31·86 square miles being hilly country where the hilly features were sketched on the 2-inch, while the village boundaries,

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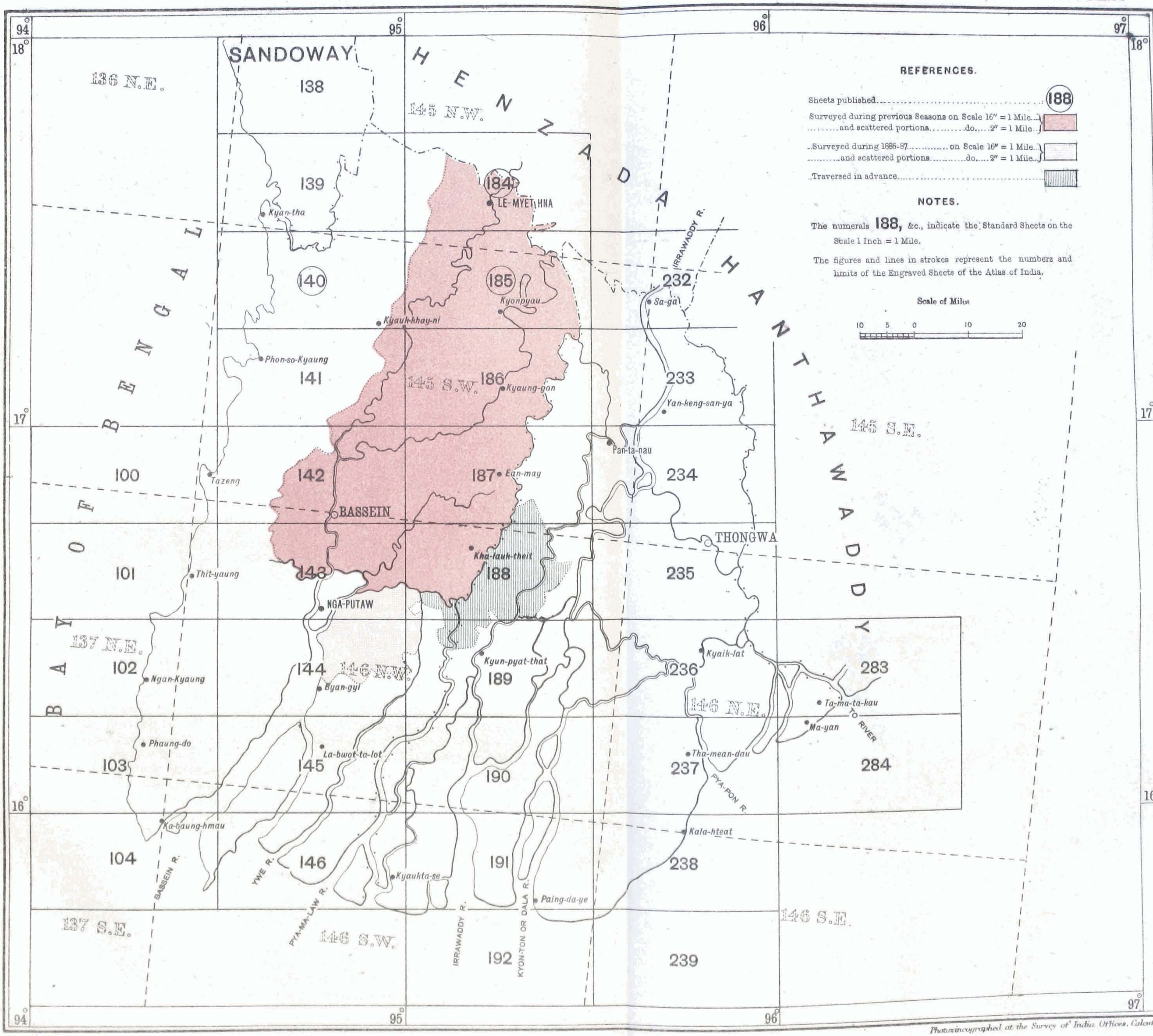

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Survey of India Offices, Calcutta, October
1887

streams, and scattered cultivation were surveyed on the 16-inch scale. In the cultivated area there are 73,600 fields of an average size of ·67 of an acre, and the total area is distributed as follows:—

	Square miles.
Cultivation	85·98
Jungle and waste	92·74
River area	17·49
Hills	31·86
TOTAL .	228·07

The area of Circle Pulu of Bassein, which remains to be cadastrally surveyed, is 75·59 square miles, and the area of four circles of the Thóngwa district which have been traversed is 258·32 square miles, giving a total of 333·91 square miles prepared in advance for next season's cadastral survey.

196. All theodolite traverse stations, of which there are 8,737, have been marked with pottery cylinders. Observations for azimuth have been taken at 81 stations, and the chain traverses have been connected with four stations of the Great Trigonometrical Survey. The detail survey in Bassein was tested by 270 linear miles of check surveys, of which 73 miles were measured by European Assistants and 197 miles by native Inspectors.

197. A scheme, proposed by the Administration of Burma and approved by the Government of India (Revenue and Agricultural Department letter No. 328 G.—96-5, dated 1st October 1886), with the object of attaching Burman surveyors more permanently to the Survey party than has hitherto been found to be practicable, has been adopted in the Bassein district with fair prospects that the scheme will prove a success, though the results cannot be ascertained from the working of one season. In previous years the difficulty experienced was not the entertainment of Burmans in the first instance, but the retaining of them afterwards, their main object in taking service being to acquire a knowledge of surveying and thus to secure a valuable qualification in their search for employment in other branches of the Government service. The chief feature in the present scheme is a system of crediting the surveyors with a certain amount of remuneration proportionate to their earnings, which amount will be deposited in the Savings Bank year by year, but will not be payable for five years, and only so if the recipient should serve continuously without a break and in whatever district to which he may be required to proceed with the Survey party. Only such surveyors as may gain, under a system of contract payments, more than R20 a month are entitled to the benefits of the scheme, and the amount of deferred pay to be credited to them is 20 per cent. of their earnings the first year and 10 per cent. in subsequent years. Besides the deferred pay, the surveyors will also receive as leave pay year by year on their return to duty from recess leave, a bonus proportionate to their earnings, according to the same system as has always been in force for the Hindustani surveyors. Under this scheme, 15 Burman surveyors have become entitled to deferred pay, and a total amount of R345, averaging R23 per man, has been drawn and deposited in the Savings Bank in their behalf. The Burmans, though not so quick as the Hindustanis, are trustworthy and accurate surveyors.

198. The cadastral area in Akyab has been mapped on 477 sheets, which will be retained in the party office pending the result of Settlement investigations. The sheets of the previous season, 1,024 in number, which had been retained for the same purpose, have all been sent to Calcutta to be printed without any revisions being called for. In Bassein, the number of cadastral survey sheets of the season is 267.

The area surveyed cadastrally and topographically in the Akyab district falls in 36 standard sections on the 2-inch scale, which are now in the course of being compiled and drawn in the office of the party. Standard sheet No. 47, which includes the Boronga islands, surveyed on the 1-inch scale, is being drawn on that scale.

199. The health of the party was on the whole good, except in the section employed on the topographical survey in the Naaf township of District Akyab, in which the daily average of sick throughout the season was 30 per cent. Among the establishment employed in Akyab there were 9 deaths, and 2 men were sent

home invalided. In Bassein and Thóngwa there were 6 deaths and 2 men were invalided.*

BENGAL AND ORISSA.

No. 8 Party.

200. On the abandonment of the cadastral survey of District Mozufferpore, which had constituted the work of this party during the previous season, the surveys of the Town of Calcutta and of the Wards' Estate of Sankarpur were assigned to be undertaken by two sections of the party, as mentioned in paragraph 207 of last year's Report, and to these separate works the survey of the Government estate of Angul was subsequently added (Government of India, Revenue and Agricultural Department, letter No. 916 S.—153-3, dated 22nd November 1886) to furnish employment for a third section. All the operations were placed under the supervision of Lieutenant-Colonel W. Barron, whose head-quarters were fixed in Calcutta, the officers selected for the charge of the detached sections being Mr. T. Shaw, for Sankarpur, and Mr. R. B. Smart, for Angul. Colonel Barron remained in charge up to 14th May 1887, when, on his being deputed by the Government of India to proceed to the Straits Settlements to advise the Government there on survey matters, in accordance with the application of that Government to the Government of India for the loan of an experienced officer, Mr. F. W. Kelly rejoining from medical leave, was placed in charge. Colonel Barron returned from the Straits Settlements and relieved Mr. Kelly on 30th August. Before proceeding on deputation, Colonel Barron visited the Sankarpur detachment twice, and the Angul detachment once. Mr. Kelly visited the Sankarpur detachment once; and Colonel Barron visited it again after his return from deputation. The section employed on the Calcutta Town survey began operations during the first week in November and continued at work up to 26th July. The section employed in the Sankarpur Estate began work in the Dinagepore district on 11th December 1886 and remained in the field until the end of June, when it proceeded to recess-quarters at Kurseong. The Angul section reached its ground, *viâ* Cuttack, on 11th January 1887 and continued its field work up to 15th June when it returned to Cuttack for recess.

Personnel.

Lieutenant-Colonel W. Barron, Deputy Superintendent, 2nd grade, in general charge to 14th May and from 30th August 1887.
Mr. F. W. Kelly, Officiating Deputy Superintendent, 4th grade, in general charge from 15th May to 29th August 1887.

Calcutta Section.

Mr. D. Atkinson, Surveyor, 1st grade, to 31st October 1886, and from 27th December 1886.
Mr. A. B. Smart, Assistant Surveyor, 3rd grade.
11 Draftsmen and Computers.
29 detail Surveyors.

Sankarpur Section.

Mr. T. Shaw, Assistant Surveyor, 1st grade.
„ C. G. Lee, Assistant Surveyor, 3rd grade.
„ C. H. Milner, Assistant Surveyor, 3rd grade, from 2nd October 1886 to 12th September 1887.
13 Sub-Surveyors and others.
173 Temporary Surveyors, Draftsmen and Computers.

Angul Section.

Mr. R. B. Smart, Surveyor, 4th grade.
„ R. C. D. Ewing, Assistant Surveyor, 1st grade, from 12th September 1887.
Mr. J. A. Higgs, Assistant Surveyor, 2nd grade, from 28th December 1886.
19 Sub-Surveyors and others.
66 Temporary Surveyors and others.

Survey of the Town of Calcutta.

201. The first action towards the present re-survey of Calcutta was taken by the Corporation of the Town, whose desire to have the town re-surveyed, both on account of the plans of the former survey of 1847 having become out of date through the many changes that had occurred, and on account of the survey having been on too small a scale, was intimated to the Government of India in letter No. 1835T.-R., dated 11th September 1884, from the Under-Secretary to the Government of Bengal, Land Revenue Department. The Govern-

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* Colonel Hutchinson has recorded the high opinion he has of Mr. H. R. Littlewood as a surveyor, and he has represented that the duties of Mr. Littlewood in the Bassein district during his absence in Akyab were of an unusually responsible nature.

Mr. Jarbo is especially mentioned for very hard work while in charge of the traverse section. Mr. Swiney is said to have supervised a cadastral section with excellent results. Messrs. Barker and Beechey are well reported on.

The undermentioned members of the native establishment are reported on favourably, *viz.* :—
Moung Hpo Kah, Ishan Chunder Ghosal, Shoshi Bhusan, Prionath, Azimulla, Mohamed Hossein, Ikbaludin and Manaur Ali.

BENGAL SURVEY.

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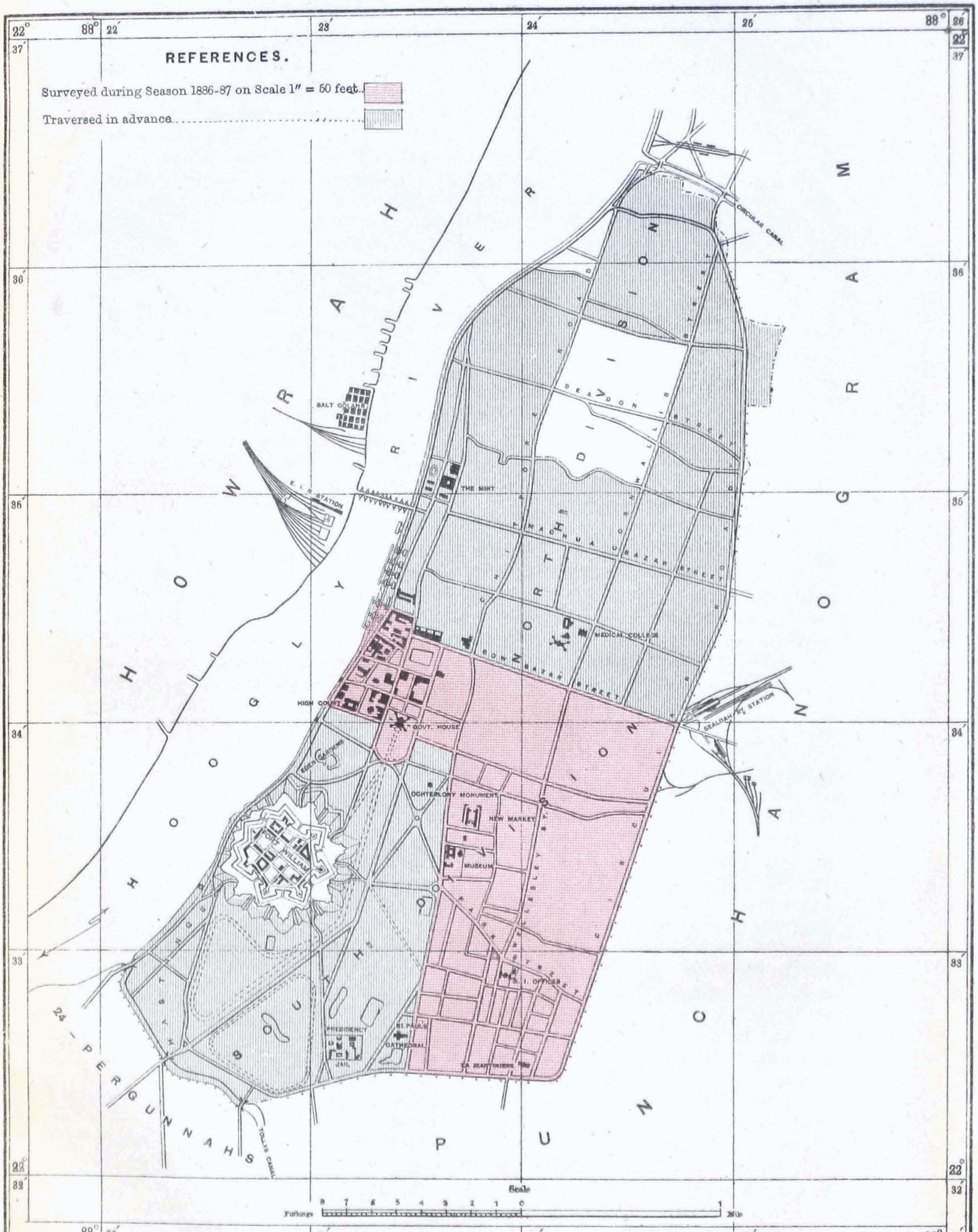

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Survey of India Offices, Calcutta, January

1888

ment of India expressed willingness to the proposed survey being assigned to the Survey of India, but at the time was unable to detach a party for the purpose. The matter was held in abeyance until a section of the Mozufferpore Party became available, and the survey was finally ordered in Government of India, Revenue and Agricultural Department, letter No. 757S.—140-2, dated 3rd September 1886. In the meantime, with the survey in contemplation, several matters connected with it had been considered by the Government of Bengal.—A proposal to extend the survey to the suburbs was discussed and for the time abandoned: a Committee was ordered to assemble under the direction of the Board of Revenue to report specially on what might be required regarding the demarcation of holdings and concerning the register of holdings that might be found to be necessary: and the need for a special Act to legalize the survey was ascertained through a reference to the Advocate General who held that the Bengal Survey Act of 1875 was not applicable to the Town of Calcutta.

202. The "Calcutta Survey Act, 1887," received the assent of His Honour the Lieutenant-Governor of Bengal on 15th January 1887, and of His Excellency the Viceroy on 31st idem. In it, the Deputy Superintendent in charge is appointed Superintendent of the Survey and is authorized himself, or others deputed by him, to enter on any land or premises for the purpose of survey either with the consent of the occupier or by giving twenty-four hours' notice. He is also authorized to inquire into the boundaries of holdings by giving three days' notice to the owners to appear and point out their boundaries. In cases of dispute the matter is to be settled by an Assistant Superintendent of Survey who will be a judicial officer and from whose decision an appeal may be made to the Board of Revenue. When the dispute is decided, the Superintendent is authorized to lay down the boundaries in accordance with the award. He may also cause the erection of any boundary-marks he may think necessary on any land which is to be or has been surveyed under this Act. The Act provides that after the survey of any part of the town has been completed, the maps and all other documents connected with the survey shall be deposited for inspection by the public for two months in the Municipal Office of the Corporation of Calcutta, the date of deposit being notified in the *Calcutta Gazette*. After any objections lodged within that time have been decided, the Local Government shall signify its approval of the survey by notification in the *Calcutta Gazette*, and no suit to set aside any demarcation of boundaries made under this Act shall lie unless brought within one year from the date of this notification.

203. The previous survey of Calcutta, which was executed from 1847 to 1849 by Mr. F. W. Simms, C.E., was in itself a plain topographical survey, on the scale of 100 feet to the inch, of streets and buildings, but to it was added a survey of the boundaries of holdings carried out by Mr. W. Heysham, Deputy Collector, whose investigations and operations extended from 1851 to 1855 and who converted Mr. Simms's topographical maps into maps showing the holdings with index numbers referring to a register of owners and of areas. These maps of Mr. Heysham's would, it was pointed out by the Committee referred to above which reported to the Board of Revenue, furnish guides to the identification, or demarcation, if necessary, of the holdings as formerly existing, but it was stated that many holdings had been subdivided and some had been amalgamated with others. The old holdings would all have to be searched out and the changes by subdivision would have to be mapped by the new survey. The Committee reported that Mr. Heysham's original registers, though still available with the Collector of Calcutta, had become useless through the changes in proprietorship not having been written up, but a new set of registers which had been begun in 1877 under the provisions of the Land Registration Act of 1876 were said to have recently undergone a thorough revision and were believed to be such as would render the preparation of a new register during the present survey quite unnecessary. The scale of 50 feet to an inch for the new survey was proposed and agreed to.

204. The survey was begun in the European quarter and has been completed throughout the whole of the southern division of the town, that is, as far north as Bowbazar, covering an area of 1,431 acres, or 2·23 square miles; but the field work only has been completed and the drawing of the final maps still remains to be done. All surface features have been shown with the greatest minuteness, the scale admitting of the plotting of measurements as low as 1 foot, while the traverse

measurements on which the skeleton basis of the field sheets has been projected have been recorded to the nearest tenth of a foot. The underground lines of sewers, gas and water-pipes, which the municipality require to be shown, will be added afterwards.

205. In surveying the boundaries of holdings, Mr. Simms's plans as amended by Mr. Heysham were found to be excellent guides, but the boundaries on those plans which are on the scale of 100 feet to the inch, are not shown with the minuteness now practicable by the present survey on double the scale, and the exact line of each boundary has been carefully inquired into in the presence of adjoining proprietors or their agents. The disputes regarding boundaries which have been met with mostly concern the proprietorship of boundary walls or drains and a few have reference to small pieces of ground adjoining lanes. In the southern division of the town, there are in all about 4,315 holdings, of which, up to 30th September 1887, the boundaries of 2,727 had been investigated, with the result that only 106 disputed portions remained for judicial disposal.

206. Throughout the town there is not much need for special demarcation of boundaries, as most of the holdings are divided off by masonry walls. Where these do not exist, and where the Corporation is interested, the demarcation has been effected either with rows of bricks on end or with stone pillars. Where such marks are wanting between private holdings, the proprietors have been warned to erect them.

207. The numbering of the holdings is the same as was adopted for Mr. Heysham's plans and registers, the numbers (which are in separate series according to Simms's survey blocks) having been brought into general use in the town in matters connected with the transfer of properties and payment of ground rents and thus obviously rendering their retention most desirable. An attempt was made to use the newly written registers in issuing notices to the proprietors to attend at the investigation of the boundaries, but these records were found to be of little or no value for this purpose, the changes of names not having been kept up as had been expected. A house-to-house visitation was then instituted to ascertain the names and addresses of owners by inquiry from the occupants, and in this way the issue of notices has been effected. A survey register of the owners is being kept, which will be available for the correction of the Collector's registers.

208. As a skeleton basis on which to plot the measurements of the details, the town has first been subdivided by theodolite traverses into sections averaging in size 3·8 acres, which again are further subdivided by lines measured to convenient points which can be fixed by two or more direct measurements. Other direct lines are run inside these and the work is thus cut up into small portions inside which the topography is surveyed by means of offsets. In the case of native houses it is often necessary to take the chain lines through the house for the purpose of surveying the inner open spaces. It may be mentioned that very little opposition has been given to the survey, and in most cases a little explanation removed it. Also, it says well both for the surveyors and the occupiers that the work has been carried on even to surveying the open spaces belonging to the parts of the house set apart for females without any trouble worth mentioning. At first there was some trouble in getting the owners to attend to point out their boundaries, but now when the objects of the survey have become better known they attend readily.

209. A very severe check was exercised over the survey of the details by the Deputy Superintendent and his European Assistants and everything is said to have been entered with the greatest accuracy. The boundaries of the holdings are all investigated by the European Assistants. For convenience of survey, the field plans have been projected in portions generally bounded by streets and they are being inked up and coloured to distinguish the masonry from the temporary structures. The final maps, which will be drawn in a suitable style for reproduction by photozincography, will be projected of a larger and more uniform size than the field plans.

Survey of the Ward's Estate of Sankarpur.

210. The cadastral survey of this estate was applied for in behalf of the ward by the Collector of Dinagepore, acting under the instructions of the Board of

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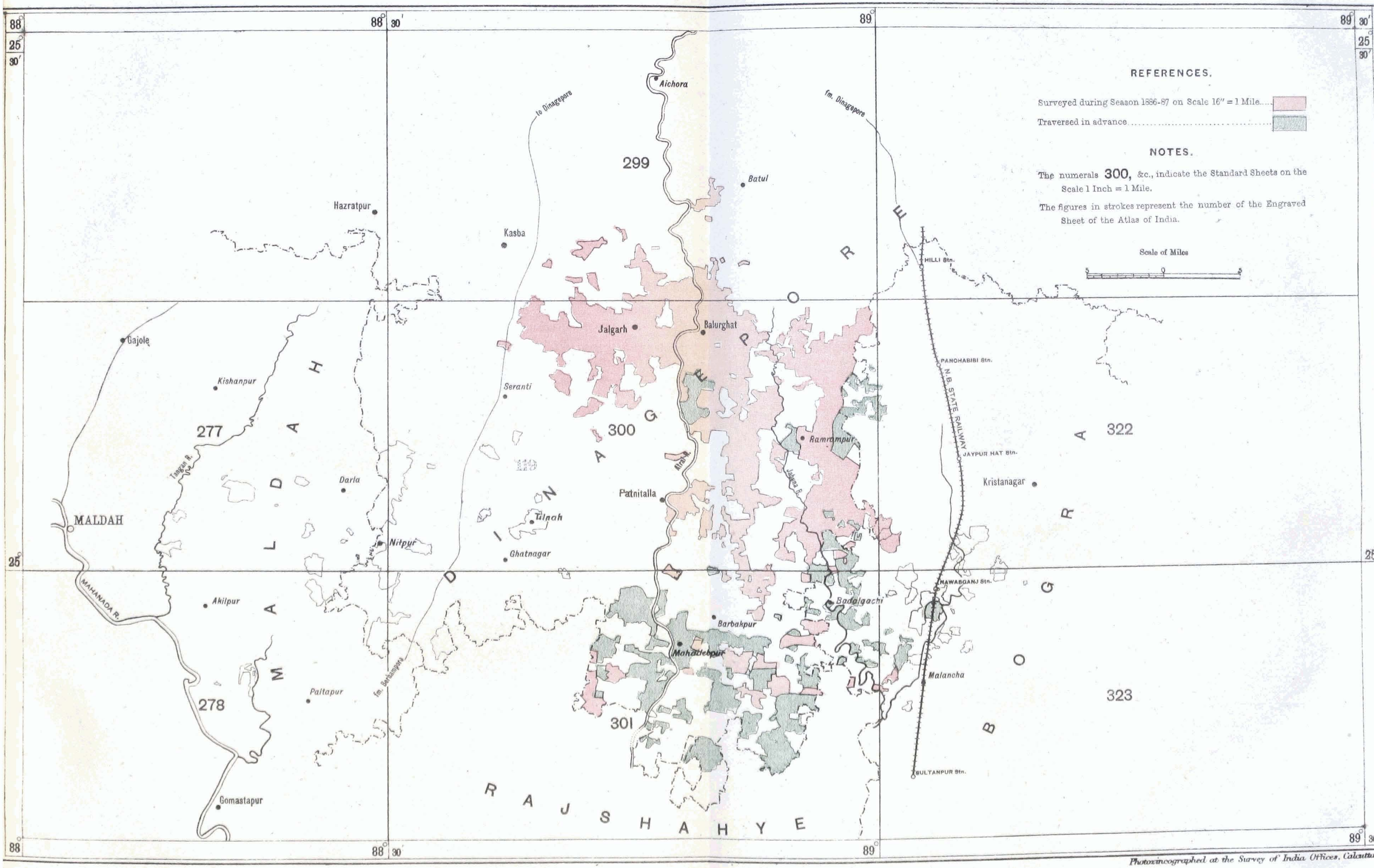

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Survey of India Offices, Calcutta, October.
1887

Revenue, in terms of section 101 (2) (a) of the Bengal Tenancy Act VIII of 1885, the provisions of the section permitting the application to be made, as the minor whose estate is being managed by the Court of Wards, although not the sole proprietor, holds the requisite 8-anna share in a large portion of the estate where there is only one other co-sharer who has joined in the application for the survey. The co-sharers in the other portions of the estate were expected to join in the application for the survey, and at first they gave a partial consent, but finally they all withdrew, and the entire expense of that portion of the survey will be borne by the ward. The estate is not situated in one compact tract, but lies in blocks of villages, and in single villages, over the districts of Dinagepore, Bogra, Rájsháhi and Maldah, the larger portion being in the first-named district. In area, the summation of the lands of the estate equals about 270 square miles, yet the lands are scattered over an area of about 1,200 square miles.

211. Besides the villages in which the estate is interested being much scattered, the condition of the estate is still further complicated through the lands in some villages, mainly so in two *parganas*, being interlaced with the lands of other estates. These interlaced lands were necessarily obliged to be surveyed along with the estate lands, as without doing so the maps would have formed a very indistinct record of the positions of the detached portions of the estate; besides, without enquiry being made regarding the proprietorship of each separate plot of land after all had been surveyed, there would have been no certainty that the register of the estate lands was complete. Considerable opposition was offered by the proprietors of the interlaced lands to the survey being made in this comprehensive manner, but it was overcome after full explanation had been given of the scope of the survey by the Manager of the Sankarpur Estate.

212. As far as the survey has yet progressed it has been possible to include the villages within main traverse lines, so that the relative positions of the blocks of villages or of single villages can be accurately mapped, but some villages remaining for survey are so far outlying that they will have to be surveyed on independent traverses of their own. The traverse survey has been completed of 673 villages containing an area of 245 square miles, and of these 532 villages have been cadastrally surveyed with an area of 198·64 square miles and containing 124,833 "fields," the scale of survey being the usual cadastral scale of 16 inches to a mile. The village records have been completed for 470 villages containing 93,466 "fields." In the greater portion of the surveyed area the *khasra* writing was simple, the village lands being held in common by the two shareholders, but in the two *parganas* where there are interlaced estates the writing was more difficult. The cadastral survey has been carried out by trained *amins* brought down from the North-West Provinces and from Behar, but locally entertained writers had to be attached to the *amins* to assist in preparing the *khasras* which the up-country *amins*, being unacquainted with Bengali were unable to write for themselves.

213. The demarcation of the boundaries, which is according to present possession, has been effected by the officials of the estate working under the Manager, which ought to be sufficient guarantee that the interests of the estate in this matter have been well guarded, but in many instances the present boundaries are found to disagree very much from the former village survey of 1857—60. Formerly there had been no permanent demarcation; now, the tri-junctions have been marked with stone prisms, and other selected points on the boundaries where theodolite stations have been fixed are marked with pottery cylinders.

214. Soon after the survey of the estate was begun, a Settlement Officer, Babu Sasi Bhusan Datt, was appointed who in the first instance was occupied in settling village boundary disputes, of which there were 41, and to whom subsequently traces of the cadastral maps and the village *khasras* and other records (as soon as they could be completed by the addition of the areas of fields) were sent for final inquiries regarding rents and the status of the tenants.

215. At the latter end of March the country became very unhealthy owing to the drying up of the innumerable tanks and marshes. Sickness spread rapidly among the survey establishment, scarcely a man was free either from fever or dysentery, and the survey camp became one large hospital. During April, the sickness abated and part of the establishment was able to resume work, with which and with some additional men got down from the North-West Provinces

an attempt was made to complete the survey of the estate by continuing the work late into the season, but when the rains set in the attempt had to be given up. An area of about 71 square miles has thus been left for next year.

216. Mr. Shaw writes in the following terms of the assistance he received from Mr. Ricketts, the Manager of the Sankarpur Estate, *viz.*,—

"The detachment is much indebted to Mr. Ricketts for his continual efforts to facilitate the work. His success in inducing the *raiyats* to supply the *amins* with voluntary labour has saved the estate a large sum. Mr. Ricketts's endeavours to get the proprietors of interlaced estates to join in an application for survey and to share expenses, although not crowned with the success they deserved, had the effect of stopping opposition to the surveyors, and so decreasing the cost of the work."

217. Towards the end of the field season, intimation was received that the Ward's Estate of Maldwar situated in the Dinagepore and Purneah districts was required to be surveyed cadastrally during the following season. Preliminary traversing was therefore undertaken in part of the estate in the Dinagepore district and has been completed for an area of 50 square miles. During September, a survey school was established for the *patwáris* of the Maldwar Estate under a scheme by which these officials would be employed on the cadastral survey, but the attendance has not been satisfactory.

Survey of the Estate of Angul, Orissa.

218. Killa Angul, formerly a tributary *mahál*, was confiscated in 1847 on account of the rebellion of the Rajah then in possession, and is now a Government estate. It was surveyed topographically on the one-inch scale in 1853-54 during the course of the operations of the Ganjam and Orissa topographical survey. Its present cadastral survey has been undertaken for the purposes of a revision of the settlement, the existing settlement, made without a complete survey of fields, having expired on 10th September 1887.

219. There having been no previous regular demarcation of village boundaries, and the exterior boundary of the Killa never having been accurately defined, a demarcation party under Babu Bisesur Banerjee was sent by the Board of Revenue about one month in advance of the survey to prepare the ground in this respect, and except as regards the exterior boundary, where there was delay on account of many parts being contested, the boundaries had been marked (though with temporary materials only) to allow of the survey work progressing without hindrance. This demarcation party was soon afterwards broken up, the demarcation of the part of the Killa left undone having been assigned to the *tahsildár*, the resident official in charge of the revenue and judicial functions. The *tahsildár* was also appointed to be a Settlement Officer and in association with him, Mr. A. K. Roy, a Government student from the Cirencester Agricultural College, was appointed to be a Joint Settlement Officer.

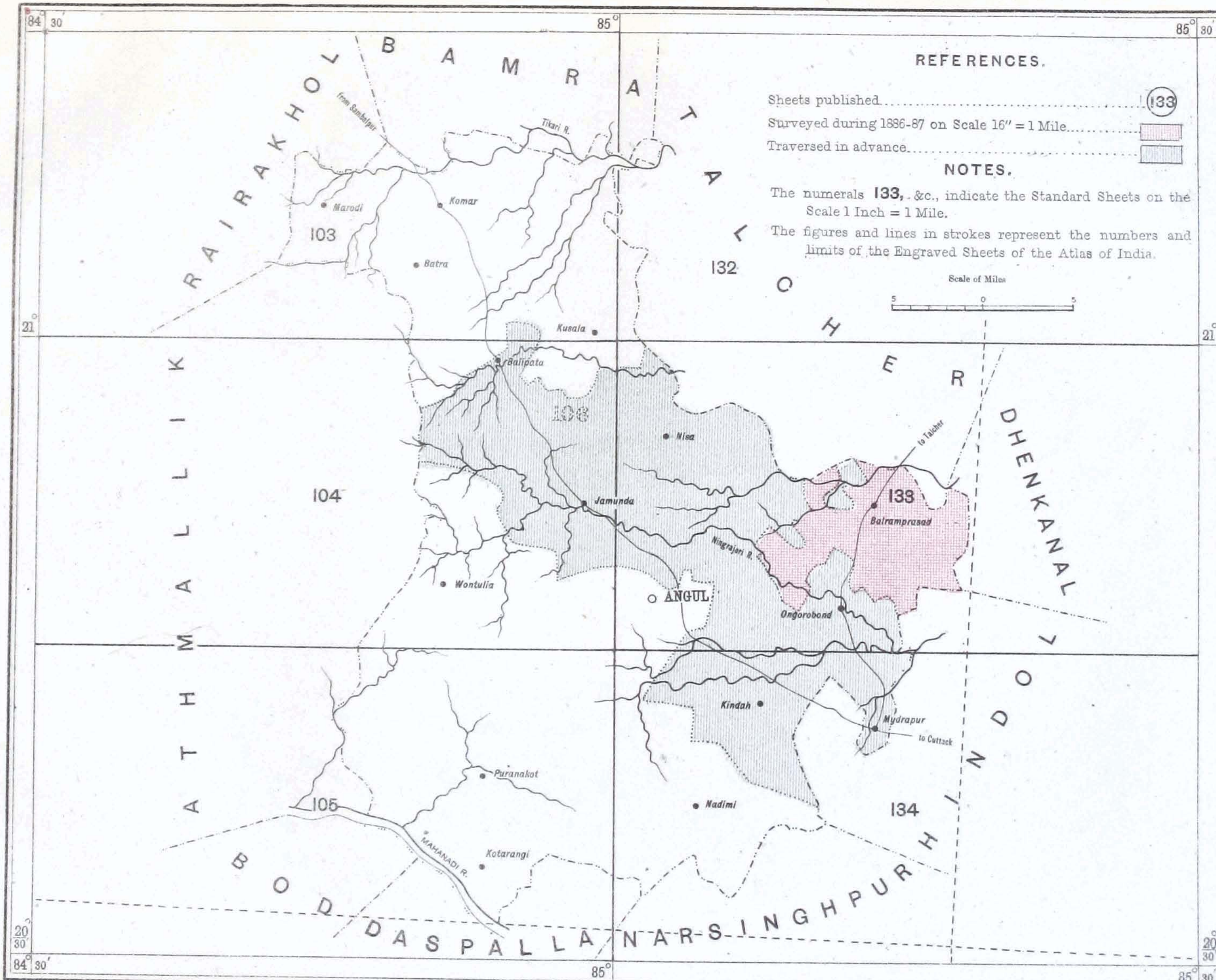
220. The survey work having been undertaken late in the season (the detachment reached Angul on 11th January 1887), the programme for the year was that the operations were to be restricted mainly to village boundary traversing, but a cadastral survey was to be initiated, and such an area completed cadastrally as a new establishment of local *amins* might be capable of accomplishing after having been trained. The traversing has been completed for 386 villages covering an area of 354 square miles, of which 83 villages, in area 61 square miles, have been surveyed cadastrally on the 16-inch scale, leaving 303 villages containing 293 square miles prepared for next season's survey. The remaining area of the Killa yet untouched includes about 336 square miles of village lands and 205 square miles of reserved forests.

221. The writing of the *khasras* and other vernacular village records has been facilitated by the exclusive employment of natives of Orissa as cadastral survey *amins*, the records being required to be written in the Ooriya character; but there has been considerable difficulty in filling up the records as regards the status of the tenants whose claims to occupancy rights are disputed by the *sarbarákárs* (or village headmen); and in the matter of classification of soils, the distinctions of which could not be readily recognised, there has also been difficulty.

222. As regards the permanent demarcation of boundaries, the marks which have yet been put down consist only of pottery cylinders at theodolite stations,

INDEX TO THE CADASTRAL SURVEY IN THE ANGUL GOVT. ESTATE

No 8 PARTY



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Published under the direction of Lieut: Colonel H. R. Thuillier, R.E., Surveyor General of India.

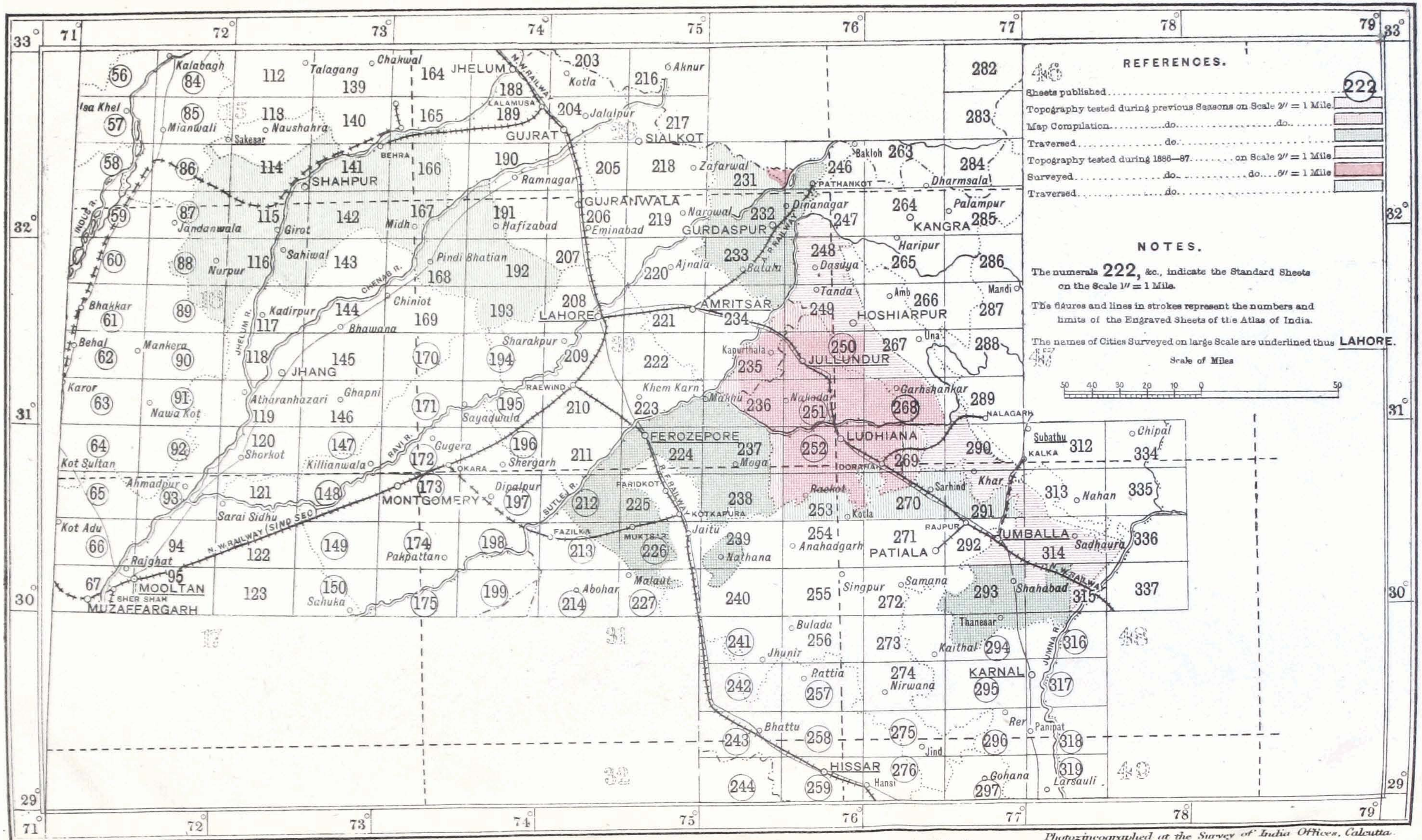
Survey of India Offices. Calcutta, October.

1887

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE PUNJAB.

No. 1 PARTY.



Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel H. R. Thuillier R.E., Surveyor General of India.

Survey of India Offices, Calcutta, January but the tri-junctions of village boundaries in the interior of the Killa are about to be marked with masonry platforms, and similar marks will eventually be placed at intervals of a quarter of a mile along the exterior boundary after the boundary has been finally confirmed by the Government of Bengal.

223. In accordance with the policy enjoined by the Government of India that all cadastral surveys should, if possible, be executed by village officials who are remunerated for the maintenance of village records, the Government of Bengal, acting on information received after the survey had been begun, directed that the *sarbarákárs* (who receive a large percentage for collecting the village assessments) shall be required to qualify as surveyors, so that they may be exclusively employed during next season in executing the survey. Survey schools for the *sarbarákárs* were therefore commenced during May, experienced surveyors who had served with cadastral surveys in the North-West Provinces having been sent for to act as instructors; and when the survey party retired to Cuttack for recess in June the schools were left in charge of the Joint Settlement Officers who continued to reside at Angul. The undertaking is an extensive one on account of the very large number of individuals who have *sarbarákári* rights; but as these rights in some cases extend only to a very few acres, all the individuals possessing them may not have to be employed as surveyors. Up to September, 304 *sarbarákárs* or their nominees had been taken under instruction, and it is believed that about 200 more will have to be taught.

A survey school was also begun during August for the *sarbarákárs* of the Government estate of Banki attached to the Cuttack district, the cadastral survey of which will be undertaken next field season.*

TRAVERSE SURVEYS.

PUNJAB PROVINCE.

NO. 1 PARTY.

Personnel.

Col. F. Coddington, S.C., Deputy Superintendent, 1st grade, in charge.
Mr. J. S. Pemberton, Surveyor, 2nd grade.
" C. W. Wilson, Assistant Surveyor, 1st grade.
" G. Campbell, Assistant Surveyor, 1st "
" F. P. Walsh, Assistant Surveyor, 3rd "
" F. S. Bell, Assistant Surveyor, 3rd " from 21st October 1886.
31 Sub-Surveyors and others.

224. This party, having closed its recess office at Simla on 13th October 1886, was, on its return to the plains and on the establishment being raised to field strength, sent to the localities for field operations in two sections, which were respectively organized in accordance with the nature of the work each had to perform. One section proceeded to the Gurdáspur district, the completion of the traversing of which was its first duty, and afterwards it had to undertake the testing of the topography obtained from the settlement survey maps of the Hoshiárpur and Umballa districts. The field work of this section was begun on 1st November and was continued up to 10th May 1887. The second section, whose field season extended from 26th October to 15th May, proceeded first to the Gujránwálla district and afterwards to the Shahpur district, in both of which it had to do traversing work only.

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* Colonel Barron reports as follows concerning the services of his assistants employed on the several operations, *viz.*,—

"Mr. D. Atkinson who had charge of the Calcutta survey has worked well and has taken great trouble in testing the accuracy of the work and inquiring into the boundaries of the holdings of which he has personally investigated 2,525.

"The report on the survey of the Sankarpur estate has been compiled from notes supplied by Mr. Shaw in charge of the detachment, and the Deputy Superintendent desires to bring to favourable notice the services of Mr. Shaw during a very trying season and under circumstances of sickness and opposition that made his charge a very difficult one.

"Mr. R. B. Smart has been in charge of the Angul detachment throughout the season. He took the detachment to Angul and started the work, and the Deputy Superintendent would bring to notice his energy in giving the out-turn he has done when he only commenced about the middle of January and had to train most of the men who did the interior work. The report on the Angul survey has been compiled from notes supplied by Mr. Smart."

The services of Messrs. A. B. Smart and C. G. Lee are favourably mentioned. Messrs. J. A. Higgs and C. H. Milner are said to have suffered much from fever during the field season.

The names of the members of the native establishment who are well reported on are:—Shaikh Abdullah, Wazir Ali, Gyasi Ram, Manohar Lall, Shamshudin, Abdul Jalil, Raghubír Saran, Janki Pershad, Murli Dhar, Rahim Bakhsh and Ganga Bishen.

225. The several operations on which the party is engaged, and which have already been described at paragraph 226 of last Report, may be again mentioned for convenience of reference; they are :—

(1) The skeleton traversing of villages for the purpose of determining the co-ordinate distances of tri-junction points; and the projection of maps of the tri-junctions on the scale of 2 inches to the mile.
(2) The insertion of topographical details on these maps by reduction from the Settlement survey village maps.
(3) The testing and correcting (where necessary) the reduced maps by examination in the field.
(4) The drawing of fair maps on the 2-inch scale.
(5) The re-drawing of the old 1-inch maps of the Sikh States to complete the portions of these territories falling within the present continuous series of maps of standard size. (This is a new work undertaken this season.)

The areas accomplished during the season under these separate heads in the several districts are as shown below :—

Districts.	(1) Area traversed.	(2) Area mapped by reduction (2-inch scale).	(3) Area tested (2-inch scale).	(4) Area finally mapped (2-inch scale).	(5) Area redrawn (1-inch scale).
	Square Miles.	Square Miles.	Square Miles.	Square Miles.	Square Miles.
Ferozepore	...	1,150	...	...	...
Gujránwálla	1,360	...	...	...	...
Gurdáspur	575	...	...	...	...
Hoshiárpur	...	482	940	951	...
Kapurthala (State) . .	...	...	...	78	...
Jullundur	...	...	...	56	...
Ludhiána	...	...	...	45	...
Shahpur	4,150	...	...	...	...
Sikh States	...	...	...	38	640
Umballa	...	1,872	1,738	1,558	...
Total .	6,085	3,504	2,678	2,726	640

The operations under head (1) have been completed in Gurdáspur; also, in Shahpur as far as they are required, the Salt Range having been excluded from the survey. The operations under the same head in Gujránwalla were restricted to the Háfizabad *tahsil* where they were required by the Irrigation Department to assist the laying out of canals. In the rest of the district, the operations may be deferred for a few years until the time for the re-settlement approaches. Under head (2), the area which has been mapped in the Ferozepore district is of the Muktsar *tahsil*, for which village maps of the last settlement were available, a new settlement being not at present contemplated for that *tahsil*. The mapping of the remaining *tahsils* will be undertaken when the settlement survey now in progress is completed. Under the same head, the mapping in Districts Hoshiárpur and Umballa has been completed, that is, for the plains portions of these districts for which portions only the Settlement Survey maps will be utilized; the hilly parts of the districts will be surveyed independently by the Himalaya Party. Under head (3), the testing has been finished of the Hoshiárpur district, but 825 square miles remain over for next season in Umballa. As heretofore, the topography obtained from the Settlement Survey maps has been proved by the testing to be satisfactory, needing only to be supplemented in such items as the high banks of rivers, limits of village sites, bridges, and mile-stones. Under head (4), the final mapping of the plains portions of sheets 266, 267, 289, 290, 291, 313, 314, and 336 has been done as far as possible, but the hill portions remain to be added by the Himalaya Party before the sheets can be published. In sheet 269 there are two detached portions of the Patiála State, the topography of which has been obtained from actual survey, and the 2-inch sections of the sheet have thus been rendered complete and ready for publication on the 1-inch scale. Village boundaries have been inserted in these detached portions by transfer from an Irrigation Survey map which was available. Sheet 270 contains a limited extent of revenue-paying territory, the main portion consisting of parts of the Patiála and Nabha States. The 2-inch sections of this sheet, which are confined to the revenue-paying area, with a small tract added for which irrigation maps were available, are therefore partial only. For the incomplete portions of this sheet, as well as of all other sheets of the new standard series similarly constituted (a proposal for a new survey of the Sikh States having been for the present negatived), it has been decided to introduce the topography of the 1-inch survey of the Sikh States which took place in 1847-50. Thus, the portions of Patiála and Nabha falling in sheet 270 have been re-drawn from the old maps, but the style of drawing is different from that adopted for the revenue-paying portions, so that the less reliable topography is readily distinguishable. Similarly, for the portions of the Sikh States falling in sheet 253, the revenue-paying portion of which had been mapped during the previous season, a drawing from the old maps of 1847-49 has been made to allow of the sheet being published with all the available topography. A small amount of new traversing has been necessary to enable the irrigation surveys to be incorporated into sheet 269, and a little new traversing has also been required for the introduction of the old surveys of the States into sheets 253 and 270.

226. At the request of the Financial Commissioner of the Punjab, a special survey on the 6-inch scale has been executed of 45 square miles of somewhat intricate country adjoining the Ravi river in the Gurdáspur district along the boundary of Kashmir territory. The object of the survey is to facilitate the adjustment of a dispute of long standing between the British and Kashmir cultivators as regards the rights to water from irrigation channels that take off in Kashmir territory, a proper investigation as to the rights, or clear representation of the facts in the report of the Settlement Officer having been found to be impracticable without a map. The survey in Kashmir territory is a skeleton survey of the water channels only, which has been effected by theodolite and chain traversing with the measurements recorded in field books, the local officials having objected to anything like a map being made on the spot without more specific orders than they had received from their State authorities. The information that has been obtained in this way was expected to be sufficient for the purpose of the survey, but the Government of the Punjab has since made a requisition for a survey of the Kashmir lands the same as of the adjoining lands in Gurdáspur. Tracings of the maps of the entire tract have been furnished to the Settlement Officer of Gurdáspur, who has expressed his approval of them and stated that they have enabled him to send in a preliminary report.

227. In accordance with the request of the Financial Commissioner, Sub-Surveyor Eed Mahomed was detached to serve under a Civil officer who had been specially deputed to carry on an inquiry into certain disputes which had arisen on the boundary between District Dera Gházi Khán and the Baháwalpur State consequent on changes in the bed of the River Indus. The duty required of the Sub-Surveyor, who was detached for four months, consisted mainly in relaying old boundaries, which work is said by the Civil officer under whom the Sub-Surveyor served, to have been done to his entire satisfaction. A portion of the boundary between Sind and the Punjab was also revised by the Sub-Surveyor as part of the same operations.

228. In the recess office, under arrangements made on the requisition of the Financial Commissioner, the plotting has been executed of the village boundary traverses and other special traverses done during the topographical survey of the Hissar district—seasons 1882-83-84,—in preparation for the field survey by *patwáris*. The skeleton sheets, which are on one or other of the Provincial scales of 27·7 or 13·8 inches to the mile, according to lists furnished by the Settlement authorities, and which amount in number to 4,599, have all been made over to the Deputy Commissioner of Hissar.

229. The Surveyor General inspected the recess office of the party at Simla in October 1887, and was highly satisfied with the state of the records and maps which were found to have been carefully prepared and completed up to date.

The general efficiency of the party under Colonel Coddington's able management has been fully maintained.*

RAIPUR DISTRICT, CENTRAL PROVINCES.

No. 3 Party.

Personnel.

Lieutenant-Colonel W. H. Wilkins, Deputy Superintendent, 2nd grade, in charge.
Mr. W. S. Buttress, Surveyor, 2nd grade.
" A. Christie, Surveyor, 3rd grade, on furlough from 18th November 1886 to 15th May 1887.
Mr. C. Tapsell, Surveyor, 4th grade, from 1st November 1886.
Mr. G. Vanderbeek, Assistant Surveyor, 1st grade.
Mr. T. W. Babonau (Jr.) Assistant Surveyor, 3rd grade, up to 30th April 1887.
44 Sub-Surveyors and others.

230. This party returned from its recess quarters at Mussooree and resumed its operations in the Raipur district on 1st November, which was a fortnight earlier than the party took the field the previous season. On the other hand, the work was stopped on the 1st May, also a fortnight earlier, the experience of the previous season having shown that very little work can be got out of a survey establishment in that part of the Central Provinces during the great heat of May. The office establishment then returned to Mussooree for recess.

231. The nature of the operations is the same as were initiated the previous season in aid of the settlement survey of fields by *patwáris*, being purely skeleton traversing of village boundaries and such amount of subordinate traversing in large villages as may be required to furnish a proper basis for the chain measurements of the *patwáris*. Part of the area of the present season, and part of the area traversed during the previous season, in all 565 square miles, have, however, been made over for cadastral survey to the Bilaspur Party, a portion of the establishment of that party having been removed from the Bilaspur district on account of the partial failure of the autumn harvest.

232. All traverse stations are required, under the sanctioned scheme for the Central Provinces traverse surveys, to be marked permanently with stones, and in some of the districts under survey these stones have to be provided and transported at a large expense, but in Raipur most of the salient points of village boundaries are marked with stones, and expense has been saved by adopting these points as traverse stations.

233. The country surveyed lies in the north-west and south-west parts of the district; it consists of portions of Tahsils Simga, Dhamtari, Drug and Raipur, and of Pargana Sahawa, an old *zamindári*, and covers a total area of 3,150 square miles. Pargana Khalári in the south-east of the district, which had been excluded from the contiguous survey of the previous season through misapprehension of the need for its being surveyed at all, it having formerly been a *zamindári*, was made over for survey, on account of the convenience of its position, to the Bilaspur Party, by which it has been traversed for the settlement survey.†

234. The area surveyed being so large—981 square miles more than the out-turn of last season—the office computations connected with it have not been fully brought up during the recess, and they will be carried on by an increased office establishment during next field season. About two-thirds of the computations had been finished at the end of the recess season.

235. The out-turn of the season has been effected by means of 7,509 linear miles of traversing and by theodolites being set up at 29,030 stations. Observations for azimuth were taken at 174 stations. No Great Trigonometrical Survey stations were met with, but connections were made on 7 triangulation points of the Ganjam and Orissa topographical survey.

236. At the request of the Commissioner of Settlements and Agriculture, Central Provinces, the area remaining to be traversed for the settlement survey of Raipur—about 900 square miles—will be made over for execution by the

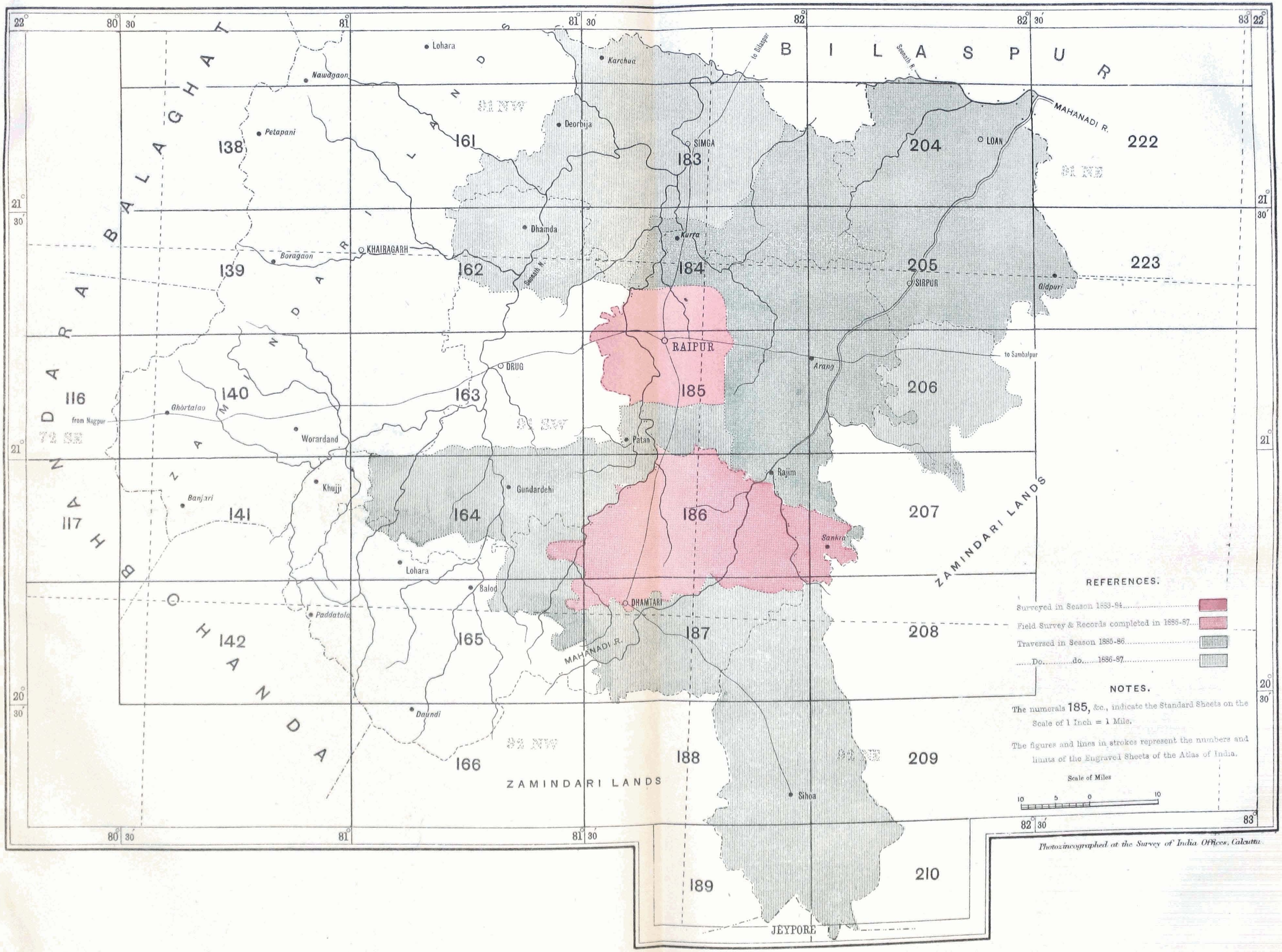
* Colonel Coddington writes very favourably of the services of Messrs. J. S. Pemberton and C. W. Wilson who were in charge of sections, and reports that Messrs. G. Campbell, F. P. Walsh, and F. S. Bell have also given satisfaction in the respective work for which each of them is qualified. The undermentioned Sub-Surveyors are said to deserve mention for the efficient way in which they have performed their respective duties, *viz.*, Eed Mahomed, Elahi Bux, Sirajudin, Mauladad Khan, Maula Bux, and Gurmukh Singh.

† See index map at page 30.

CENTRAL PROVINCES SURVEY.

INDEX TO THE CADASTRAL & TRAVERSE SURVEY OF DIST. RAIPUR.

Nos. 2 & 3 PARTIES.



REFERENCES.

Surveyed in Season 1883-84.

Field Survey & Records completed in 1886-87.

Traversed in Season 1885-86.

Do. do. 1886-87.

NOTES.

The numerals 185, &c., indicate the Standard Sheets on the Scale of 1 Inch = 1 Mile.

The figures and lines in strokes represent the numbers and limits of the Engraved Sheets of the Atlas of India.

Scale of Miles

10 5 0 10

Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel H. R. Thuillier, R. E., Surveyor General of India.

traversing section of the Bilaspur Party, so that the entire Raipur Party may be transferred to the Nágpur and Wardha districts.*

JUBBULPORE AND DAMOH DISTRICTS, CENTRAL PROVINCES.

No. 9 Party.

237. This party, under Mr. G. H. Cooke, returned to Jubbulpore from recess quarters at Mussooree on 1st November, and immediately, on being subdivided into two sections, proceeded to resume traverse survey operations in Districts Jubbulpore and Damoh. The Jubbulpore section continued in the field until 1st May, and the Damoh section until 20th May, the recess station for both sections having in the meantime been changed to Jubbulpore.

Personnel.

Mr. G. H. Cooke, Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. J. Todd, Surveyor, 2nd grade.
" H. Dowman, Surveyor, 3rd grade.
" A. George, Assistant Surveyor, 2nd grade.
" A. Ewing, ditto, do.
36 Sub-Surveyors and others.

238. The nature of the operations was the same as during the previous season, *viz.*, a system of skeleton traversing designed to form the basis of a field survey by the village *patwáris*, and consisting of traverse lines following closely the village boundaries, so as to admit of the actual boundaries being readily plotted by offsets, and in large villages, of additional traverse lines, at intervals of about 30 chains in cultivated lands, or separating the cultivation from the jungle in villages where the jungle was excessive.

239. Every survey station was marked by a roughly cut stone prism 2 feet long by 6 inches in thickness, many stones having to be embedded at dilapidated trijunction platforms as well as at the newly fixed stations. In all, 40,545 stones were embedded in both districts, furnishing an average of 16 marks per square mile, and being laid down at the average cost of R2-8 per square mile, the price of the stones being one rupee (per 16 stones) and one and a half rupee for carriage of the stones and for labour. The first class reserved forests were found to be demarcated by masonry pillars about 5 feet high and rounded at the top so that they could not be utilized as survey stations, and mark-stones had to be embedded at their bases. The second class forests are demarcated by cairns of stones only.

240. The out-turn of the season is shown in the following statement:—

Districts.	Number of Villages.	Number of Sub-Traverses.	Number of Traverse Stations including Trijunctions.	Square miles.
Jubbulpore	668	779	22,247	920
Damoh	909	1,228	24,671	1,670
Total	1,577	2,007	46,918	2,590

The traversing of the Damoh district has been completed. About 2,000 square miles remain to be traversed in Jubbulpore.

241. Observations for azimuth were taken at 263 traverse stations as checks on the angular work; and to test the chain measurements, connections were made on stations of the Great Trigonometrical Survey, which, with those connected last year, have enabled ten comparisons of rays to be made, with the result that the chaining has been found to have an average error of 3·64 feet per mile.

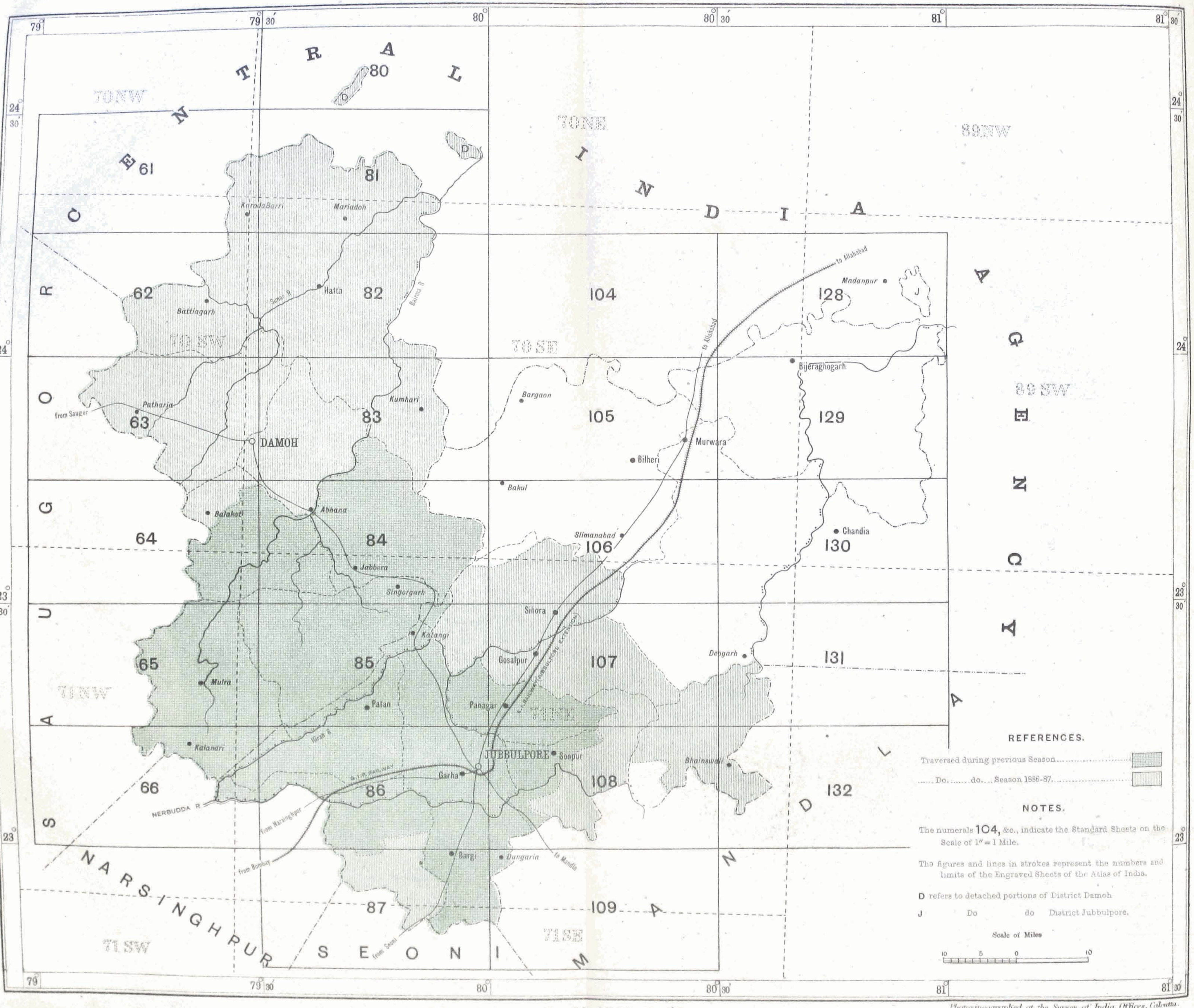
242. The intricate nature of many parts of the country operated in, more especially in the Jubbulpore district where much hilly and raviny ground was met with, added greatly to the labour of the traversing on account of the shorter lines and additional number of stations which had to be adopted. In office, the strain of dealing with the increased number of lines and angles has been chiefly

* Colonel Wilkins reports favourably of the following Surveyors and Assistant Surveyors, *viz.*, Messrs W. S. Buttress, A. Christie, C. Tapsell, and G. Vanderbeek. He also makes favourable mention of the following members of the native establishment, *viz.*, Bhagobutty Chunder Chuckrabutty, Kedar Nath, Mahomed Zakaria, Alladad Khan, Chaju Singh, Rameshardial, Hira Singh, and Dharaneedhar Mookerjee.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTS. JUBBULPORE AND DAMOH.

No. 9 PARTY



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Survey of India Offices, Calcutta, October
1887

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felt. Besides, there has been considerable difficulty in securing the mathematical proof of the village polygons in broken country, without many re-measurements of the lines. Thus it has not been possible to complete the whole of the office work by the end of the recess, and the return of completed work on 31st October showed that the skeleton plots of 331 villages in Jubbulpore and of 693 villages in Damoh had up to that date been furnished for the settlement survey. The office work connected with the remaining villages will be continued in camp during the field season without interfering with the new field work to be undertaken. Besides the skeleton plots, copies of the traverse data to enable these plots to be again projected if required, and statements of the areas of the polygons, are furnished to the Settlement authorities.

243. The total cost of the season's operations for twelve months ending 30th September has been R60,863 for the traversing and R6,475 for the station marks, giving the following rates, *viz.* :—

	Per square mile. R	a.	p.
For traversing	23	8	0
For stone-marks	2	8	0

The rate for traversing shows a reduction of R8 on the rate of the previous season.

244. The recess office of the party was inspected at Jubbulpore during September by the Deputy Surveyor General in charge of the Revenue Branch, who was satisfied that the character of the work which had been executed was good, and that, through the exertions of Mr. Cooke and all concerned, good progress had been made with the office computations, which on account of the intricate nature of the greater part of the country are exceptionally heavy.*

SEONI AND CHHINDWARA DISTRICTS, CENTRAL PROVINCES.

No. 11 Party.

Personnel.

Lieutenant-Colonel D. C. Andrew, S.C., Deputy Superintendent, 2nd grade, in charge.

Mr. W. A. Wilson, Surveyor, 2nd grade, from 6th November 1886.
Mr. J. Hickie, Assistant Surveyor, 1st grade.
" P. White, Assistant Surveyor, 1st grade.
" C. George, Assistant Surveyor, 2nd grade.
" A. George, Assistant Surveyor, 2nd grade, up to 31st October 1886.

34 Sub-Surveyors and others.

245. This party, which had been employed for thirteen seasons on topographical surveys in the Bombay Presidency, has been transferred, under instructions conveyed in Government of India, Revenue and Agricultural Department, letter No. 28—25-1, dated 11th January 1886, to the Central Provinces to undertake traverse surveys in aid of field surveys by village *patwáris* under the supervision of Settlement Officers. Districts Seoni and Chhindwara were assigned to the party, the operations in both districts being required to be undertaken simultaneously by separate sections.

246. A small detachment was sent from the recess quarters at Poona to Seoni in the beginning of October for the instruction of newly-entertained *employés* and for the collection of materials for permanent marks. The main body followed on the 1st November when the field establishments were fully entertained and field work was commenced. Field operations were continued by the Seoni section up to the end of June and by the Chhindwára section up to the end of July, the office establishments being withdrawn about these dates to Poona, which had been retained as the recess station of the party.

247. The operations were of the same character as those which had been undertaken for the same purpose during the previous seasons in other districts of the Central Provinces, in accordance with the specification of the Chief Commissioner. Boundary traverse lines were placed so that the offseting

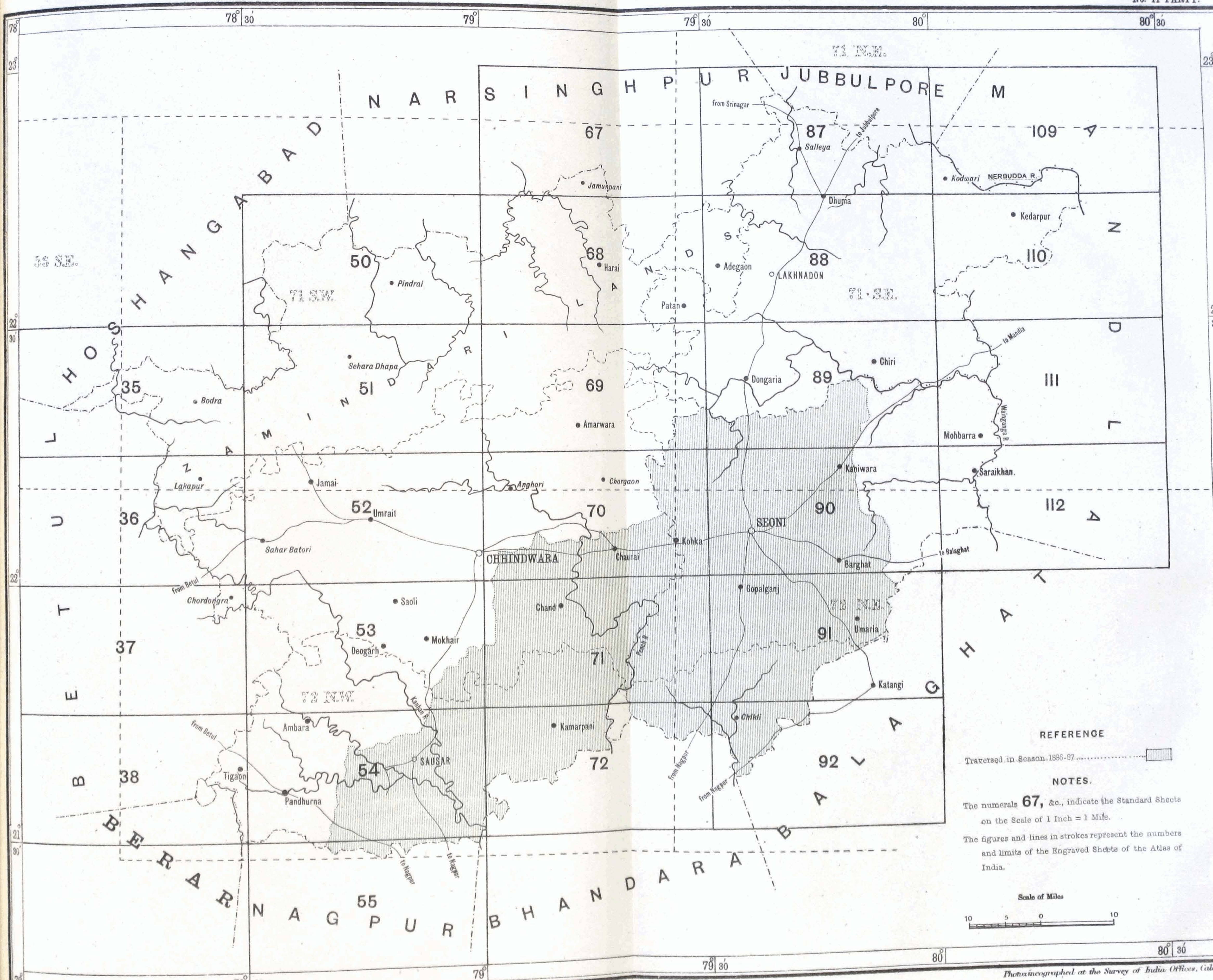
* Mr. Cooke makes special mention of Mr. H. Dowman for accurate and extensive work in connection with the Damoh section which he supervised. The Jubbulpore section was supervised by Mr. J. Todd satisfactorily. Messrs. A. George and A. Ewing are favourably mentioned.

The following members of the native establishment are commended, *viz.*:—Taraprosono Roy, Lal Mohun Gungopadhya, Monohar Daji, Upendra Nath Mokerjee, Kesho Baijnath, Gopal Setaram, Purna Chunder Dass, Behari Lall, Mahmud Bux, Irfan Ali, Rur Singh, Murli Monohar, Piari Lall, Ganpat Rai, Moorad Ali, Prag Singh and Suchait Singh.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICTS SEONI & CHHINDWARA.

No. 11 PARTY.



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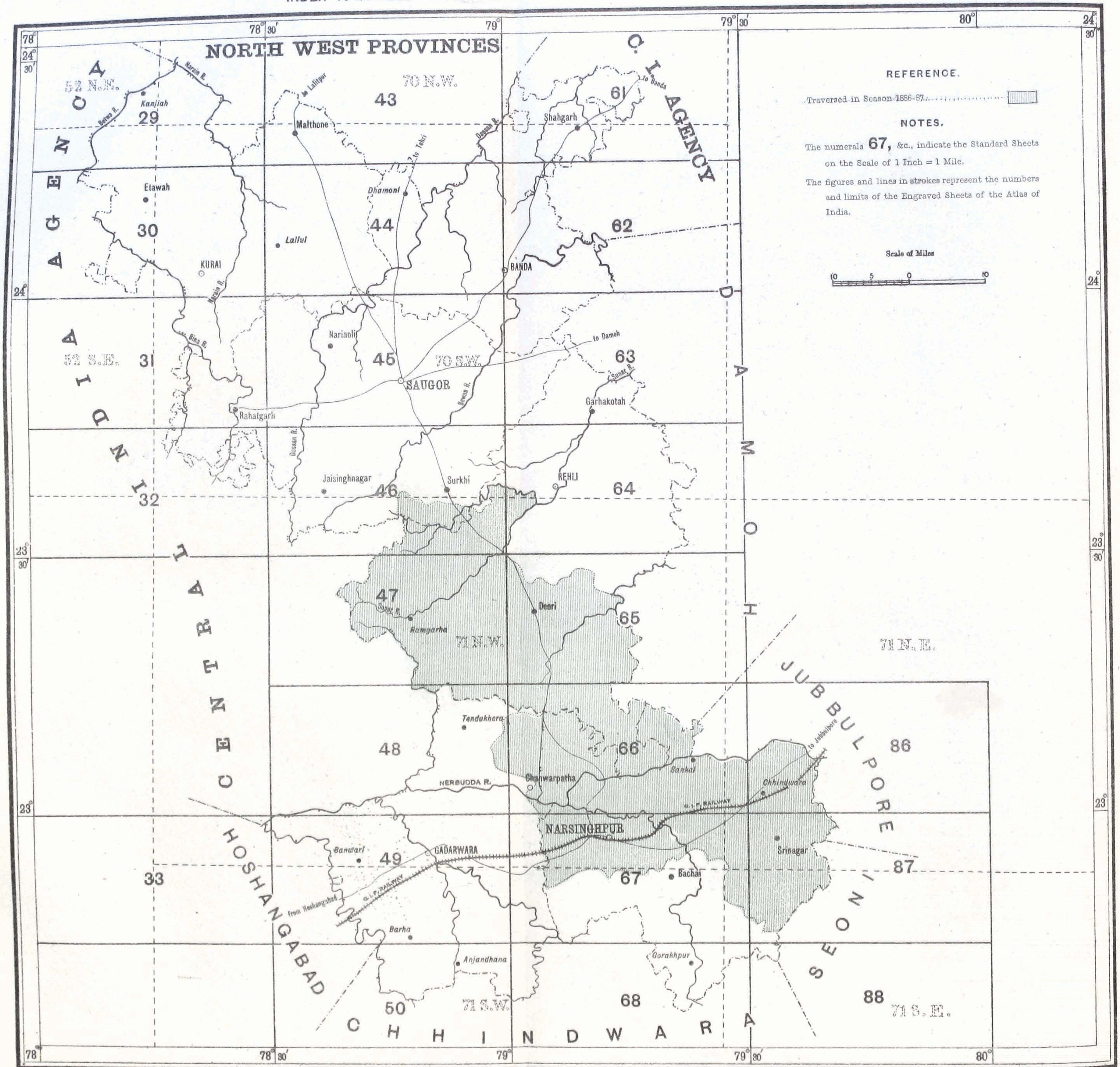
Survey of India Offices, Calcutta, August

1887

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICTS SAUGOR & NARSINGHPUR.

No. 12 PARTY.



Published under the direction of Lieut: Colonel H. R. Thuillier, R.E., Surveyor General of India.
Survey of India Offices, Calcutta, August 1887

Photozincographed at the Survey of India Offices, Calcutta.

distances did not exceed 2 chains; sub-traverses to subdivide large villages were laid out at intervals of about 30 chains; chain lines were kept under 30 chains in length (the average length of the lines being only 14·3 chains); and every traverse station was permanently marked with a stone at least 2½ feet in length. Also, skeleton plots of the traverses on the 16-inch scale, with statements of the areas of the polygons, were begun to be furnished during the recess to the Settlement authorities; and copies of the traverse data, to enable the skeleton maps to be replotted if necessary, were likewise prepared.

248. The areas, of which the field work has been completed in each of the districts, are shown separately in the following statement :—

DISTRICTS.	Number of villages.	Number of sub-traverses.	Number of Theodolite stations.	Area in square miles.	REMARKS.
Seoni . . .	537	732	16,275	1269·5	Besides the villages herein returned, there are 79 forest blocks.
Chhindwára . .	512	650	16,157	1042·5	
TOTAL .	1,049	1,382	32,432	2312.0	

249. Observations for azimuth have been made at 175 traverse stations, and connections have been effected on 4 stations of the Great Trigonometrical Survey. Although the field work of the area stated above has been completed, the office work has only been entirely finished for the Seoni area, of which the skeleton plots on the 16-inch scale have all been supplied to the Settlement authorities, while of the Chhindwára area the plots of about one-third only had been sent on 30th September, the main cause of the delay being the inexperience of the establishments transferred from topographical work or newly entertained, whose work has required considerable revision. It is expected that the Chhindwára work will be fully rendered during January.

250. The recess office of the party was inspected at Poona during September by the Deputy Surveyor General in charge of the Revenue Branch, who found the standard of work executed by the party to be good, and that everything possible under the circumstances was being done to bring up the arrears of the Chhindwára work.*

SAUGOR AND NARSINGHPUR DISTRICTS, CENTRAL PROVINCES.

NO. 12 PARTY.

Personnel.

Colonel A. Pullan, Deputy Superintendent, 2nd grade, in charge up to 28th October 1886.
Mr. E. J. Jackson, Deputy Superintendent, 4th grade, in charge from 29th October 1886.
Mr. A. J. Gibson, Surveyor, 2nd grade, from 1st November 1886.
Mr. W. R. Vyall, Surveyor, 3rd grade.
" J. T. U. Coxen, Surveyor, 4th grade (was on medical leave from 10th November 1886 to 9th May 1887).
Mr. C. Tapsell, Surveyor, 4th grade, up to 31st October 1886.
Mr. G. T. Hall, Assistant Surveyor, 1st grade.
" H. A. Charrier, Assistant Surveyor, 3rd grade.
40 Sub-Surveyors and others.

251. This party, formerly the Cutch Topographical Party, has been brought up to the Central Provinces and re-organized for traverse surveying in accordance with the instructions conveyed in the Government of India, Revenue and Agricultural Department, letter No. $\frac{396}{36-10}$, dated 2nd September 1885.

252. Mr. E. J. Jackson, on return from furlough, was appointed to the charge of the party, *vice* Colonel A. Pullan, transferred to No. 17 Party (Gujarát), and having relieved Colonel Pullan at Poona on the 28th October he immediately proceeded to Narsinghpur, which he reached on 31st October. The establishment had then all assembled and field operations were at once commenced. The party remained in the field, notwithstanding the intense heat experienced after 15th April, until 27th May, when it moved into recess-quarters at Saugor.

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* Colonel Andrew reports favourably of Mr. W. A. Wilson, who was in charge of the Seoni section, and mentions Mr. C. George as an energetic and willing assistant. The following members of the native establishment are also commended, *viz.*, Chandoo Meean, Krishnaji Mahadeo, Shadi Lall, Rambharoselall, Ram Richa, Ram Jas, Sitaram and Bhagwan Deen Tribedi.

253. Owing to the establishment consisting mainly of apprentice surveyors who had been newly entertained so as to raise the topographical survey nucleus to the requisite strength, the out-turn of the party has not been equal to that of the other parties which have had for longer a special organization for traverse surveying; and besides the deficiency of experienced surveyors, the new party has also felt the want of a full complement of trained menials on whose expertness the rapidity and accuracy of the chain measurements chiefly depends. Mr. Jackson has energetically encountered these difficulties, and though he has not been able to obtain credit for a very large out-turn, he has carefully guarded against inferior work by insisting on re-measurements wherever the apprentices' work did not come up to the usual standard. There were also disappointments through apprentices failing to qualify who had to be discharged after time and labour had been lost in their instruction. It should likewise be mentioned that many parts of the country were very rocky and covered with jungle which greatly hindered the work of the traversers.

254. As the operations were required to be carried on simultaneously in two districts, the separate localities for beginning work were selected as near to each other as possible for convenience of supervision, and the extreme southern part of the Saugor district, though presenting many difficulties to a new establishment from its rugged character, was first entered upon. In Narsinghpur, the operations were begun from the east on the Jubbulpore boundary. The nature of the work has been the same as was carried on during the previous season by other traverse survey parties in the Central Provinces according to the specification of the Chief Commissioner, the work being specially designed to form the basis of a survey of fields by village *patwáris*, and consisting of traverses following closely the lines of the village boundaries with additional sub-traverses in large villages. As required by the same specification, the theodolite traverse stations have all been marked with stones either specially quarried and transported for the purpose or such as were already found standing as village boundary-marks. Most of the tri-junction points were found to be already marked with masonry platforms, but for many, temporary materials only had been used, and at these points stones were embedded. In all, 26,071 stones were put down, *viz.*, 12,518 in Saugor and 13,453 in Narsinghpur.

255. The areas that have been accomplished in both the districts are shown in the following statement :—

Districts.	Number of villages.	Number of sub-traverses.	Number of stations.	Area in square miles.
Saugor	427	570	14,266	771
Narsinghpur	539	767	15,790	784
Total .	966	1,337	30,056	1,555

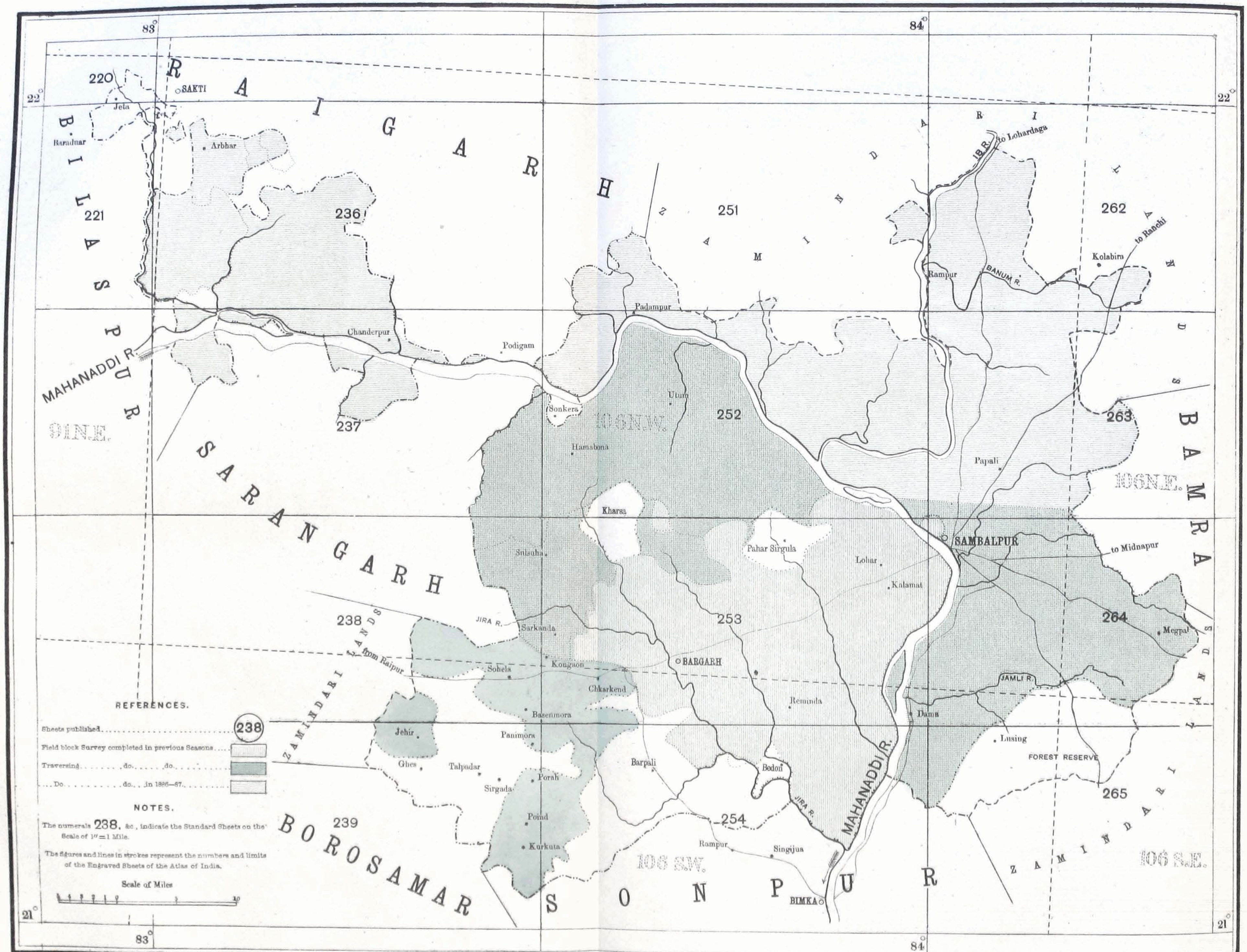
The aggregate length of the traverse lines is 5,100 linear miles. During the operations, 88 new sets of observations for azimuth were taken, and 24 sets of observations taken during the Jubbulpore and Damoh survey on the common boundary were utilized. Connections were made with 6 stations of the Great Trigonometrical Survey, furnishing the means of comparing the direct distances of 8 rays with the measured distances of the same and showing that the latter have an average error of 5·9 feet per mile.

256. Owing mainly to the want of experience of a large number of the members of the new establishment, the work of many having to be revised, the computations of all the villages that have been surveyed have not been completed during the recess, and at the end of the season 92 villages in Saugor and

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT SAMBALPUR.

No. 13 PARTY.



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Survey of India Offices, Calcutta, September.
1887

Photozincographed at the Survey of India Offices, Calcutta.

241 in Narsinghpur remained unfinished. In Saugor, 335 villages had been completed and 481 plots furnished; in Narsinghpur, 298 villages and 491 plots. The incomplete records will be proceeded with during the field season, as soon as re-measurements can be made.

257. The areas remaining for survey are 3,242 square miles in Saugor and 1,140 square miles in Narsinghpur. The traversing of the latter district will be finished during season 1887-88, but about 1,780 square miles of Saugor will be left over for the following season.*

SAMBALPUR DISTRICT, CENTRAL PROVINCES.

No. 13 PARTY.

Personnel.

Mr. A. D'Souza, Assistant Superintendent, 1st grade, in charge.
Mr. P. A. G. Cowley, Surveyor, 1st grade, on medical leave.
Mr. C. W. F. Seyers, Assistant Surveyor, 1st grade.
Mr. C. S. Kraal, Assistant Surveyor, 1st grade, up to 30th April 1887.
Mr. T. W. Babonau, Assistant Surveyor, 2nd grade, from 1st May 1887.
22 Sub-Surveyors and others.
18 Temporary ditto.

258. This party under Mr. D'Souza resumed traverse operations in the Sambalpur district on 23rd November 1886, and continued to work up to 20th April 1887, when, on completing the tracts for which traversing was required in Sambalpur, it returned to recess-quarters in Nagpur.

259. The traverse work has been of the same character as during the previous season, having for its object the preparation of skeleton maps of villages on which the field details would be plotted by the village *patwáris* working under the Settlement Officer. Besides the traverse stations established on the village boundaries, other stations were also established by means of sub-traverses within the large villages, and all the stations were secured with permanent marks.

260. The out-turn is as follows:—

Number of villages	469
Number of sub-traverses	660
Number of stations	10,404
Linear miles of traversing	2,808
Area in square miles	969

Observations for azimuth were taken at 75 traverse stations, and connections were made on 5 stations of the Great Trigonometrical Survey, which furnished tests showing that the traverse measurements have an average error of 2·65 feet per mile.

261. In order to meet the requirements of the programme of the Settlement Officer, special arrangements were made to push on the office computations during the field season, and 746 plots were furnished for the use of the village *patwáris* before the party left the field. The remainder of the plots, 366 in number, and area statements for the entire tract, were all supplied at the end of the recess season.

262. This party which has hitherto been only of half strength has been raised to full strength from 1st October 1887, in order that it may be employed in two sections on the traverse surveys of the Hoshangabad and Betúl districts required to be carried on simultaneously.

263. The recess office of the party was inspected at Nagpur during September by the Deputy Surveyor General in charge of the Revenue Branch, who expresses himself as having been well satisfied with the character of the records that had been prepared as well as with the manner in which Mr. D'Souza had carried out all duties connected with the superintendence of the party.†

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* Mr. Jackson reports very favourably of Mr. G. T. Hall, also of the undermentioned members of the native establishment, *viz.*, Rhidoy Chunder Dass, Jogendra Nath, Govindro Swamy, Abdul Guni, Narsoo Dinkur and Balkishen.

† Mr. D'Souza reports that Messrs. Seyers and Kraal have both done excellent work.
Of the native establishment, Boith Ram, Rajdhari Lall, Abdul Khalik, Ram Dass, Dahini Khan, and Narain Pershad are specially commended.

GEODETIC.

NOS. 22 AND 23 PARTIES (ASTRONOMICAL).

LATITUDE OPERATIONS.

Personnel.

Lieutenant S. G. Burrard, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Babu Harsahai, Recorder.
Babu Dhondu Balwant Joshi, Computer.
Babu Mangat Rai, Writer.

264. Owing to there being but one officer available for astronomical work, as was stated in paragraph 282, page 58 of last year's Report, the Telegraphic Longitude operations were suspended and Latitude operations resumed during the year under report. In 1884-85 Lieutenant-Colonel Heaviside had carried these operations from north to south over the Amúa Meridional Series, his last station being Potenda in latitude 24°37′, and Lieutenant Burrard has continued the operations as far south as Rájuli, a station of the Jubbulpore Meridional Series in latitude 20°13′, in pursuance of the design to have a series of latitude stations, about half a degree apart as near as may be to meridian 80°, from the Himalayas to Madras. Lieutenant Burrard's work consists of observations at five stations, a very creditable number, considering that his working season was curtailed at both ends. Having had no experience with a zenith sector, he remained nearly a month at Dehra Dún at the beginning of the season for preliminary practice; he was further detained for ten days at Nágpur on account of the very unhealthy state of the country where his operations were to commence (as reported by the Civil Surgeon), but he improved this occasion by establishing a latitude station at Nágpur at which he took complete observations. He had to close field operations early, that is to say, on 1st March, in order to undertake a series of experiments at Dehra Dún with the longitude transit instruments. His work, as judged by the accordance of his zenith distance measures, compares well with the best work of his predecessors.

ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

265. Though there is nothing to report in the way of direct progress in these operations, mention has now to be made of the various experimental observations that have been undertaken for the testing of the telescopes employed thereon, concluding with the exhaustive series of experiments projected in accordance with the intimation in paragraph 285, page 59, of last year's Report, and carried out in March and April last. These instruments were made by Messrs. Cooke and Sons in 1870 and 1871, and despatched to India early in 1872. They are, it is believed, the largest of the kind ever made as *portable* transit instruments, and the experience gained from their performances from the first to the present time leads to the suspicion that they are too large and ponderous to stand the vicissitudes of transport to which they are of necessity exposed. During their first season's work in 1872-73, one of them (called No. 2) was found to be so capricious in its performance that the two arcs then measured had both to be rejected. The cause of this failure was easily detected and was remedied, and throughout three subsequent field seasons the instruments worked satisfactorily, but the results of the fourth season's (1881-82) work indicated that unsteadiness was creeping in again in one or other of the instruments. This time, however, the *locale* of the cause of error was by no means easy to discover, for the existence of error was only shown when the observations were reduced and the errors of circuits* of three arcs taken out, no signs of instrumental unsteadiness having presented themselves while measuring the individual arcs. There were three such circuits, the first two of which showed errors much larger than had occurred before, while the third, formed by the three arcs last measured in the season, had but a normal error which was probably due to fortuitous cancelment of large arc errors and which ministered the unpleasant *caveat*, that while a large circuit error proves the *presence* of large arc errors, a small circuit error by no means proves the *absence* of large arc errors. Instrumental weakness was

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* For an explanation of this term see note † at foot of page 59 of last year's Report.

accepted as a fact though its *locale* was not actually discovered; the instruments were sent into the Mathematical Instrument Office, Calcutta, and the parts where weakness had before been detected were further fortified. After this, work was resumed and carried on during two field seasons with fairly good results, but indicating nevertheless the presence of a capricious source of error which could not fail to cause continued anxiety to the observers and general distrust in the degree of accuracy exhibited by even small circuit errors which might possibly conceal large arc errors. The instruments were therefore sent back to England in 1884, to be carefully overhauled by the makers and to have every possible seat of weakness or instability strengthened or renovated. The makers carried out these instructions, and on account of suspicion attaching to the bearings in which the axial pivots revolved and which were of a very beautiful but novel design* they supplied new Ys of the old established pattern. Lieutenant-Colonel G. Strahan, R.E., then on furlough in England, was deputed to examine the instruments on the makers reporting the execution of their orders. As stated in paragraph 284, page 58, of last year's Report, Colonel Strahan carried out his examination in the enclosure of the Greenwich Observatory. One oversight of the makers in wiring the micrometer diaphragms necessitated the return of the instruments from Greenwich to York for correction. This done, they were sent back to Greenwich, and Colonel Strahan examined them to see that they were in good working order. After satisfying himself that the line of collimation in each instrument was practically permanent as regards freedom from *lateral* displacement, by revolving the instrument through various arcs and pointing it after each arc motion on the cross of a collimator, bringing it to the cross alternately from above and below, he then with each instrument took a series of star transits, having selected 24 stars, of which half transited north and half south of the zenith, devoting three nights to instrument No. 1 and four nights to No. 2, changing the position of the pivots† in the middle of each night's observations. Colonel Strahan's observations as far as they go are complete, and his report full and precise. The object of the observations was to see that the makers' orders had been thoroughly executed; and having satisfied himself that such was the case, Colonel Strahan "passed" the instruments, and they were sent back to India in time for resumption of the longitude operations in the field season of 1885-86. Colonel Haig, the Deputy Surveyor General in charge of the Trigonometrical Branch, however, having carefully analyzed Colonel Strahan's report, noticed that the observations, if treated similarly to those of 1883-84, of which the results are given in Table III, page lxxv, of the Report for that year, indicated the presence of residual errors in the two instruments respectively of —·065 and —·068 of a second in place of $-^{s}\cdot011$ and $+^{s}\cdot140$ as there exhibited, and, moreover, that there were indications of some accidental error on one night at Greenwich, which, if corrected as appearances seemed to justify, gave a set of very uniform results, but increased the residual of No. 2 from $-^{s}\cdot068$ to $-^{s}\cdot128$. Now if these residuals were invariably found to exist and to maintain a constant or fairly constant value, it would virtually solve the mystery that has been causing the trouble and discussion of the past few years, for they represent the respective correction peculiar to each instrument necessary to be applied to the means of two sets of observations—one taken with I. P. E. and the other with I. P. W. It was, therefore, thought advisable before regular operations were resumed, to take the further series of experiments at Agra mentioned in paragraph 284, page 59, of last year's Report. These observations occupied twelve nights—six to each instrument—24 stars, 12 north and 12 south of zenith, being observed every night with a change of pivot position in the middle; and the evidence of the results was much more favourable than that of Colonel Strahan's observations, and went towards largely reducing the residuals of both instruments—the five values of that of No. 1 ranging from $-^{s}\cdot005$ to $+^{s}\cdot035$ with a mean of $+^{s}\cdot017$, while the five values of that of No. 2 had the still smaller range from $-^{s}\cdot025$ to $-^{s}\cdot040$ with a mean of $-^{s}\cdot033$. These results, while failing to establish the constancy of the residuals determined by Colonel Strahan's lesser series of observations, confirmed his testimony to the proper fulfilment of

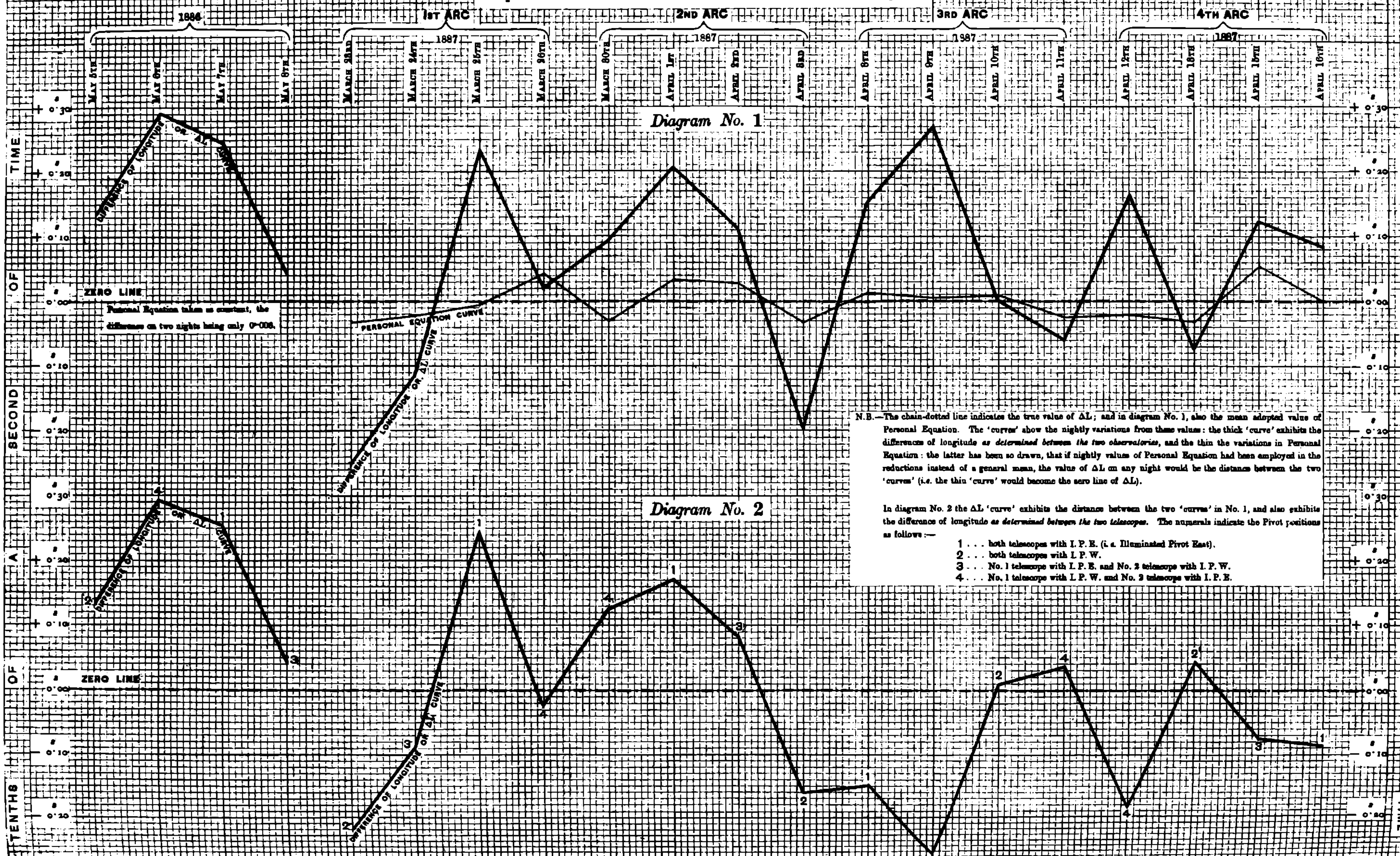
* This is fully described in Professional Volume IX, page 3.

† In each instrument one of the pivots is perforated for the purpose of illuminating the wires and is called the "illuminated pivot": the term always used to denote the position of the instrument when that pivot is to the east is defined as I. P. E., and when west, I. P. W.

their engagement by the makers, and regular operations were at once resumed. During the field season nothing occurred to shake the confidence of the observers in the perfection of the instruments. Nine arcs were measured, and in order to test the accuracy of the observations for personal equation, there was an interchange of observers on one of the arcs in the middle of the observations, four nights being given to each disposition, the respective telescopes and equipment remaining fixed. The result showed a difference between the two observers, Colonels Strahan and Heaviside, of ·082 of a second, while two sets of observations taken by them in the ordinary way gave one a difference of but ·003 and the other of ·068 of a second. At the end of the season an experimental arc was measured, the two instruments being placed on the same meridian 51⅓ feet apart, in order to see what error would occur in the measurement of an arc the exact magnitude of which was known (*viz.*, $\Delta L = 0^s{\cdot}000$). When the season's observations came to be reduced, the results were most disappointing, three out of five circuit errors being abnormally large, *viz.*, $-^s{\cdot}325$, $-^s{\cdot}257$, and $+^s{\cdot}251$, and the single experimental arc having an error of $0^s{\cdot}180$. These results occurring in the face of abundant testimony to the excellence of the instruments, Colonel Haig determined to have a further and exhaustive series of observations taken on the experimental arc at Dehra Dún, in the course of which there should be every possible interchange of observers, telescopes, electrical apparatus and stations, so as to localize the source or sources of error if it should still be impossible to determine the precise causes. This series of observations was undertaken by Lieutenant Burrard, assisted by Mr. Eccles, in March and April last, and a detailed report thereon drawn up by Lieutenant Burrard will be found at page xxiv of the appendix. These experiments go to show that the Longitude operations have been harassed by three sources of error, *viz.*, (1) electrical, (2) local, and (3) instrumental. The discovery of the *electrical* cause of error is valuable. It was always supposed that the "retardation" in transmitting a signal depended on the length of the line of wire between the two stations, and it was the custom to divide the retardation equally over the two passages from east station to west, and from west station to east; whereas it has been established that the retardation on the line wire is practically *nil* and that the whole amount may be caused by the chronograph at one station. This being discovered, the retardation caused by each chronograph will, in future, be independently measured each night by a simple process, and the difference between the retardations at the two stations on any night will afford a correction to all the measures of the arc of longitude taken that night. The error caused by neglecting that correction is variable; sometimes during the experiments it was observed to amount to ·05 of a second, but on examining the records of the observations of the Agra-Mooltan arc, the retardation was found to be ·4 of a second on one night, and if this was entirely due to one chronograph, the error in the mean of that night's observations due to dividing it equally between the two would be ·2 of a second, and this would affect the general mean of the six nights by ·033 of a second.

266. The presence of a *local* disturbing force seems to be pretty clearly established. Since the two instruments were within a few yards of each other, the effect of "local attraction" causing deflection of the plumb-line would of course affect both instruments alike; but it appears that there was a local disturbing force causing stars to transit earlier in one observatory than in the other, irrespective of the instruments with which they were observed. The mean value of the effect of this force was ·052 of a second. The only apparent difference in the environments was, that while one instrument was surrounded by a tent the other was in a built observatory and rather close to the large photo-heliographic observatory, and if this difference produced such an effect, it is not unlikely that other local accidents have affected the measurement of many arcs to a similar extent. If, however, the disturbing force be constant, it would not affect the closing of the circuits, as it would operate equally on all arcs meeting at a station, unless those arcs were not all measured during the same season and the local conditions were altered in the *interim;* but supposing it were due to lateral refraction from want of homogeneity of atmosphere caused by currents of air circulating round an adjacent building, it would be liable to some fluctuation varying both with the season of the year and the night, and this would affect circuit error. It is noticeable that the error ascribed to this disturbance has the same sign as the error in the measurement of the experimental arc in May 1886,

Graphical Illustration of the Variations in Difference of Longitude



N.B.—The chain-dotted line indicates the true value of ΔL; and in diagram No. 1, also the mean adopted value of Personal Equation. The 'curves' show the nightly variations from these values: the thick 'curve' exhibits the differences of longitude *as determined between the two observatories*, and the thin the variations in Personal Equation: the latter has been so drawn, that if nightly values of Personal Equation had been employed in the reductions instead of a general mean, the value of ΔL on any night would be the distance between the two 'curves' (i.e. the thin 'curve' would become the zero line of ΔL).

In diagram No. 2 the ΔL 'curve' exhibits the distance between the two 'curves' in No. 1, and also exhibits the difference of longitude *as determined between the two telescopes*. The numerals indicate the Pivot positions as follows:—

1 . . . both telescopes with I. P. E. (i.e. Illuminated Pivot East).
2 . . . both telescopes with I. P. W.
3 . . . No. 1 telescope with I. P. E. and No. 2 telescope with I. P. W.
4 . . . No. 1 telescope with I. P. W. and No. 2 telescope with I. P. E.

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, February 1888.

and that its mean as determined by Lieutenant Burrard measures more than a quarter of the amount of the latter error.

267. In the investigation of the sources of error, Lieutenant Burrard has assumed that the local disturbing force is constant. It is probably not really so, but its variation is likely to be small in comparison with the fluctuations in the nightly mean measures of difference of longitude, otherwise it would have led to detection before both here and in other parts of the world. It is, therefore, convenient to suppose it constant for the facile exhibition of the inconstancy of the nightly means under one source, and to the *instrumental* cause of error has been ascribed the whole of the caprice in those means. The caprice has this strange peculiarity, that while it is capable of producing a difference ranging from $+\cdot175$ to $-\cdot175$ of a second between the times of meridional passage of a zenith star, as observed by the two telescopes, the amount of that difference remains constant through any one night's observations, though probably the constant would change were change made in the disposition of the observers, telescopes, or pivots, in the course of a night's work, which was, however, not done, and is not now usually done in the ordinary routine work. The only way to deal with this enemy is to distribute the observations over a sufficient number of nights, that the error varying in its caprice from night to night in quantity and sign may nullify itself to a great extent when striking the general mean of all the nights. If the "probable error" on any night from this mysterious cause be $\pm\cdot088$ of a second; and six nights (the usual number) be given to the measurement of each arc, the mean of the six nights would have a reduced "probable error" of $\pm\cdot036$ of a second; but beyond six nights it would not be expedient to extend the observations, for the reduction in the "probable error" would not be an adequate compensation for the cost, *e.g.*, nine nights would only reduce the "probable error" to $^{s}\cdot030$.

268. Besides the three principal causes of error, Lieutenant Burrard has deduced two minor causes, and he regards them as constant; one an inherent difference between the two telescopes equal to $^{s}\cdot017$, and the other an inequality of resistance offered to electric currents by the two chronographs equal to $^{s}\cdot015$, which can be made to cancel each other by always using the quick chronograph with the slow telescope.

269. The results of each night's observations and their fluctuation, of which it has been sought to discover a law instead of ascribing them to caprice or accident, are now graphically exhibited in the accompanying diagrams which include the experimental arc measurements of 1886, as well as those of 1887. It will be observed that there are exhibited in all twenty nights' work divided into arcs of four nights each. On each arc a night was given to each of the four pivot positions, *i.e.*, (1) both instruments with I. P. E., (2) both with I. P. W., (3) No. 1 with I. P. E., and No. 2 with I. P. W., and (4) No. 1 with I. P. W., and No. 2 with I. P. E. The arc of 1886 was measured as in the ordinary way without any interchange of telescopes between the observers or observatories. Each arc of 1887 was marked by a change. Between the first and second arcs there was an interchange of observers only: between the second and third there was an interchange of both telescopes and observers; and between the third and fourth there was another interchange of observers only. In the regular operations it is usual to take advantage of occasions as they may occur when the two observers are together to take observations for relative personal equation, and as the variation between the personal equations determined on such occasions is supposed to be generated gradually, a graduated correction for it is applied to the arcs, proportionate to the intervals between their measurement and the personal equation determinations. At Dehra Dún during the 1887 experiments, observations for personal equation were taken every night. During the 1886 experiments, such observations were taken on two nights only, and with results so very accordant that the difference between applying the actual correction on those nights of determination and applying a mean or proportionate correction is practically *nil;* but in the 1887 experiments, the differences from the mean are sufficiently appreciable to exhibit on the diagrams. Across the centre of the diagrams will be seen a chain-dotted zero line. In the upper diagram, on the vertical line accorded to each date, two points are plotted: these points indicate by their distance from the zero line, the respective values of (1) the observed difference of longitude (the true difference being $0^{s}\cdot000$), and (2) the deviation of that night's personal equation from the mean of all the nights; and,

therefore, two series of points are formed, and these are exhibited by the thick and thin continuous but crooked lines, called respectively "difference of longitude or ΔL curve" and "personal equation curve." The actually observed difference of longitude on each night is represented by the distance between these two "curves." On the first glance at this diagram it will be noticed that the ΔL (difference of longitude) "curve" is violently erratic, while the P. E. (personal equation) is very moderately so; only in one instance, *viz.*, between the last two nights, is the fluctuation in the former less than that in the latter. Now each of the points furnishing the ΔL "curve" is, as a rule, the mean of 32 observations to as many stars, and each of the points furnishing the P. E. "curve" is the mean of eight observations to as many stars. Supposing all the individual measures from which each mean in both curves is derived were plotted on the diagram, there would be instead of the single point marked by the "curve," a row of 32 points at each angle of the ΔL "curve" and one of eight points at each angle of the P. E. "curve," the great majority of points in the ΔL row would lie within two-twentieths of an inch on either side of the curve with an occasional larger digression, and the largest digression of all would be seven-twentieths. [*N.B.*—The paper is divided into halves and twentieths of an inch, a half-inch representing one-tenth of a second of time.] A similar description would almost exactly suit the P. E. rows of points. The lower diagram is but a modification of the upper: in it the distances of the ΔL "curve" from the zero line are equal to the distances between the two "curves" in the upper, and for the last two arcs those distances have been plotted on the opposite side of the zero line, so that while the upper diagram exhibits the ΔL observed between the two observatories, the lower exhibits the ΔL observed between the two telescopes, and this is convenient for exhibiting the positions of the pivots on each night. The four positions have been enumerated above, and they are indicated by the numerals 1, 2, 3, 4 on the lower diagram. The perplexity involving the problem which it has been attempted to solve, may be estimated by the erratic character of the ΔL "curve" in the face of comparative consistency between the measures from which each point in the curve is derived. It is evident from inspection of the ΔL "curve" that the vagaries are such that even sixteen or twenty nights are insufficient for the deduction of very precise conclusions, though they are sufficient to indicate the sources from which the variations proceed; and in future operations all precautions will be taken so as to preclude errors which cannot be called accidental, and to make those which can be so called, neutralize each other as much as possible. Further detective measures have also been devised and will be adopted, so that, while the regular operations progress, all possible light may be thrown on the nightly caprice of the mysterious disturbing force. After all, it should be remembered that the variations that are brought so prominently to view in the diagrams are in reality of very small magnitude, and that by no other means could difference of longitude be measured with any approach to the accuracy attained in these Telegraphic Longitude operations.*

TIDAL AND LEVELLING OPERATIONS.

NO. 25 PARTY.

270. The direction of these operations was under Major Hill, R.E., throughout the year. Major Baird, on his return from officiating as Master of the Calcutta Mint, rejoined the party and assisted in the preparation of the Tide Tables for 1888 until his transfer to the head-quarters offices at Calcutta.

Personnel.

Major J. Hill, R.E., Offg. Deputy Superintendent, 2nd grade, in charge.
„ A. W. Baird, R.E., F.R.S., Deputy Superintendent, 3rd grade, attached to party from 8th January to 25th May 1887.
Mr. G. Belcham, Surveyor, 3rd grade.
„ E. J. Connor, „ 4th „
„ H. Corkery, B.A., LL.B., Assistant Surveyor, 1st grade.
Sub-Surveyors Narsing Das and Dhondu Venayek and 16 recorders and computers.

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* Lieutenant Burrard reports very favourably on his Observatory Recorder, Babu Har Sahai.

TIDAL OPERATIONS.

271. The recording of the tidal curves by means of self-registering tide gauges, their reduction and the publication of predicted heights have been continued as usual during the past year, during which tidal observations were carried on at 17 stations, namely :—*Aden*, *Kurrachee*, Bhávnagar, *Bombay*, Mormugáo (Goa), Cochin, Colombo, Galle, Negapatam, *Madras*, Cocanada, *Kidderpore*, Chittagong, Akyab, Elephant Point, *Rangoon* and *Port Blair*. The ten tidal stations the names of which are not italicised, are minor stations at which as a rule only five years' registrations are required, after the completion of which period the instruments are removed and set up elsewhere. The seven names which are italicised are those of permanent stations where tidal observations should be continued until the work at all the minor stations is completed.

272. Since the date of the last Annual Report, work has ceased at two tidal stations. On the 9th October 1886, the Amherst observatory was closed and the instruments sent to Akyab: and on the night of the 29th September 1886, the tidal observatory at Dublat, near the mouth of the Hooghly, was swept away with all its contents by a heavy wind and sea, and none of the instruments or records could be recovered. Fortunately the clerk was absent, and the accident was unattended with loss of life. Dublat used to be regarded as a permanent tidal station, and five years' registrations had been completed at the observatory about five months before its destruction; but the station is now classed as a completed minor one, and it is unlikely that the observatory will be re-established. As it is desirable, however, to have one permanent tidal station on the Hooghly, Kidderpore now occupies that position.

273. One new tidal observatory has been established during the year under report: this is at the minor tidal station of Akyab, and its registrations commenced on the 9th May 1887. Particulars regarding its erection will be found in the appendix.

274. It will be seen from the foregoing, combined with the particulars given in the last Annual Report, that since the resumption of systematic tidal operations in 1877, observations have been taken at 26 tidal observatories, of which 9 have been closed on the completion of their registrations and 17 are now in operation.

275. When an observatory is closed, it is desirable to set up in its place a graduated staff the zero of which should correspond with the datum to which the heights at the station in the Tide Tables are referred, so as to obtain actual values to compare with the predictions. This has been done at Moulmein, and arrangements have been made for setting up another at Amherst. As opportunity offers, similar staves will be introduced at all the tidal stations where observations have been completed.

276. The places which appear most suitable for selection as future minor tidal stations are Tuticorin, Mergui, Singapore, Fao telegraph station at the mouth of the Bussora river in the Persian Gulf, and a site in the Gulf of Siam in about the latitude of Mergui to be, if possible, connected with Mergui by spirit-levelling. Another proposed site for a tidal station is Diamond Island at the mouth of the Bassein river, mentioned in the last Annual Report; but recently received information appears to show that the difficulty of communicating with it during the rainy season would probably neutralize its advantages, and it seems doubtful now whether a tidal observatory can advantageously be established there. It has accordingly been decided to establish Tuticorin and Mergui as tidal stations before taking any steps towards setting up a tidal observatory at Diamond Island.

277. All the observatories with the exception of Aden have been inspected either by the officer in charge of the party or by one of his assistants.

The usual account of the working of each observatory will be found in the appendix. On the whole the registrations have been very satisfactory; failures have been few and for the most part unimportant; the observatory clerks know their duties and perform them punctually, and the officers who superintend the registrations of the several tidal stations spare no pains, as a rule, to ensure good results.

278. The reductions of the observations have been carried on steadily during the year. The observations for one year at 12 ports and for two years at 3 ports

have been reduced, equivalent to the reduction of the observations at 18 ports. The tabulated values of the tidal constants and the discussion of the results will be found in detail in the appendix.

279. In addition to the current calculations the usual work in connection with the yearly issue of the Tide Tables for 1888 has been satisfactorily accomplished. These tables will contain the predictions of the heights and times of high and low water for 27 ports, being four more than in the volume for 1887.

280. The results of the predictions for 1886 may be summarised as follows :—

Percentage of predictions within 15 minutes of actuals.

	High water per cent.	Low water per cent.
Open coast stations	67	66
Riverain	68	66

Percentage of predictions within 8 inches in height of actuals.

	High water per cent.	Low water per cent.
Open coast stations	98	98
Riverain	48	47

281. The figures in the preceding paragraph and the tabulated statements from which they have been deduced give a very good idea of the correctness of the time predictions, but they scarcely show what percentages may be considered good as regards height, for although 98 would be a remarkably good percentage of predictions within 8 inches of height in the case of Amherst where the mean range at springs is over 20 feet, such a percentage could not be accepted as indicating that the height predictions were good in the case of Galle where the corresponding range barely exceeds 2 feet. There has therefore been added in the appendix a table of average errors in time in minutes, and of height in terms of the range, for the year 1886, which will enable a better estimate to be framed of the relative values of the predictions at the several tidal stations.

282. In addition to the usual tables showing the values of the tidal constants for the current year at the ports where observations are still being recorded, a first instalment of the completed tidal work is given this year. This is contained in tables Nos. 1 and 2, page xlii of the appendix, the first of which gives the values of the tidal constants for 12 stations at which observations have been completed, the second shows for the same ports the observed and theoretical values of the co-efficients in terms of the main lunar tide M_2.

283. For some years to come the number of tidal observatories is not likely to be reduced, and the ordinary computations connected with the reduction of the tidal registrations will continue to be carried on as at present. When the observatories become fewer the calculations of the meteorological corrections, and of the probable errors of the observations can be taken in hand, and will fully employ the computing staff of the party for many years.

SPIRIT-LEVELLING OPERATIONS.

284. The levelling operations during the year under report consisted of six sections as under :—(1) from Tuticorin to Madura, (2) from Madura to Trichinopoly and Tanjore to join the line executed in 1885-86, (3) from Trichinopoly to Erode to join the line executed in 1884-85, (4) from Shoranur to Cochin Tidal Station, (5) from Kárwár Tidal Station to Mormugáo Tidal Station, (6) from Agoada Fort Jetty to Agoada.

285. The total out-turn amounted to 450 miles of double levelling, in the course of which the heights of 418 permanent bench-marks and of 6 stations of the Great Trigonometrical Survey have been finally determined. The apparent mean generated error of levelling in the season's work was ·0008 foot per mile. The length of lines levelled fell short of last year's out-turn; this is accounted for by the nature of the country levelled over, which necessitated the instruments being set up at 332 extra stations: the total rise and fall in this year's work exceeded last year's by 6,741 feet. The heights of two stations on the South Konkan Series were also determined by levelling, and the data necessary for the revision of the heights of that series thus completed.

286. Three more pairs of test bench-marks for detection of secular change of relative level between land and sea by periodic determinations thereof, have been laid down in connection with the tidal stations of Mormugáo, Kárwár and Cochin.

287. It is intended in the ensuing season to undertake a line of levels between Madras and Vizagapatam in continuation of the general scheme of the Levelling operations.*

GEOGRAPHICAL SURVEYS.

UPPER BURMA.

288. During the year under report the detachment under Captain (now Major) Hobday was brought up to the strength shown in the margin and has been employed almost entirely on reconnaissance surveys in connection with the various military movements undertaken for the pacification of the country. In July 1887, Captain Hobday was forced to take privilege leave to recruit his health which had suffered much by his incessant work in unhealthy parts, and during his absence Lieutenant Jackson held charge of the party.

Personnel.

Major J. R. Hobday, B.S.C., Deputy Superintendent, 4th grade, in charge.
Lieutenant H. M. Jackson, R.E., Officiating Deputy Superintendent, 4th grade.
Mr. A. G. Wyatt, Surveyor, 3rd grade, from 1st January 1887.
Mr. F. Kitchen, Surveyor, 4th grade.
„ R.A. Gibson, Assistant Surveyor, 1st grade, from 17th November 1886.
Mr. J. M. Kennedy, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

Mr. J. Macollough, Sher Shah, Faida Ali, Gobardhan Dass, Shib Charan, Sharf-ud-din, Mahomed Latif, Mahomed Ibrahim.

289. The operations of the various sections are as follows :—

In November Captain Hobday and a Sub-Surveyor accompanied a column which proceeded from Mandalay to Thonze *viâ* Pyin-ul-win, and returned by the same route. In January Captain Hobday joined another expedition from Mandalay to the Shan State of Mainlon, *viâ* Lamaing and Kalagwe and then proceeded with the troops to the Ruby Mines, returning from Mogok (the ruby-mining centre) to Thabeit-kyun on the Irrawaddy. In March Captain Hobday took advantage of the return of the Tsawbwa of Thibaw from Mandalay to his capital, under escort, and accompanied the party which travelled through Nammaw and Goteik to Thibaw. During a halt there he was enabled to explore the surrounding country. During these various expeditions the area reconnoitred and mapped in the Northern Shan States and in the Ruby Mines district amounts to about 3,000 square miles. An extract from Captain Hobday's report on the country passed through will be found at page lxxvi of the appendix.

290. During the early part of the season Lieutenant Jackson was employed in extending the regular triangulation from Myingyan on the Irrawaddy in a south-easterly direction to Hlaindet, a distance of about 75 miles: on completing this he joined a military expedition to Nyaungywe, now called Fort Stedman, in the Southern Shan States. From thence he accompanied various expeditions to Hopon, Meinpon, Mone, Maukme and Yatsauk, returning eventually to Mandalay by Kyaukse. His out-turn, together with that of the Sub-Surveyor who was attached to his party, was about 3,000 square miles of reconnaissance survey. An account of his operations also is given in the appendix, page lxxviii.

291. Mr. Wyatt and 3 Sub-Surveyors who were transferred from No. 20 Party on the suspension of the operations in the Prome district, were attached to the 3rd Brigade in the Mehtila and Yemethin districts and surveyed an area of 2,000 square miles, whereby a very useful map for the use of the brigade was compiled. Mr. Kitchen and a Sub-Surveyor accompanied the column which proceeded from Pagan on the Irrawaddy into the Yaw country. Mr. Kennedy extended the triangulation northwards to Kyan Nayat on the Irrawaddy and accompanied the expedition to the Ruby Mines.

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* Major Hill reports very favourably of Messrs. Belcham and Connor in the Tidal Division and of Mr. Corkery and Sub-Surveyor Nursing Das in the Levelling Division. Sub-Surveyor Dhondu Venayek is also specially mentioned and Major Hill expresses himself well satisfied with the recorders and computers.

292. The result of the labours of these officers is as follows:—

Triangulation has been effected over an area of 15,000 square miles and the out-turn of reconnaissance surveys amounts to 11,000 square miles on the scale of 4 miles = 1 inch in the following States and districts—

	Square miles.
In Northern Shan States and Ruby Mines district . .	3,000
„ Southern Shan States	3,000
„ Yemethin and Mehtila districts	2,000
„ Yaw country	1,000
„ Mandalay and Kyaukse districts	2,000

293. A survey of the ruins of old Pagan, on the scale of 6 inches = 1 mile, was undertaken at the special request of the Chief Commissioner and completed during the recess season. Lieutenant Jackson, under whose direction this survey was executed, has submitted a report on the old Pagodas of Pagan which will be found in the appendix. He has also made a few sketches of some of the more artistic specimens which however he has not been able to complete at present. Captain Hobday recommends that an archæological expert should be sent to draw large plans and elevations of the ruins of peculiar interest.

294. In addition to the general geographical survey of the country, a survey of the town of Mandalay, on the scale of 40 feet to the inch, has been in progress since November 1886. This was urgently called for by the Deputy Commissioner of Mandalay to assist him in the demarcation of holdings, assessment of lands, &c., in the thickly populated portions of the town. The services of Mr. Gibson and 2 Sub-Surveyors were, therefore, placed at the disposal of the Local Government for this purpose and the work has been nearly completed, but the deputation of Mr. Gibson has been further extended for the purpose of surveying the area included within the embankment surrounding the town of Mandalay on the scale of 16 inches= 1 mile.

295. The compilation and incorporation into the work of the Survey Department of the independent reconnaissance sketches of military officers and of native soldiers who have passed the survey course at Roorkee, has continued to be one of the duties of Captain Hobday and his staff which has occupied a considerable portion of their time, but the additional information thus obtained has been of great value to military movements and to the object of obtaining some knowledge of the geography of tracts which in the ordinary process of survey operations with the limited staff of the professional department, would take considerable time to evolve.

296. Captain Hobday reports that the difficulties in geographical survey in Upper Burma are very great owing to the dense forests, undergrowth, and high grass met almost everywhere, which impede the view and delay the progress of the operations. In March the undergrowth either dies or is burnt and then an impenetrable haze pervades the atmosphere till the commencement of the rains. These drawbacks, coupled with the necessity of keeping up with troops marching from 10 to 15 miles a day, render the carrying on of a connected triangulation and topography a matter of great difficulty, and Captain Hobday and his assistants deserve great credit for the large amount of valuable work which they have thus furnished. Captain Hobday's services were brought to notice by the General Officer Commanding the Upper Burma Field Force in his despatches to the Government of India and in recognition of those services he has received a Brevet Majority. His Excellency the Commander-in-Chief in India has also been pleased to express his appreciation of the work done in Upper Burma by the Survey Department, which was conveyed in the following terms in a letter from the Quarter Master General in India:—

"I am desired by the Commander-in-Chief in India to express His Excellency's appreciation of the important work carried out in Upper Burma by the Survey Department under Captain J. R. Hobday during the past eighteen months.

"2. In doing this I am to remark as follows:—

"For the first time during military operations in the field, the Survey Department, working in association with the Intelligence Branch of the Quarter Master General's Department, has been able to make full use of the reconnaissance sketches and reports prepared by military officers during movements against the enemy; it has further had placed at its disposal the information obtained from maps of the country prepared by Burmese draftsmen and has received the sketches and reports of trained Military Intelligencers belonging to the Native Army who have been trained at Roorkee.

"3. The compiled maps, which have been produced from time to time, have been of great value and may be regarded as the outcome of a satisfactory system under which no method of gaining topographical information has been overlooked. The rapid production of new maps for issue to officers commanding troops in the field, and the correction of old ones with the idea of facilitating military movements, have been successfully accomplished, in addition to the completion of a ¼-inch map of the entire Province.

"4. Sir Frederick Roberts attributes the success which has attended this work very largely to the efforts of Captain J. R. Hobday and Captain E. W. Dun, Deputy Assistant Quarter Master General in charge of the Intelligence Office at Mandalay, and of the officers and subordinates who have assisted them; he, however, recognises the fact that the appreciation of experience gained during the Afghan war has, during recent operations in Burma, been very happily applied, so as to render the work of the Survey Department of immediate importance to the Commanding General in the conduct of difficult movements.

"5. I am to request that an expression of His Excellency's approval may be communicated to Captain Hobday and those serving under his orders."

297. This detachment has now been absorbed by No. 21 Party which has been transferred from the Nicobars to Upper Burma and placed under Major Hobday's charge. During the next season, the general reconnaissance surveys of the country will be continued and advantage will be taken of opportunities afforded by the military expeditions proceeding to unexplored parts.*

KUBO VALLEY DETACHMENT.

Personnel.

Colonel R. G. Woodthorpe, R.E., Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. M. J. Ogle, Surveyor, 2nd grade.
Sub-Surveyor Bapu Jadu, and Sowar Kishen Sing, 13th Bengal Lancers.

298. It having been decided that during the cold weather of 1886-87 a military column should proceed from Assam *viâ* Manipur into the Chindwin Valley to co-operate with the field force in Upper Burma, it was considered desirable that a small survey party should accompany the column, as a great deal of the country that would be traversed was entirely unknown. Colonel Woodthorpe, who had but just returned from Gilgit, where he had been for more than a year with Colonel Lockhart's Mission, at once volunteered for the charge of this party, and his services were gladly availed of. He selected as his assistant Mr. Ogle, who had previously accompanied him in various adventurous expeditions on the north-east frontier; Sub-Surveyor Bapu Jadu and Sowar Kishen Sing, who had accompanied Colonel Woodthorpe throughout the Gilgit Mission and had done excellent survey work therewith, were also attached.

299. Leaving Calcutta on the 13th November, the party proceeded to Silchar in Assam where a short halt was made to complete arrangements for the advance. Manipur was reached on the 8th December, and the party separated on the 13th—Colonel Woodthorpe and Mr. Ogle to undertake the triangulation in extension of the surveys executed in Manipur in 1881-82, and the Sub-Surveyor to continue the said survey southward in Manipur and also to embrace the Kubo valley.

300. Towards the end of January this survey was almost finished, so leaving Mr. Ogle to complete what remained of the triangulation and topography and sending the Sub-Surveyor to survey the course of the Yu river from Tammu to its junction with the Chindwin with the aid of a subtense compass, Colonel Woodthorpe crossed the Angoching range with General Gordon who was in command of the column, and proceeded to Auktaung on the Chindwin river. Here he met Lieutenant Daly, and during the next month Colonel Woodthorpe accompanied that officer on his tours about the Lekayain district of which he was in political charge. A large amount of topography was thus obtained.

301. At the end of February the party re-assembled at Kendat and measures were taken for carrying the triangulation down the Chindwin river to Alon, whence

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* Of his Assistants Captain Hobday reports as follows:—"The out-turn completed by Lieutenant Jackson is a highly creditable performance and I can testify to his untiring zeal and ability. Brigadier-General Lockhart, C.B., has expressed his acknowledgment of the valuable services rendered by Mr. Wyatt and his assistants. Major Stead, Commanding the Yaw column, reported favourably on the assistance given him by Mr. Kitchen. Mr. Gibson is a most valuable assistant; he possesses ability and tact and is an indefatigable workman; Mr. Bridges, Deputy Commissioner, Mandalay, speaks highly of his services. Mr. Kennedy has worked well and is I consider a very promising officer. Of the Sub-Surveyors, Faida Ali, Sher Shah, and Shiv Charan are deserving of special mention."

a junction might be effected with the Mandalay triangulation. These operations were somewhat delayed by a disturbance occurring in the Mingin district early in March, which rendered it necessary to recall all detached parties. By the middle of March, however, the country was quiet again and the triangulation was continued.

302. While Mr. Ogle and the Sub-Surveyor were engaged on this triangulation, Colonel Woodthorpe accompanied Captain Raikes, Deputy Commissioner of the Chindwin district, to Indin, about 35 miles to the west of Mingin, on a visit to the Tsawbwa of Kale, who wished to tender his submission to the British Government. The journey to Indin and the halt there during the negotiations enabled Colonel Woodthorpe to survey a good deal of the Myittha river and to obtain a fair amount of topography in the valley, though the smoke of the jungle fires and hazy state of the atmosphere prevented as much being done as might have been expected under more favourable circumstances. On his return from this trip, Colonel Woodthorpe rejoined Mr. Ogle, and they conjointly continued the triangulation which was completed as far as Alon by the end of April. Colonel Woodthorpe was then prostrated by fever which lasted during the whole of May, but Mr. Ogle with his usual energy continued the triangulation and effected a junction with Captain Hobday's series, brought up from Mandalay. The result of the junction is found not to be entirely satisfactory; but considering the difficulties under which the operations from both sides have been carried on, this is not surprising. During the ensuing season a further connection will be made, and it is hoped that the errors may thus be localised and the work adjusted.

303. Observations for latitude were taken at Kalewa, Mingin and Alon, and their positions thus determined agree fairly well with those obtained by the triangulation. At Alon an azimuth was observed to Shwe-ta-u *pagoda* and the result was again fairly accordant with that of the triangulation.

304. The results of the season's operations are as follows:—

An area of 2,800 square miles was triangulated; 360 square miles of country were surveyed topographically on the ½-inch scale in the south-east of Manipur in continuation of the survey of 1881-82; the whole of the Kubo valley and a large portion of the Lekayain district, comprising an area of 3,924 square miles, was surveyed on the ¼-inch scale, and an accurate map was obtained of the course of the Chindwin river between the point where the Uyu or Uru river joins it and Monyua.

In recognition of his services in Burma, Colonel Woodthorpe has been appointed to be a Companion of the Order of the Bath.

305. The party returned *viâ* Rangoon and Calcutta and reached Shillong, their recess quarters, on the 17th July 1887.

306. Colonel Woodthorpe reports that he received the most cordial assistance from all officers, both civil and military, with whom his work brought him into contact. Extracts from Colonel Woodthorpe's narrative report regarding the country passed through will be found in the appendix, page lxxxii.*

TRANS-HIMALAYAN EXPLORATIONS.

BHUTAN AND TIBET.

307. The report on the explorations of M—H, referred to in paragraph 266 of the last Annual Report, has been published during the year. It is accompanied by a sketch map, and besides tracing the Dudhkosi to its source, it supplies a long existing *desideratum* in the geography of Tibet, between Dingri, Jongkhajong and Kirong, and furnishes new information as to the course of the Gandak above Tirbenighat.

308. The detailed report and map of explorer R. N.'s work, also referred to in the last Annual Report (paragraph 267), are still unfinished, but a condensed

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* Colonel Woodthorpe reports that Mr. Ogle sustained his high reputation as an accomplished surveyor, that Sub-Surveyor Bapu Jadu worked well and fully justified the high opinion that had previously been formed of him.

account by Colonel Tanner will be found in the appendix, accompanied by a sketch map of Bhutan, which, it is believed, will be very acceptable to geographers, as it embodies all the information available up to date regarding that little known country.

309. A new sketch map of the lower Sangpo and adjoining regions has been compiled by Colonel Tanner from the late Captain Harman's plane-table sections of the country round Sadiya in conjunction with the information furnished by K. P., who was sent by that officer in 1880 to explore the great river below Gyala Sindong. This man accompanied a Chinese *lama* as an assistant, and besides being ordered to explore the country between the most extreme point reached by explorer G. M. N. and Assam, they were instructed to throw marked logs into the Sangpo at the lowest point reached in their travels, so that watchers having been placed at the point where the Dihang debouches into Assam, the identity or otherwise of the great river of Tibet with the Dihang might be determined. The *lama* having sold K. P. as a slave in the Pemakoi country, decamped, and the latter after various wanderings returned to Sikhim last year.

310. A succinct account of the information brought back by K. P. is included in the notes by Colonel Tanner which are given in the appendix. K. P. states that he went down the Sangpo as far as Onlet in the country of the Lo people, about 35 miles from the British boundary, and saw Miri Padam, the abode of the Miris and Abors, about 12 miles down the river and beyond this the haze of the plains of India. He states that below Gyala Sindong the Sangpo flows south and making a little westing turns by a gradual bend nearly eastward from Miri Padam, in which direction it emerges from the hills into Assam. This course agrees with the approximate course given on one of the late Captain Harman's plane-table sections, on which a large river is shown coming in from the north-east at a point some 50 miles west and a little north of the gorge through which the Dihang enters Assam. This large feeder is assumed to be A—K's Nagong Chhu and is taken to be identical with K. P.'s Yangsong or Zyul Chhu, which he states drains Zyul Ted or Upper Zyul. Below Gyala is a country called Pemakoichhen inhabited by the Chingmis, who were met by R. N. in Bhutan. A few miles below Pema Koichung are the great falls of the Sangpo where the river descends over a cliff of about 150 feet into a deep basin above which K. P. noted the rainbows caused by the spray of the cataract.

311. The Chingmis extend to Dangam at the junction of the Lo river with the Sangpo, below which Tibetan names and influence cease. At this place commences the country of the three tribes of aborigines called collectively Lo Kabta, who are divided into sections named Lo Nakpo, Lo Karpo and Lo Tawa Lo means "barbarous" in Tibetan and is not to be confused with A—K' Lho which means "south." These people occupy a pleasant tract, having brought the lands on either side of the Sangpo into a high state of cultivation, and mangoes, plantains and oranges thrive. They are averse to anything which savours of Buddhism or to Tibetan habits; they are great hunters and shoot, either with bows and arrows or with matchlocks, the bison and other game which is found in plenty on the mountain slopes. From Gyala Sindong downwards the river is enclosed by snow-clad mountains on which the wild *yak* and *shao* or Tibetan stag abound. The Padams are known to us (on the authority of Mr. Needham) as Abors. K. P. has given a short vocabulary of the language of the Chingmis and also of the Lo and Po countries.

It is intended to publish as early as convenient a complete report including the itineraries and narratives of R. N. and K. P. as well as a short account of the Pemakoichhen country by Lama U. G. from information furnished by the Mongolian *lama* Serap Gyatsho.

312. In addition to the work noticed in the foregoing, an extensive exploration by Mr. Dalgleish in Eastern Turkestan and Mongolia was examined and a preliminary adjustment made of the route, a copy of which was supplied to Mr. Carey. This route extends over 3,000 miles of ground, and, as it is well checked by latitude observations as well as by the work of both A—K and Prejevalsky, which it strikes at more than one point, it is undoubtedly a valuable addition to our previous knowledge of the tract through which it passes. The account of Mr. Carey's remarkable journey will be found in the Proceedings of the Royal Geographical Society, December 1887.

Scale of Survey.	Number of Party.	Locale of Field Operations.	TRIANGULATION.														
			Instrument used.	Area triangulated in square miles.	Number of Stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Secondary—in which each angle is usually observed on two zeros. Number of Stations fixed.	Secondary: Number of triangles.	Secondary: Triangular error in seconds.	Secondary: Error per mile in feet.	Secondary: Number of heights.	Tertiary—in which two angles of each triangle are observed. Number of intersected points fixed.	Tertiary: Number of triangles.	Tertiary: Error per mile in feet.	Tertiary: Number of heights.	Number of extra heights determined.
50 feet=1 inch	...	Town of Calcutta	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16 inches=1 mile	2	Bilaspur and Raipur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	3	Raipur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	4	Basti	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	5	Gorakhpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	„	Tarai	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	6	Darrang and Nowgong	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	7	Akyab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	„	Bassein															
	8	Sankarpur, Dinagepore	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	„	Angul, Orissa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	9	Jubbulpore and Damoh	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	11	Seoni and Chhindwara	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	12	Saugor and Narsinghpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	13	Sambalpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	14	Mirzapur	7″	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8 inches=1 mile	5	Gorakhpur (Forests)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	10	Belgaum „	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	17	Thana „	5″, 6″, 7″, 8″	107	145	0·2	0·2	132	158	5·9	0·50	159	416	686	0·8	396	493
6 inches=1 mile	1	Gurdaspur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	16	Baluchistan	8″	40	16	0·6	0·6	14	24	10·0	0·18	13	53	109	0·3	...	54
4 inches=1 mile	4	Gorakhpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	18	Himalayas	5″, 6″, 7″, 12″	883	334	1·0	1·2	334	301	17·0	1·10	285	530	750	1·6	463	629
	20	Lower Burma (Forests)	8″, 5″	295	12	22·7	29·5	10	15	7·2	0·30	10	1	1	...	...	...
	21	Nicobar Islands	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2 inches=1 mile	1	Punjab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	7	Akyab and Bassein	12″	167	7	17·0	24·0	5	7	18·0	0·01	3	14	18	1·7	5	651
	10	South Maratha Country	5″, 6″, 7″	1,570	150	10·4	8·3	150	267	16·5	0·69	150	...	...	...	...	40
	14	Mirzapur	12″, 7″	525	31	2·4	2·5	24	57	14·0	0·40	24	194	348	1·2	183	...
	16	Baluchistan	7″, 6″	910	56	2·1	2·6	46	115	11·4	0·26	33	318	613	0·5	280	...
	17	Gujarat	10″, 6″	1,085	89	1·5	1·6	66	231	2·6	0·37	87	676	1,352	1·2	600	94
	18	Himalayas	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 inch=1 mile	7	Akyab	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	19	Madras	12″, 8″	4,370	69	6·2	6·4	57	140	11·0	0·30	57	691	1,224	0·7	649	...
½-inch=1 mile	15	Baluchistan	6″	8,500	49	13·5	14·2	49	91	7·0	0·50	49	580	679	1·5	550	2
	16	Ditto	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	21	Nicobar Islands	14″, 6″	(*f*)	27	(*f*)	(*f*)	27	40	5·0	0·70	24	66	120	1·7	25	...
	24	Madras Coast	12″	1,162	60	18·0	20·0	57	19	5·0	0·20	62	13	18	0·2	3	...
	25	Madras and Bombay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
½- and ¼-inch=1 mile	Detachment.	Kubo Valley, &c.(*h*)	6″	2,800	56	...	...	56	91	14·1	0·50	54	63	119	2·1	51	...
¼-inch=1 mile	Ditto	Upper Burma (*h*)	...	15,000	...	...	...	...	...	...	...	...	...	...	...	...	...

Field Parties during the year 1886-87.

	SPIRIT LEVELLING OPERATIONS.				TRAVERSING.					TOPOGRAPHY.					
	Number of miles levelled over.	Number of permanent bench-mark stones embedded.	Number of Trigonometrical stations connected with lines of level.	Number of permanent points fixed as bench-marks.	Number of stations at which theodolite was set up.	Linear miles.	Average angular error per station in seconds.	Average error per *mille* in links.	Square miles of village survey.	Area in square miles.	Average number of plane-table fixings per square mile.	Number of linear miles of test lines.	Number of villages.	Number of fields.	Average size of fields in acres.
1	...	...	...	...	...	...	...	...	...	2·2	...	...	...	4,315(*a*)	0·33(*a*)
	...	...	...	...	12,836	3,808	2	0·3	1,233	1,022	...	1,700	697	9,36,887	0·40(*b*)
	...	...	...	...	29,030	7,509	4	0·4	3,150	...	...	...	1,445	...	...
	...	...	...	...	4,009	1,860	3	0·2	567	774	...	2,337	1,956	18,47,354	0·27
5	...	...	...	...	23,212	3,863	2	0·1	1,179	1,048	...	2,771	1,685	9,30,427	0·72
	...	...	...	...	2,048	394	...	...	76	76	...	360	60	31,078	1·57
	...	...	...	...	7,113	1,611	3	0·3	456	547	...	1,156	630	2,41,617	1·45
	...	...	...	...	8,737	1,688	1	0·1	562 }	350	...	504	134	4,35,198	0·22(*b*)
										196	...	270	82	73,600	0·67(*b*)
	...	...	...	...	...	...	...	...	199	199	...	...	532	1,24,833	1·02
10	...	...	...	...	...	...	...	...	61	61	...	...	83	50,000	0·78
	...	...	...	...	46,918	8,019	...	...	2,590	...	...	...	1,577	...	...
	...	...	...	...	32,432	5,810	5	0·3	2,312	...	...	...	1,049	...	...
	...	...	...	...	30,056	5,100	4	0·4	1,555	...	...	...	966	...	...
	...	...	...	...	10,404	2,808	5	0·3	969	...	...	...	469	...	...
15	...	...	...	...	4,105	860	7·5	0·8	...	...	...	...	536	...	...
	...	...	...	...	...	...	...	...	...	28	...	...	...	...	...
	...	...	...	...	8,623	862	8	0·8	215 (*c*)	...	...	...	...	...	...
	...	...	...	...	1,722	159	16	2·9	...	53	203	...	...	...	...
	...	...	...	...	...	...	...	...	...	45	...	...	...	...	...
20	...	...	...	...	...	...	...	...	...	27	161	...	...	...	...
	...	...	...	...	...	...	...	...	...	72	...	...	...	...	...
	...	...	...	...	2,012	523	26	0·9	...	272	40	...	...	...	...
	...	...	...	...	5,573	3,871	6·3	3·4	...	46	290	9·8	...	...	...
	...	...	...	...	...	...	...	...	...	6	138	6·6	...	...	...
25	...	...	...	...	17,757	7,914	2	...	6,085	2,726(*d*)	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	539	...	...	...	...	...
	...	...	...	...	2,094	1,088	5	0·6	...	1,412	16	76	...	...	...
	...	...	...	...	...	...	...	...	...	454	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	760	22	...	...	...	...
30	...	...	...	...	1,166	433(*e*)	19	0·7	...	1,841	22	309	...	...	...
	...	...	...	...	...	...	...	...	...	35	29	...	...	...	...
	...	...	...	...	...	...	...	...	...	85	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	172	2·0	...	...	...	...
	...	...	...	...	...	...	...	...	...	8,832	1·2	...	...	...	...
35	...	...	...	...	...	...	...	...	...	2,276	1·7	...	...	...	...
	...	...	...	...	1,272	434	...	4·6	...	678(*g*)	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	450	44	6	373	...	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	4,284	0·1	...	...	...	...
40	...	...	...	...	...	...	...	...	...	11,000	...	...	...	...	...

REMARKS.

(*a*) Holdings.

(*b*) Calculated on cultivated portions only.

(*c*) Includes survey of village and forest boundaries.

(*d*) Area tested only and maps compiled from *patwari* survey.

(*e*) Includes 236 miles boundary survey.

(*f*) A large expanse of the sea being covered by the triangulation in passing from island to island, any statement of area would mislead. The area of the whole group of Nicobars is 678 square miles.

(*g*) Chiefly reconnaissance; 10 latitudes and 2 azimuths by astronomical observations, and 2 chronometric longitudes were also determined.

(*h*) Reconnaissance surveys.

Statement showing the Cost-rates of work executed by the

Number of Party.	Nature and *locale* of Field Operations.	COST-RATE PER SQUARE MILE IN RUPEES.									
		Triangu-lation.	Travers-ing.	Detail Survey on Scales of							
				¼"	1"	2"	4"	6"	8"	16"	105·6"
	Topographical Surveys.										
10	South Maratha Country	3·5	6·8	...	...	7·7	...	...	...	...	...
14	Mirzapur	15·0	...	...	...	80·1	...	...	...	...	...
15	Baluchistan	2·8	...	6·5	...	...	...	...	...	...	...
		149·8	...	...	...	...	...	329			
16	Baluchistan	19·4	...	...	...	42·1	...	...	...	...	...
		...	...	4·9	...	...	...	...			
17	Gujarát	8·7	5·4(*c*)	...	...	23·5	...	...	...	...	...
18	Himalayas	28·0	23·7(*d*)	...	...	106·2	121·3	...	...	...	...
19	Madras	10·9	...	...	16	...	...	...	...	...	...
	Forest Surveys.										
10	Belgaum	...	118·2(*f*)	...	...	...	...	...	...	...	...
17	Thana	85·5		...	...	...	...	...	206·6	...	...
	Cadastral Surveys.										
2	Bilaspur and Raipur	...	18·9	...	...	...	...	...	...	58·3	...
4	Basti	...	27·3	...	...	...	...	...	...	94·8	...
5	Gorakhpur	...	20·2	...	...	...	...	...	...	60·2	...
	Tarai	...	38·1	...	...	...	...	...	...	36·0	...
6	Darrang and Nowgong	...	35·3	...	...	...	...	...	...	96·1	...
7	Akyab and Bassein	...	95·8	...	...	(*m*) 47·0	...	...	...	185·9	...
8	Sankarpur Estate, Dinagepore	...	58·1	...	...	...	...	...	...	113·6	...
	Angul, Orissa	...	42·3	...	...	...	...	...	...	131·2	...
	Traverse Surveys.										
1	Punjab	...	6·1(*r*)	...	...	7·3(*s*)	...	46·4	...	...	...
3	Raipur	...	19·7	...	...	...	...	...	...	...	...
9	Jubbulpore and Damoh	...	23·5	...	...	...	...	...	...	...	...
11	Seoni and Chhindwara	...	29·2	...	...	...	...	...	...	...	...
12	Saugor and Narsinghpur	...	37·4	...	...	...	...	...	...	...	...
13	Sambalpur	...	36·2	...	...	...	...	...	...	...	...
	City Survey.										
8	Calcutta	...	1,352·2	...	...	...	...	...	...	...	12,549·9

several Field Parties during the year 1886-87.

Rate in annas for traversing, detail survey, and preparation of maps. Scale 16" = 1 mile. Per acre.	Scale 16" = 1 mile. Per field.	Cost-Rates. Stone embedding. Per square mile.	Records (Khanapuri). Per square mile.	Records (Khanapuri). Per field.	Completion of Vernacular Records, Assessment Statistics, &c. Per square mile.	Completion of Vernacular Records, Assessment Statistics, &c. Per field.	Total cost.
a. p.	a. p.	R	R	a. p.	R	a. p.	R
...	...	...	...	...	...	...	25,422 (a)
...	...	...	...	...	...	...	63,087 (b)
...	...	...	...	...	...	...	84,776
...	...	...	...	...	...	...	77,531
...	...	...	...	...	...	...	54,031
...	...	...	...	...	...	...	74,770 (e)
...	...	...	...	...	...	...	50,255
...	...	...	...	...	...	...	25,421
...	...	...	...	...	...	...	20,098
1 11	1 4	1·4	54·3(g)	0 11	...	...	1,46,546
3 6	0 11	6·4	43·4	0 3	65·8	0 5	1,83,625 (h)
2 1	1 6	6·7	23·9	0 5	30·6	0 6	1 54,441 (i)
1 10	2 10	4·4	...	...	20·4	0 9	10,579 (k)
3 3	4 8	...	50·1	1 10	17·4	0 5	1,09,235 (l)
7 1	4 9	..	...	...	...	...	1,90,889 (n)
4 4	4 5	1.6	57·8	1 5	22·3	0 7	54,714 (o)
4 5	3 5	2·9	36·2	0 8	20·4	0 5	40,155 (p)
...	...	...	...	...	...	...	62,392 (t)
...	...	...	...	...	...	...	62,115
...	...	2·5	...	...	...	...	67,338
...	...	...	...	...	...	...	67,408
...	...	3·5	...	...	...	...	71,214 (v)
...	...	...	...	...	...	...	35,089
R a. p. 21 8 10	Per holding R a. p. 7 1 9	...	...	...	...	...	38,277

Remarks.

(a) Includes R192 expended on drawing 4" maps of District Thana.

(b) Includes R11,705 on account of traversing for Cadastral Survey of Chakia estate, R6,762 for compilation of the Bhadohi maps and R383 on account of the Dudhi Survey.

(c) Per linear mile; Baroda State boundary traverse.

(d) Per linear mile; executed for subsequent Settlement Surveys.

(e) Includes R500 for mapping of Daling Survey.

(f) Includes the survey of village and forest boundaries.

(g) Includes the completion of vernacular records, assessment statistics, &c.

(h) Includes R6,034 expended on 2" and 4" mapping and R480 for instruction of junior Civilians and *patwáris.*

(i) Includes R408 expended on the survey of 28 square miles of forests on the 8" scale, R392 for instruction of junior Civilians, R1,660 expended on 2" and 4" mapping.

(k) Includes R3,016 for instruction of *patwáris* and payments to substitutes for doing their district duties.

(l) Includes R801 expended on revision work and R2,819 on 2" mapping.

(m) Includes cost of 85 square miles on 1" scale.

(n) Includes R1,665 expended on revision work.

(o) Includes R1,533 expended on traverse work and Survey School in Maldwar estate.

(p) Includes R8,308 expended on Mozufferpore records, and R4,378 on Survey Schools at Angul and Banki.

(r) Traversing limited to fixing village boundary trijunction marks.

(s) Topography not surveyed but obtained by reduction from Settlement Survey maps; the reduced maps are tested.

(t) Includes R583 expended on 4" mapping in District Rawalpindi; R846 on survey of boundary between District Dera Ghazi Khan and Bahawalpur State; R509 on records for Settlement Department, Hissar; and R1,818 on traversing and mapping in Sikh States.

(v) Includes R5,076, pay of establishment before field work began; R864, pay of computers employed on other work; R900, pay of officer on sick leave; R801, cost of 11,803 mark-stones paid for in advance.

Tabulated Statement of the principal Records prepared in the several Recess Offices of the Field Parties of the Revenue Branch for the year 1886-87.

Number of Party.	Nature of Survey and Locality.	Mapping. Original field Sections.	Mapping. Cadastral 16-inch sheets.	Mapping. Sheets, 4-inches = 1 mile 7½′ × 3¾′.	Mapping. Quarter sheets, 2 inches = 1 mile 15′ × 7½′.	Mapping. Index Maps.	Mapping. Triangulation Charts.	Traverses. Main circuit with azimuth computations. Vols.	Traverses. Village or sub-circuits. Vols.	Field Books. Main circuit. Vols.	Field Books. Village or sub-circuits. Vols.	Area Books. Villages.	Area Books. Fields.	For Settlement Department. Sheets or tracings.	For Settlement Department. Village registers (khasras).	Remarks.
	Cadastral Surveys.															
	North-Western Provinces.															
4	Basti	12 on 64″ 1,523 on 16″	12 on 64″ 1,523	...	21	1	...	1 1 Az.	2	1	4	1,956	1,847,343	3,912	1,956	Besides the *khasras* the records prepared for Settlement Department are, Urdu *khasra* with 2 dispute lists, *jamabandi* slips, book *jamabandi*, *patwári* serial list, *terij*, caste statement, soil statement, crop statement, agricultural statistics and English village assessment statement with details of soils, crops and castes.
5	Gorakhpur	1,976 on 16″ 11 on 8″ 8 on 4″ 3 on 2″	1,976	11 on 8″ 8 on 4″ 3 on 2″	...	2	...	1 1 Az.	8	1	20	1,695	930,427	3,390	1,695	The same as above. Eight skeleton quarter-sheets on 2-inch scale have been projected for the Surveyor General's Office, where the topographical maps are being drawn.
	Tarai	...	113	...	...	...	...	...	1	...	3	60	31,078	60	...	
	Central Provinces.															
2	Bi spur	694 on 16″	694	...	...	1	...	1 1 Az.	4	1	8	436	520,176	872	436	The *khasras* have been furnished in duplicate, and besides these the following other vernacular records have been furnished to the Settlement Department, all in duplicate, *viz.*, *khewat*, *jamabandi* slips, book *jamabandi*, abstract of the same and crop statement.
	Raipur	624 on 16″	624	...	..	1	...	1 1 Az.	1	1	2	342	556,764	684	342	In Pargana Khalari, District Raipur, 285 skeleton sheets have been plotted for Settlement Department.
	Bengal.															
8	Cuttack Dinagepore	110 on 16″ 477 on 16″	110 477	... ...	... ...	1 1	... ...	1 5	4 5	1 5	7 10	81 471	50,000 93,466	81 471	81 471	
	Assam.															
6	Darrang	718 on 16″	718	...	2	...	...	1	1	1	1	630	241,617	630	630	Besides these, the following records have been prepared for Settlement Department:— 202 *lakhiraj* and *nisfkhiraj* field area statements. 41 Waste Land Grant field area statements. 14 Jungle Section field area statements.
	Nowgong	...	...	...	10	1	...	1 1 Az.	2	1	2	...	...	...	...	

	Burma.															
7	Akyab	26 on 2"	477	1 on 1"	36	1	2	...	...	...	...	134	435,198	477	...	Besides the tracings of sheets, copies of the area books have been furnished to the Settlement Department.
	Bassein	1 on 1"	267	...	...	1	...	1	1	2	3	82	73,600	267	...	
	Thongwa	...	...	...	...	...	...	...	1	...	2	...	...	...	...	
	TRAVERSE SURVEYS.															
	Central Provinces.		Skeleton Plots.													
3	Raipur	...	2,270	...	...	...	...	2	8	3	21	...	...	...	...	22 volumes of co-ordinates and area statements have been furnished to Settlement Department.
9	Damoh	...	4,303	...	...	1	...	1	6	3	7	...	...	...	...	11 volumes of co-ordinates and area statements have been furnished to the Settlement Department.
	Jubbulpore							1	6	2	7	...	...	...	...	
11	Chhindwara	...	1,024	...	...	10	...	2	5	1	5	...	...	...	...	
	Seoni	...	1,034	...	...	12	...	2	6	1	6	...	...	...	...	
12	Narsinghpur	...	505	...	...	...	...	1 1 Az.	6	2	11	...	...	...	...	
	Saugor	...	592	...	...	...	...	2 2 Az.	4	2	11	...	...	...	...	
13	Sambalpur	...	1,112	...	...	1	...	2	5	3	8	...	...	...	...	
	TOPOGRAPHICAL SURVEYS.															
	Punjab.															
1	Gujranwala, Gurdaspur, Shahpur, Hoshiarpur, Umballa, and Sikh States.	60 on 2" 7½'×7½'	...	2 on 1"	34	2	...	3	4	4	12	...	...	...	...	212 index charts to 1,525 villages have been furnished to the Settlement Department.
	Bombay.															
10	Belgaum, Dharwar and Kaladgi	20 on 2"	...	64n	12	1	1	...	8	...	7	...	...	...	...	64 sheets on 8" scale have been prepared for the Forest Department.
	CITY SURVEY.															
8	Calcutta	129 on 50 ft. =1 inch.	...	...	...	1	...	1	2	1	5	...	...	...	...	

Abstract of Out-turn and Cost of the Revenue Branch Parties according to Jurisdictions.

Provinces.	Scale of Survey.	Out-turn in square miles.	Cost.	Remarks.
			R	
N.-W. Provinces .	16 inches = 1 mile .	1,898	3,48,646	
	8 " = 1 " .	28		
	4 " = 1 " .	72		
Bengal . . .	16 " = 1 " .	260	94,869	
	50 feet = 1 inch .	$2\frac{1}{4}$	38,277	
Punjab . .	2 inches = 1 mile .	2,726(*a*)	62,392	(*a*) Topography tested only on maps compiled from the Settlement Survey maps.
	6 " = 1 " .	45		
Assam	16 " = 1 " .	547	1,09,235	
Lower Burma .	16 " = 1 " .	546	1,90,889	
	2 " = 1 " .	539		
	1 " = 1 " .	85		
Bombay . . .	8 " = 1 " .	215(*b*)	50,843	(*b*) Survey of forest and village boundaries without topography.
	2 " = 1 " .	1,412		
Central Provinces .	16 " = 1 " .	1,022	1,46,546	
	16 " = 1 " .	10,576(*c*)	3,03,164	(*c*) Traverse survey skeleton maps are plotted on 16-inch scale.
Total .		$19,973\frac{1}{4}$	13,44,861	

PART III.

THE OPERATIONS AT THE HEAD-QUARTER OFFICES.

313. These offices comprise :—

(1) The Head-Quarter Offices at Calcutta.

(2) The Trigonometrical Branch Office at Dehra Dún.

There has been little or no change in the general administration of these offices, except that Lieutenant-Colonel R. Beavan, S.C., Officiating Assistant Surveyor General, proceeded on furlough in June 1887, when Major Baird, R.E., was appointed to fill the post temporarily. The work in all the various offices is described below.

I.—HEAD-QUARTER OFFICES, CALCUTTA.

SUPERINTENDENCE, CORRESPONDENCE AND ACCOUNTS.

Personnel.

Colonel H. R. Thuillier, R.E., Surveyor General of India.
Colonel J. Sconce, S.C., Deputy Surveyor General, in charge Revenue Branch.
Colonel D. Macdonald, S.C., Deputy Superintendent, 1st grade, Assistant Surveyor General.
Lieutenant G. B. Hodgson, S.C., Officiating Deputy Superintendent, 4th grade, Personal Assistant to the Surveyor General.
Mr. T. W. Babonau, Registrar.

Correspondence.

Mr. M. Francis, Head clerk.
„ E. D. Algar, do.
„ J. A. Vallis, do.
„ T. E. Ware, clerk.

Babu Kally Podo Banerjee, clerk.
„ Banee Madhub Banerjee, „
„ Doorga Narain Ghose, „
Mr. H R. D'Mello, „
Babu Ram Kristo Chunder, „
„ Bheecum Sing, „
„ Chuni Lall Dey, „
„ Gopal Chunder Dass „
„ Raj Coomar Dutt, „
And 14 others.

Accounts.

Mr. H. H. Fenwick, Head Accountant.
Babu Bama Churn Chuckerbutty, clerk.
„ Raj Krishna Mukerjee, „
And 5 others.

314. The Revenue Survey section of the office has been supervised by Colonel J. Sconce, Deputy Surveyor General, who has also carried on the duties connected with accounts as well as the correspondence of this branch. The duties of the General and Topographical sections were superintended by Colonel D. Macdonald, Assistant Surveyor General. Lieutenant G. B. Hodgson has continued to hold the post of Personal Assistant to the Surveyor General.*

DRAWING OFFICE.

Personnel.

Lieutenant-Colonel R. Beavan, S.C., Officiating Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General, in charge up to 6th June 1887.
Major A. W. Baird, R.E., Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General from 7th June 1887.
Mr. G. A. McGill, Chief Draftsman.
„ P. J. W. Doran, Draftsman.
„ W. Green „
„ W. J. R. Adels „
„ A. J. Musgrove „
„ R. Sinclair „
„ A. S. Bateman „
„ G. Gill „
And two other Draftsmen.

Additional Establishment.

Mr. W. Stotesbury, Surveyor, 4th grade, Draftsman.
And seven other Draftsmen.

Native Draftsmen.

Munshi Sonaullah.
„ Nabi Buksh.
Babu Harihur Sen.
„ Mohesh Chunder Shaw.
Munshi Muttiullah.
Babu Purna Chunder Sen.
„ Gopal Chunder Roy.
And 36 others.

Surveyors and Assistant Surveyors on duty.

Mr. S. M. Smylie, Surveyor, 1st grade.
„ F. Adams „ 2nd „
„ S. O. Madras, Assistant Surveyor, 1st grade.
Mr. E. J. Martin, Assistant Surveyor, 1st grade.
Mr. W. H. Penrose, Assistant Surveyor, 1st grade, from 3rd February 1887 to 6th April 1887.
Mr. W. H. D. Ewing, Assistant Surveyor, 2nd grade, from 1st February 1887.
And one Sub-Surveyor.

315. Up to 6th June 1887 Colonel R. Beavan continued to act as Assistant Surveyor General in charge of the Drawing Office, and after that date Major A. W. Baird, R.E., has superintended it. The office is divided into three sections, which are described below and a statement in detail of the work executed in each section is given in the appendix.

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* Colonel Macdonald reports as follows :—

Messrs. T. W. Babonau, M. Francis, H. H. Fenwick, and J. A. Vallis have all worked well and steadily and given entire satisfaction.

Babus Banee Madhub Banerjee, Doorga Narain Ghose, Bama Churn Chuckerbutty, Bheecum Sing, Chuni Lall Dey, Raj Krishna Mookerjee, Hem Nath Dutt, Khetter Mohun Dass, Kanty Chunder Sen, and the remaining clerks have been working very steadily.

The Deputy Surveyor General, Revenue Branch, names Mr. E. D. Algar and Babus Kali Podo Banerjee, Ram Kristo Chunder, and Raj Coomar Dutt as deserving of special mention.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

316. The urgent demand for maps of Afghanistan and Baluchistan as well as for compilations from rough military reconnaissances in Burma, in addition to all the regular routine work, has caused considerable pressure on this section. Most of the $\frac{1}{4}$-inch sheets of the Afghan Boundary work are being compiled under Major Gore's superintendence at Dehra, but some have been undertaken by this office. Of these two have been printed whilst two are in hand. In Baluchistan three new sheets on the $\frac{1}{4}$-inch scale have been drawn and published and one of the old sheets of Afghanistan has been redrawn. Of Burma, 14 sheets on the $\frac{1}{4}$-inch scale were prepared from route surveys and reconnaissances furnished by Major Hobday, and from these again a map of Upper Burma on the scale of 1-inch = 16 miles has been compiled. All these are as yet necessarily of a very sketchy description, but it is hoped that they will be soon superseded by more detailed maps.

317. A new edition of the 32-mile map of India is in progress; it is being prepared by transfers to stone from the copper-plates; the blank tracts as well as the trans-frontier countries are being filled up on the stone from the best available material. It is also contemplated to produce an outline map of India from these copper-plates by the electrotype process, a matrix being prepared from which the hills will be burnished out; after this has been done, duplicate copper-plates will be prepared by the same process and the damage done to the outline and writing in the course of the burnishing process will then be remedied and the plates completed by the engravers. Thus it is hoped that in a comparatively short time and with a minimum amount of skilled labour a first rate map of India without hills will be obtained. It is believed that such a map will be largely used for representing lines of railway, canals, telegraphs, postal communications, &c.

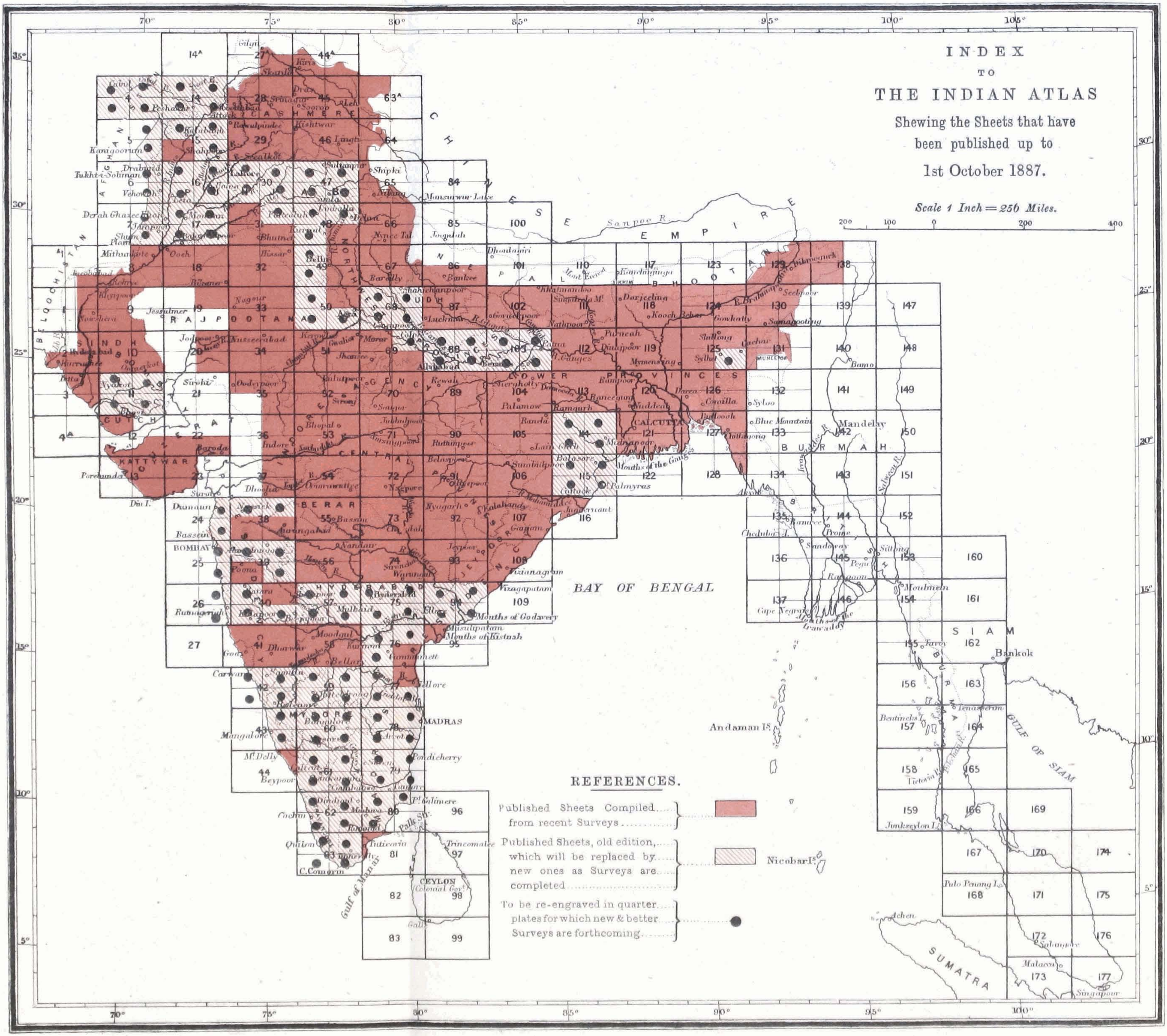
318. A map of Mysore on the scale of 1-inch=16 miles has been compiled and published in a preliminary form by photozincography. This map is now being engraved and is nearly complete in outline.

319. The experiments that were alluded to in last year's report as being carried on with a view to the production of the sheets of the Indian Atlas in some more rapid and economical way than by hand-engraving, have been only partially successful. The photozincographed sheet, though a good specimen of the process, will not for a moment bear comparison with an engraved map; the delicate cross-shading in the border especially having completely filled up and blotted. Another experiment by which it was hoped to reproduce brush-shading for the hills by the photo-electrotype process on copper was also a failure; the brush-shading is faulty and ugly, whilst the outline and names are not sharp and clear. A third method, however, has proved decidedly more successful; the original was drawn on paper very carefully in imitation of copper-plate work, about one-third larger than the true scale of the map; this was reduced by photography and then transferred to copper by the photo-electrotype process. The maps thus produced, though not equal to hand-engraved work, are good and the process is suitable for sheets in which geographical knowledge is at present limited, and which are likely to be superseded by more reliable materials. The saving in time, though considerable, is not quite so great as was at first anticipated, as the drawing of the original requires to be very carefully done by a first-rate draftsman.

320. The routine work of examining the fair maps sent in by the field parties of the Topographical Branch, before passing them on to the Photographic Office for reproduction, has been carried on; drawings for the preparation of the Atlas sheets have also been supplied to the Engraving Office.

SECTION II.—REVENUE.

321. The work in this section consists of examining and preparing for photozincography the fair maps drawn by the Revenue Survey parties, of correcting according to the latest orders the boundaries of districts, &c., on the office copies of all maps, and of supplying traverse data, plots of villages and tracings of unpublished maps to various Government officials. In the case of the Gorakhpur district, the cadastral sheets on the 16-inch scale are being reduced in this office and drawn fair on the 2-inch scale for reduction to one-half to lighten the office work of the field party.



Published under the direction of Colonel H. R. Thuillier, R.E., *Surveyor General of India,*
Survey of India Offices, Calcutta, January 1888.

SECTION III.—CADASTRAL.

322. This section has undergone no changes during the year. The usual work of examining the original sheets as they are received from the field parties, making them suitable for photographic reproduction, and comparing the details and the field numbers on the printed proofs with the originals has been carried on. The number of sheets so dealt with, as well as the number of sheets published is less than that of last year: this is owing to a decrease in the number of maps received from the field parties. As there was no likelihood of the supply increasing, the extra establishment consisting of nine temporary draftsmen was reduced to six; these men prepare tracings on transfer paper for zincography, of the maps of small villages or of those with very little detail on them. A map of the City of Benares in five sheets on a scale of 32 inches to the mile was examined and sent to the Photographic Office for publication.

323. Of original maps 110 volumes were arranged and bound up for record, and 24 volumes of printed sheets were also bound, indexed and examined for the Government of Burma. It is interesting to observe that the cadastral maps of District Benares are appreciated by the *zamindárs;* this is evidenced by the fact that the stock originally supplied to the Government Press at Allahabad has been exhausted, and, as the demand for these maps still continues, this office has been asked to issue a second supply of twelve copies of each village map. In the districts of Gorakhpur and Basti a depôt has been formed where cadastral maps of those districts may be purchased; for this purpose ten copies of all *pattidári* and five copies of all *zamindári* village maps are supplied.*

ENGRAVING OFFICE.

324. On the 22nd September, Mr. C. W. Coard, who has superintended this office from the time of its first commencement nearly eighteen years ago, retired on pension. He was selected in 1868, together with a small staff of European engravers, by General Sir Henry Thuillier, then Surveyor General, with a view to engrave and publish the sheets of the Atlas of India under his own superintendence instead of through the agency of the India Office. During these eighteen years many Europeans and Natives have been trained in the art of engraving, and their work will bear comparison with that done in Europe. Mr. Coard gave entire satisfaction throughout the whole of his service, and he has left the office in a high state of efficiency. Mr. G. G. Palmer, who also came out from England, but subsequent to Mr. C. W. Coard, has been appointed Superintendent on the retirement of the latter.

Personnel.

Lieutenant-Colonel R. Beavan, S.C., Officiating Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General, in charge up to 6th June 1887.
Major A. W. Baird, R.E., Deputy Superintendent, 3rd grade, Officiating Assistant Surveyor General, in charge from 7th June 1887.
Mr. C. W. Coard, Superintendent, up to 22nd September 1887.
Mr. W. Donaldson, Engraver, on furlough.
" G. G. Palmer, Engraver, Superintendent, from 23rd September 1887.
Mr. D. L. Mitchell, Engraver.
" J. Fulford, "
" T. B. Rodger, "
" A. G. Palmer, "
" S. M. Coard, "
" A. W. N. James, "
" A. R. Coard, "
" A. D. M. Chamarette, "
" E. C. Ollenbach, "
23 Native Engravers.
4 Apprentices and 1 Storekeeper.

Copper-plate printing section.

Mr. W. T. Collins, copper-plate printer.

325. The work completed during the year under report is much the same as that of last year; the amount of lettering is considerably below last year's outturn, in consequence of the absence on leave of Mr. Donaldson and of another writing engraver; the outlining is somewhat greater whilst the hill-etching is slightly less; two of the hill-etchers have been absent during the year, one having been employed on the heliogravure plates in the Photographic Office.

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* The Officer in charge reports that Messrs. G. A. McGill and S. M. Smylie, who have been respectively in charge of Sections I and II, have done very good work; Mr. F. Adams, who superintends the examining of all maps belonging to Section I, has worked hard to try and prevent the examination of maps falling into arrears, the number of hands in his office having been considerably reduced in the last few years. Mr. Stotesbury has, besides superintending the cadastral section, rendered considerable assistance in checking the manuscripts of the catalogue, which is under preparation. Amongst the draftsmen, Mr. A. J. Musgrove and R. Sinclair have done especially good work. Assistant Surveyors S. O. Madras and E. J. Martin have given every satisfaction in their respective duties.

326. The number of sheets printed is less, there having been a smaller demand for miscellaneous plates, principally due to the fact that a press for the heliogravure plates has been set up in the Photographic Office, whereby this office is relieved of some of that class of work. This was desirable, as the printing section could not keep pace with the demands on it for departmental maps when so much of its time was occupied with these miscellaneous plates.

327. The six plates forming the map of India on the scale of 1 inch=32 miles have made good progress; there are still blanks which are due to want of finished survey work, but preliminary editions are published by transfers to stone, the blanks being filled in by the lithographer. It is difficult to say when the engraved plates will be fully complete, as this will depend on the progress of regular surveys throughout the whole of India. The two plates of Bengal, scale 1 inch =16 miles, are very nearly finished and the map will soon be published. The map of Rajputana and Central India on the same scale has been completed as far as the survey has been carried out; as the field party was ordered elsewhere, the portion left unsurveyed in the desert must necessarily remain blank for the present; the map will however be transferred to stone and completed from the best available sources and published as soon as possible. The 16-mile map of the Punjab has been outlined and good progress is being made in the writing. A similar map of Mysore has also been outlined. The other provincial maps have been corrected where necessary.

328. Small maps of Bengal and the North-Western Provinces on the scale of 1 inch =80 miles have been cut in outline; it is proposed to make electrotype duplicates of these in various stages, so as to have a series of maps commencing with one in pure outline and ending with one as highly finished as the scale will admit of. It is believed that these will be found very useful in illustrating different kinds of reports. Four new plates of the Atlas have been projected, forty-six repaired and added to, seven completed, whilst sixty-three plates are in hand in various stages of progress. Details of the work performed are given in the appendix, page civ.*

PHOTOGRAPHIC OFFICE.

329. The Photographic Office was in charge of Lieutenant-Colonel W. F. Badgley from the commencement of the year until the 28th October, when he was relieved, on his transfer to No. 19 Party (Madras), by Mr. T. Archdale Pope, whose appointment to the office was reported last year. Mr. Pope joined the office on the 14th October and officiated in charge from the 29th October until the 17th December when Lieutenant-Colonel J. Waterhouse returning from furlough, resumed charge of the office which he retained throughout the remainder of the year. Lieutenant-Colonel Waterhouse reports that Mr. Pope has been of considerable assistance to him in carrying on the work of the office during the year.

Personnel.

Lieutenant-Colonel J. Waterhouse, S.C., Assistant Surveyor General, in charge from the 17th December 1886.
Lieutenant-Colonel W. F. Badgley, S.C., Officiating Assistant Surveyor General, in charge from 1st to 28th October 1886.
Mr. T. A. Pope, Officiating Assistant Superintendent, 1st grade, assumed charge of his duties on the 14th October 1886 and was in charge from 29th October to 16th December 1886.

NEGATIVE SECTION.

Normal Establishment.

Mr. J. Mackenzie, Photographer, retired on 16th July 1887.
Mr. C. DeCruze, Assistant ditto.
„ Ismail Khan, „ ditto.
2 Negative retouchers.

Cadastral Establishment.

Mr. C. Marshall, Photographer, on furlough for 6 months from 3rd April 1887.
Mr. L. Lagnier, Photographer, on medical leave for 6 months from 13th June 1887.
Mr. T. Lloyd, and 3 other Assistant Photographers,
3 Negative retouchers.

COLLOTYPE SECTION.

Normal Establishment.

Mr. J. T. Meade, Printer, from 1st February 1887.
1 Printer.

ZINC PRINTING SECTION.

Normal Establishment.

Mr. B. Mackenzie, Zincographer
1 writer, 4 zinc-correctors.

Cadastral Establishment.

Mr. J. Watson, Zincographer.
„ E. A. LeFranc, ditto, on deputation to Litho. Office from 16th August 1887.
Mr. J. B. Mackenzie, Assistant Zincographer, 1 writer, 9 zinc-correctors.

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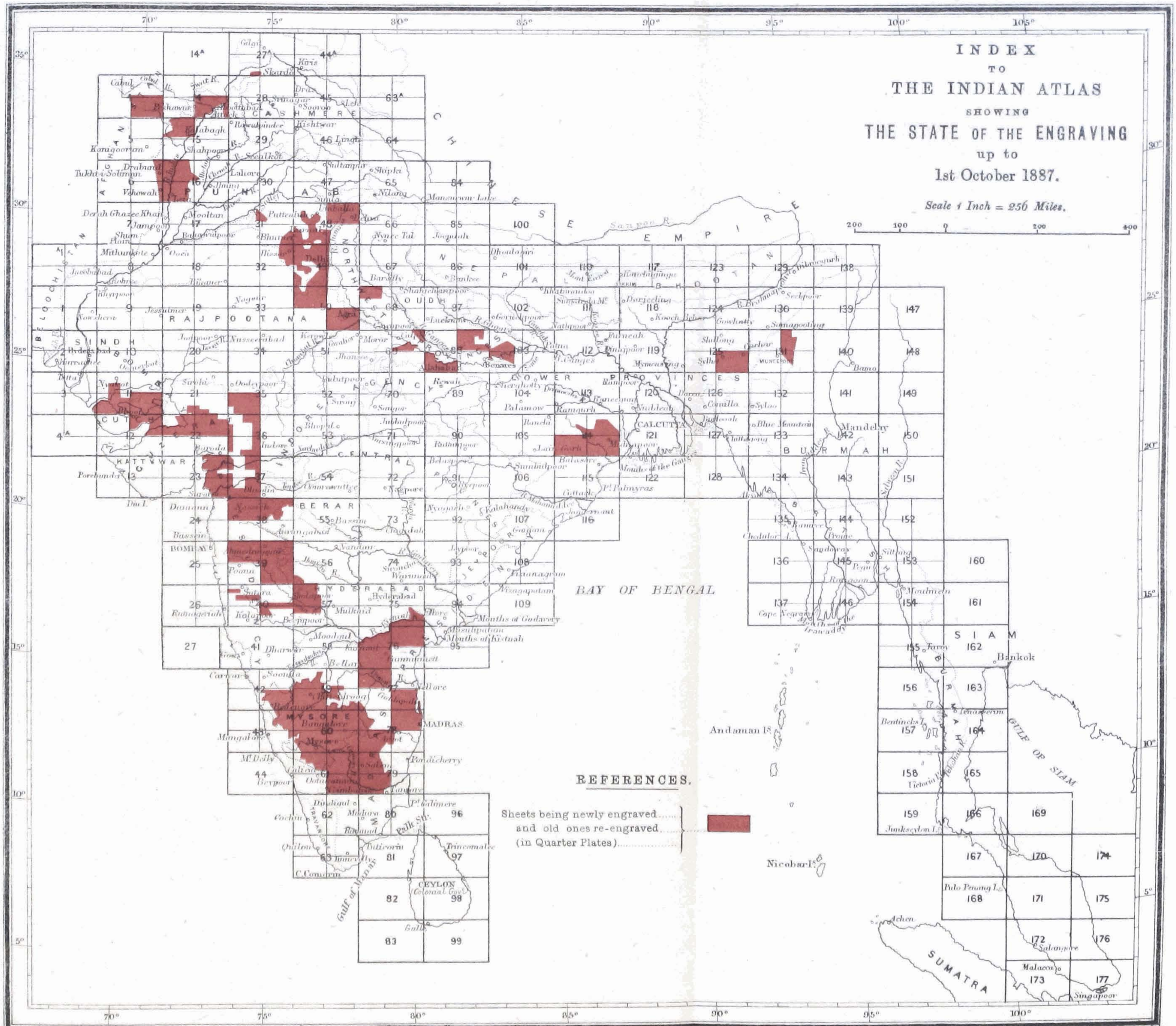
* The European engravers have all been reported to have done their work well and ably; the same may be said of the natives with one exception. The apprentices have made good progress and are now capable of working in the simpler kinds of maps.



Engraved under the Superintendence of C.W. Good.

Published under the direction of Colonel H. R. Thuillier, R.E., *Surveyor General of India,*

Survey of India Offices, Calcutta, January 1888.

PHOTOGRAPHIC TRANSFER PRINTING SECTION.

Normal Establishment.

Mr. J. Harrold, Photographer.
Habibul Hossain, Asst. ditto.

Cadastral Establishment.

Mr. R. George, Photographer.
2 Assistant Photographers.

SILVER PRINTING SECTION.

Normal Establishment.

Mr. G. G. Dempster, Photographer, working in the Negative Section (Normal Establishment)
1 Assistant Photographer.

HELIOGRAVURE SECTION.

Normal Establishment.

Mr. A. W. Turner, Photo-Engraver, in charge Collotype Section in addition.
Mr. L. H. Musgrove, Engraver, working in the Engraving Office.
Babu Joykristo Shaw, Engraver.
3 Copper-plate Printers, 4 pressmen.

GENERAL OFFICE ESTABLISHMENT.

Normal Establishment.

Mr. W. Moore, Store-keeper.
Babu Kanny Lall Sen, Clerk and Accountant.
Babu Gopal Chunder Mookerji, Clerk.
1 Clerk.

Cadastral Establishment.

Mr. H. Haward, Head Assistant in charge Collotype and Silver-Printing Sections, from 1st October 1886 to 11th August 1887, and in charge of Negative Section from 12th August to 30th September 1887, and 1 clerk.

APPRENTICES.

Mr. C. J. Meade, working in the Silver-Printing Section.
Mr. U. S. Ravenscroft, working in the Lithographic Office.
Mr. P. C. Michael, working in the Negative Section.
Mr. E. Savedra, working in the Silver-printing Section from from 1st June 1887.

330. Mr. J. Mackenzie, the Head Photographer, who had been in a bad state of health for some time past, retired on an invalid pension on the 16th July. He had been in charge of the Negative Section since the formation of the office in 1862, and by his skill, care and zealous attention to his duties, assisted largely in keeping up the high standard of work required. His place has been filled by Mr. H. Haward, the Head Assistant, who is thus placed in a position of greater responsibility and usefulness than he occupied in charge of the Photo-collotype and Silver Printing Sections, the work of which can now be carried on by two of the apprentices whom he has trained in that work.

331. The out-turn and value of work are shown in the abstract which follows: The number of original maps and drawings of all kinds received for reproduction was much under the average and the out-turn is consequently comparatively small. Only 4,803 original subjects were received (719 Departmental, 3,618 Cadastral and 466 Extra-Departmental) against 6,721 of last year (892 Departmental, 5,203 Cadastral and 626 Extra-Departmental). The falling off is principally in the Cadastral sheets, which is due to a smaller number of field parties having been employed on that class of survey, but the receipts of Departmental and Extra-Departmental maps and drawings were also below the average. The diminution in the receipt of Departmental maps is principally owing to the contraction of topographical surveys and the transfer of field parties to traverse surveys in which the reproduction of maps is not required. The number of negatives taken was 4,345, against 5,988 of last year. In the Zinc Printing Section the amount of ordinary departmental work was very much less than that of last year, the number of pulls being 72,920 from 495 plates, against 96,361 pulls from 612 plates, of last year; but on the other hand the Extra-Departmental work shows an increase, the number of pulls being 56,636 from 279 plates, against 55,440 pulls from 211 plates of last year. The out-turn of Cadastral sheets also shows a very large decrease, in consequence of the reduced number of sheets received; the number of sheets printed off being 3,744 with 116,081 pulls, against 5,282 sheets with 154,893 pulls of last year.

332. Less work than usual was also done in the Silver Printing Section, the total number of prints, silver and cyanotype, being 1,436 against 5,571 of last year. The exceptionally large out-turn of last year was, however, due to Exhibition work, and the reproduction of Colonel Durand's sketches taken while on the Afghan Boundary Commission.

333. In the Heliogravure and Collotype Sections the work done is more satisfactory both in quantity and quality, and both processes have now quite emerged from the experimental stage and taken their places as practical working methods. Thirty plates were prepared by the collotype process and 6,608 copies printed from them. Last year the numbers were 43 plates and 4,880 copies, but much of the work done was experimental or for purposes of instruction. This year also some of the work was experimental, but the greater part of it was undertaken in the current routine of the office for the reproduction of photographs of inscriptions, coins and architectural subjects for the illustration of the Archæological Survey Reports and the Journal of the Asiatic Society of Bengal, also of a photograph of a new species of *Ficus* for the Superintendent of the Royal Botanical Gardens.

334. The Heliogravure Section has been in steady work throughout the year and, by the adoption of methods which Colonel Waterhouse learnt at Vienna in 1886, considerable improvements have been made in the photo-etching process, details of which will be found in the appendix. A specimen of the work now produced, *viz.*, a medallion portrait of Her Majesty the Queen-Empress, is given in the frontispiece of this Report. There have been 22 plates reproduced in photo-electrotype, including Quarter Sheet No. 6 S.E. of the Indian Atlas which was reproduced from an original drawing in pen and ink, specially drawn for the purpose. A reduction in one sheet on the quarter inch scale of two standard sheets of the Andaman Islands, on the scale of 2 miles to an inch, was also done by this process, and it is intended to reduce the whole of the standard sheets of the Andaman and Nicobar Islands in this manner for publication instead of engraving them by hand. Twenty-two plates were prepared by the photo-etching process, including a reproduction of Atlas Sheet No. 14 S.W., from a brush-shaded original. This sheet, though rather coarse, owing to imperfections in the original drawing, shows the capabilities of the process in this direction, but there will always be a great difficulty in satisfactorily reproducing the combination of brush-shaded hills and outline on a map. The total number of plates produced by both processes was 45, against 30 of last year, and the number of copies printed was 292 (including 92 pigment prints). Further experiments have been carried on in the preparation of photo-typographic blocks in half-tones, with promising results, but the difficulty of printing these very delicate subjects in combination with type is likely to hinder the practical application of the process which would otherwise be a most valuable one.

335. There has been a considerable increase in the work of electrotyping the hand-engraved copper-plates, apart from photo-electrotype work. During the year 21 matrices and duplicates have been prepared, against 13 of the previous year. The plates duplicated include 3 quarter-sheets of the Atlas of India and 2 sheets of the 32-mile map of India, from which it is intended to prepare an outline map on the same scale for statistical purposes.

General Abstract.

Description of Work.	Sheets or Subjects.	Negatives. Negatives (Direct).	Negatives. Negatives (Reversed and transparencies.)	Photo-zincographic Printing. Photo-transfer Prints.	Photo-zincographic Printing. Zinc Plates transferred.	Photo-zincographic Printing. Zinc Plates printed.	Photo-zincographic Printing. Pulls.	Photo-zincographic Printing. Copies.	Silver and other Printing. Silver Prints.	Silver and other Printing. Blue Prints.	Heliogravure and Electrotyping. Plates Photo-electrotyped.	Heliogravure and Electrotyping. Plates Photo-etched.	Heliogravure and Electrotyping. Prints.	Heliogravure and Electrotyping. Photo Blocks.	Heliogravure and Electrotyping. Electrotypes.	Photo-collotype. Plates.	Photo-collotype. Prints.	Value. R a. p.
Departmental Maps and Plans	719	1,146	8	1,074	317	495	72,920	88,303	195	118	16	16	63	3	21	12	28	36,640 8 11
Cadastral Maps . .	3,618	2,502	...	2,524	3,744	3,744	1,16,081	1,08,832	...	...	...	...	...	...	...	...	...	54,501 7 0
Extra-Departmental Maps and Plans . . .	466	697	16	701	261	279	56,636	73,478	1,113	10	6	7	229	...	...	18	6,580	22,080 5 0
TOTAL .	4,803	4,345	24	4,299	4,322	4,518	2,45,637	2,70,613	1,308	128	22	23	292	3	21	30	6,608	1,13,222 4 11

336. The departmental publications have been of the usual character and include nothing very specially worthy of notice; full details regarding them are given in the appendix. Considerable progress has been made with the series of District maps for administrative purposes, on the scale of 1 inch = 8 miles. Among the plans of Cities and Cantonments, those of Baroda City and Environs, in 16 sheets, on the scale of 200 feet to 1 inch; Dalhousie Sanatarium, on the scale of 6 inches = 1 mile; Dúngarpur Environs and Kherwára Cantonment, in 3 sheets, on the scale of 12 inches = 1 mile, and 9 sheets of Simla, on the scale of 24 inches = 1 mile, reproduced last year, have been printed off. A plan of Moulmein Cantonment, scale of 12 inches = 1 mile, and Rangoon Town District, in 20 sheets, scale 16 inches = 1 mile, have been reproduced and printed during the year.

Of Standard sheets, 283 have been printed off, including 10 of the Andaman Islands; 6 of Assam (District Cachar), 4 of Baluchistan, 5 of North-Western Provinces (Districts Ballia, Gházipur and Sarun), 40 of Bombay, 85 of Burma, 5 of Central India and Rajputana, 9 of Cutch, 15 of Gujarát, 43 of the Hooghly River Survey, 11 of Hyderabad, 1 of Káthiawár, 12 of the Konkan, 27 of Mysore and 11 of the Punjab. A preliminary map of Upper Burma was also published during the year.

337. A statement of the amount and value of work done for other departments is given in the appendix. Among the most important of the extra-departmental items may be mentioned maps of India showing Railways open to traffic, under construction and under survey; also India, showing Railways with stations, on the scale of 64 miles = 1 inch, both for the Director General of Railways. For the Quartermaster General, 8 more maps of the country round various cantonments have been reproduced, as well as several maps connected with the military operations in Upper Burma and a map of the Camp of Exercise at Lawrencepur, besides many miscellaneous maps and sketches. For the Port Commissioners, 5 sheets of the Hooghly River Survey and a chart of the Sandheads have been printed off, besides plans, &c., of the new Kidderpore Docks. For the Marine Survey, only one chart, White Point to Mergui, has been reproduced during the year. For the Meteorological Office a large number of Weather Charts and diagrams were photo-zincographed and a plate for the new Weather Chart of India was prepared by the photo-electrotype process, so that transfers can be made from it to stone whenever required. For the Government of the Punjab, 10 District maps on the scale of 1 inch = 4 miles were photo-zincographed. For the various branches of the Public Works Department, Imperial and Provincial, and for the Inspector General of Military Works, a large number of plans and drawings were reproduced as usual.

338. A commencement has been made in reproducing a series of archæological drawings, for the use of Art schools throughout the country and also for the illustration of the Journal of Indian Art. Six plates of some very beautiful drawings made for the Archæological Survey of Western India have been reproduced by heliogravure and transfers of all of them were sent to England to Mr. W. Griggs for publication in the Indian Art Journal. Unfortunately these transfers were not so successful as a preliminary one sent for trial, and it remains to be seen whether the plan will answer as well as was expected.

339. The book debit system upon which all business with other departments is transacted, has worked well throughout the year on the basis of the rates fixed in 1886. These rates were looked into shortly after Colonel Waterhouse's return from furlough, but there appeared no necessity for revising them during the current financial year. They will again be scrutinised and revised if necessary. Every effort is being made to reduce expenditure as far as possible.

340. Colonel Waterhouse reports that with the assistance of Mr. Pope a Code of Rules has been prepared for the guidance of the Lithographic and Photographic Offices which will be of great use as embodying the experience of many years. The stores accounts have been thoroughly revised and a new system of keeping the store ledgers adopted, which is working well.

341. Colonel Waterhouse has devoted a good deal of attention to the processes of orthochromatic photography for the better reproduction of coloured maps and drawings. Specimens of a very highly coloured water-colour drawing by Colonel Woodthorpe, reproduced on an orthochromatic as well as on an ordinary dry plate, are given with the extracts from Colonel Waterhouse's report in the appendix. The special advantage of this method is that the yellow and orange shades, which are usually reproduced by photography as black, come out light; while the blues, or shadows containing blue, which photograph white or much lighter than they should do, reproduce in their proper value as shadows. Full details of these and other processes which have been modified during the year will be found in the appendix.*

* Colonel Waterhouse continues to report very favourably of his European and native assistants and apprentices who have generally performed their duties to his entire satisfaction.

LITHOGRAPHIC OFFICE.

342. This office was in charge of Lieutenant-Colonel W. F. Badgley until the 28th October 1886; Mr. T. A. Pope then officiated in charge till the 16th December, when Lieutenant-Colonel J. Waterhouse, returning from furlough, resumed charge of the office and retained it for the remainder of the Survey year.

Personnel.

Lieutenant-Colonel W. F. Badgley, S.C., Officiating Deputy Superintendent, 2nd grade, Officiating Assistant Surveyor General, in charge from 1st to 28th October 1886.
Mr. T. A. Pope, Assistant Superintendent, 2nd grade, in charge from 29th October to 16th December 1886.
Lieutenant-Colonel J. Waterhouse, S.C., Officiating Deputy Superintendent, 2nd grade, Assistant Surveyor General, in charge from 17th December 1886 to 30th September 1887.
Mr. H. L. Lepage, Head Assistant.
Babu Ambica Churn Mookerji, Examiner.
Munshi Sobhan Buksh, and 24 others. } Draftsmen.
Mr. D. Deas, Head Litho. Printer.
„ B. Wilson, Assistant Litho. Printer, and 74 others.
Mr. E. DePyvah, Head Type Printer, and 25 others.
6 clerks and 12 others.
Mr. G. A. LeFranc, „ E. Dowling, } Apprentices.

343. The out-turn of work during the year, as shown in the following abstract, has been smaller than that of last year, which was an exceptional one; but on the whole it is up to the average, and the decrease is mainly due to the smaller number of departmental forms and printed copies of maps, &c., required.

The number of subjects printed off amounted to 647, of which 130 (including 45 forms) were departmental and 517 extra-departmental. This is 30 subjects less than last year, which reduction is more than accounted for by the difference in the number of forms printed in the two years. The total number of pulls was 263,136, or 161,736 less than last year. The number of complete copies was 244,777, or 112,100 copies less than last year.

344. In the Type Printing Section the amount of work in number of pulls was also below that of the previous year, owing to fewer professional and other forms having been demanded, but the actual number of items or pages set up was greater, *viz.*, 6,330 against 5,566 of the year before. The total number of pulls was 841,121, and of complete copies 424,886, against 928,114 pulls and 488,796 complete copies of last year.

General Abstract.

Description of Work.	Lithographic Printing.				Type-Printing.		Total Pulls.	Total Copies.	Value.	Remarks.
	Sheets or Subjects.	Stones.	Coloured Copies.	Uncoloured Copies.	Pages or items.	Pulls.				
Departmental.									R a. p.	
General Maps	10	20	1,170	125	...	...	4,610	1,295	1,286 15 0	
	3	3	...	...	...	...	...	...	897 6 0	Not yet printed.
Provincial Maps	1	1	...	285	...	...	285	285	41 0 0	
District Maps	7	7	...	1,150	...	...	1,150	1,150	1,013 10 0	
	7	7	...	...	...	...	...	...	1,146 6 0	Not yet printed.
Atlas Sheet	1	1	...	50	...	...	50	50	89 14 0	
Standard Sheets	16	16	...	3,100	...	...	3,100	3,100	5,467 10 6	
	6	6	...	...	...	...	...	...	2,448 8 0	Not yet printed.
Index Maps	4	7	1,500	250	...	...	3,250	1,750	210 4 0	
Miscellaneous	30	32	220	8,251	...	...	8,352	8,471	595 6 0	
Departmental Forms	45	46	...	86,710	...	...	98,478	86,710	8,275 0 6	
TOTAL	130	146	2,890	99,921	...	...	119,275	102,811	21,472 0 0	
Work done for other Departments.	517	438	18,015	123,951	...	...	143,861	141,966	24,416 5 0	
Total of Drawing and Printing	647	584	20,905	223,872	...	...	263,136	244,777	45,888 5 0	
Work done in Type Printing Section.	...	...	...	...	6,330	841,121	...	424,886	14,359 3 0	
TOTAL VALUE	...	...	...	...	...	...	...	...	60,247 8 0	

345. The principal items of departmental work printed are:—A map of the Rajputana Agency, in two sheets, on the scale of 1 inch = 16 miles, transferred from the copper-plates; nine standard sheets of the Oudh Revenue Survey, scale 1 inch = 1 mile, Districts Hardoi, Unao, Sitapur, Lucknow, Rae Bareli, Bahraich, Kheri and Bara Banki; and seven sheets of the Bengal Survey, District Jalpáiguri, on the same scale, were printed off.

Four sheets of the Oudh Revenue Survey, Districts Kheri, Sitapur, Bahraich, Gonda, Partabgarh and Sultanpur, and one sheet of District Mymensingh, on the scale of 1 inch = 1 mile, have been drawn during the year, and one sheet of District Jalpáiguri has been re-transferred.

The map of India showing Density of Population, on the scale of 80 miles = 1 inch, noticed in last year's Report, was completed and printed off. Also five sheets of the Canal map of India in six sheets, on the scale of 1 inch = 32 miles.

A commencement has been made of a new edition of the 32-mile map of India, which is very much needed for general purposes. Sheets 2, 4 and 6 are well advanced and the remainder will be proceeded with as soon as transfers can be obtained from the copper-plates.

The following District maps on the scale of 1 inch = 4 miles, made up from copper-plate transfers from the sheets of the Atlas of India, have been printed off, *viz.*:—(*Bengal*), Sonthal Pergunnahs, Khoolna, Jessore, 24-Pergunnahs and Nuddea; (*Central Provinces*) Hoshangabad; and the following have been completed on stone but not yet printed:—(*Assam*) Sibságar and Nowgong; (*Bengal*) Moorshedabad, Chumparun, and Burdwan; (*North-Western Provinces*) Ghazipur; (*Central Provinces*) Jubbulpore.

346. Among the principal items of extra-departmental work, the new Military and Railway map, in twelve sheets, on the scale of 1 inch = 32 miles, under preparation for the Quartermaster General's Department, has been steadily progressing during the year, three or four draughtsmen having being employed upon it most of the time. Five sheets, Nos. 1, 2, 3, 4 and 9, have been drawn and corrected this year. The four sheets, Nos. 5, 6, 11 and 12, of which the drawing was completed last year, have been examined and corrected. Sheets 3 and 4 will have to be re-done, newer material being now available. The last three sheets, Nos. 7, 8 and 10, are now in hand, and it is hoped that the whole map will be completed and printed off during the current Survey year.

A series of Crop maps of India, representing the cultivation of Rice, Jute, Sugar-cane, Tobacco, Indigo, Cotton, Wheat, Tea and Coffee, has been commenced for the Revenue and Agricultural Department, Government of India, and will be proceeded with as fast as possible. The Sugar-cane map is well advanced.

347. With the exception of the above, the extra-departmental work has been of the usual varied character; but the out-turn of printed work shows a falling off from last year, though the number of subjects reproduced is more, and the number of indenting officers has increased. During the year 517 subjects have been received from 55 indenting officers. The number of impressions printed off was 143,861 and the value of the work done was R24,416. Last year 487 subjects were received from 47 indenting officers, the number of impressions was 158,369 and the value R27,226.

348. The falling off in the demands for extra-departmental work is in some cases due to reduction in the number of printed copies of maps and plates required for the illustration of annual reports. It is possible also that the new rules for inter-departmental payment by book-debit for all work done for other departments may have tended to cause a reduction in the demands upon the office for printing work, without being deterrent to officers and departments requiring lithographic work done.

349. The book-debit system of charging for all extra-departmental work has been in force all the year. An examination was made early in the year of the rates fixed in 1886, but it was not found necessary to introduce any changes into them, and the financial result of the year's operations would go to show that they are about correct. Further experience is, however, necessary, and the rates will be examined again, if possible, before the commencement of the next financial year.

The tabular statements showing the details and cost of the work done will be found at page cxxxiii of the appendix. *

MAP RECORD AND ISSUE OFFICE.

Personnel.

Lieutenant-Colonel R. Beavan, S.C., Officiating Deputy Superintendent, 3rd grade, and Officiating Assistant Surveyor General, in charge up to 6th June 1887.
Major A. W. Baird, R.E., Deputy Superintendent, 3rd grade, on duty from 30th May, and Officiating Assistant Surveyor General, in charge from 7th June 1887.
Mr. A. E. Byrn, Head Assistant.
,, H. R. Vallis, Map-Curator, and 11 clerks.
Mr. B. M. Wilson, Assistant Surveyor, 2nd grade, attached.
Sub-Surveyor Modhusudon Dutt, ditto.

350. Colonel Beavan held charge of this Office until the 6th June 1887, when he proceeded on furlough and was succeeded by Major Baird, R.E., who held the post during the remainder of the Survey year.

351. During the period under report the number and value of maps issued were as follows:—

Maps issued.	Number.	Value.
		R
General maps to Government officials	61,278	43,251
Ditto to India Office, London	3,253	4,065
Ditto to Agents	1,100	1,522
Ditto to private individuals on cash sale	6,816	8,043
Total	72,447	56,881
Cadastral maps to Government officials	1,05,951	79,463
GRAND TOTAL	1,78,398	1,36,344

352. Compared with the issues of the previous year, there has been a considerable decrease in the number of both general and cadastral maps issued during the year to Government officials: in the former because the demand for war maps and maps belonging to the Burma and North-Eastern and North-Western Frontier Series has diminished, and in the latter in consequence of there being only one cadastral party working in Burma and the number of maps received from the field parties was proportionally less.

The system of book debit, introduced last year for the inter-departmental adjustment of the value of maps published by this Department, has also doubtless operated in reducing the demand for maps, as officials are now required to provide in their Budget Estimates for the cost of all maps they may require for the administrative work of their departments.

The income derived from map sales amounted to R9,254, *viz.*, R8,043 realized from private individuals and R1,211 from sale Agents.

353. In the Revenue Section of the Office 558 applications were received for extracts from original records of the Revenue Surveys, from private individuals chiefly, and 2,251 copies of village plans were supplied at a cost of R5,144.

The following figures shew briefly the details of work:—

Applications received for maps	3,178
Letters issued in reply	2,946
Cash and credit map sale bills	1,021
Invoices and receipts issued for published maps	1,883
Ditto ditto for cadastral maps	240
Ditto ditto for extracts from original records	178
Packets, parcels and local despatches	3,006
Ditto received in the office	740
Packages despatched by rail and steamer	430
Ditto received by ditto	210
Maps coloured for sale and issue	20,233
Ditto for other departments	1,725

* Lieutenant-Colonel Waterhouse reports that Messrs. Lepage and Deas continued to perform their duties very satisfactorily. Mr. DePyvah has also worked well, and the apprentices, Messrs. E. Dowling and G. A. LeFranc, have again made good progress. The native draftsmen and clerks have worked satisfactorily. Babu Ambica Churn Mookerji, Munshis Abdul Hamid, Abdul Mujid, Mahomed Yeasin, draftsmen, and Babus Russick Lal Shaw, Kedar Nath Ghose and Rajani Kanto Chatterji, clerks, deserve special mention.

354. The new catalogue of maps published by the Department is approaching completion. It is being prepared and issued in geographical sections; in addition to the parts of the sheets of the Atlas of India and of the Punjab Province, which were reported last year as having been published, those comprising the North-Western Provinces and Oudh have been published, whilst those of India and adjacent countries and of Bengal, Assam and Central India and Rajputana are in the press. The lists of the Central Provinces, Berar, Hyderabad, Madras Presidency and Bombay Presidency are in manuscript but require examination. Mr. Doran has been employed on this duty and a better out-turn would have been shown, but for the sudden demand for his services on field duty, on which he was employed for nearly six months. The catalogue of Burma Maps is held in abeyance till the Provincial Index is ready and the charts of India and of the North-Eastern and North-Western Frontier Series have yet to be compiled.

A list of the maps published during the year is given at page 92.*

MATHEMATICAL INSTRUMENT OFFICE.

Personnel.

Colonel D. Macdonald, B.S.C., Deputy Superintendent, 1st grade, Officiating Assistant Surveyor General in charge.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument-maker.
Mr. F. Marshall, Assistant Mathematical Instrument-maker.
64 Artificers on permanent establishment.
125 Artificers on an average on the temporary establishment.
3 Eurasian apprentices.

Store Branch.

Mr. C. O. Gray, Instrument Storekeeper, to 9th January 1887 and from 31st March 1887.
Mr. W. Campagnac, Officiating Instrument Storekeeper from 10th January 1887 to 30th March 1887.
Babu W. C. Chowdry, Material Storekeeper.

Office Establishment.

Mr. M. O'Brien, Head Clerk.
Mr. C. O. Gray, Officiating Head Clerk, from 10th January 1887 to 30th March 1887.
Mr. W. Campagnac, 2nd Clerk, to 9th January 1887 and from 31st March 1887.
Mr. M. C. Belletty, Officiating 2nd Clerk, from 10th January 1887 to 30th March 1887, and
6 other permanent clerks.

355. During the period under report, *viz.*, from 1st April 1886 to 31st March 1887, this office has been incessantly and most actively employed on work of various descriptions, which shows no tendency to diminish: on the contrary, the figures go to show that the establishment as at present constituted, is barely strong enough to cope satisfactorily with the current duties. Even with the assistance of the extra grant of R300 per mensem for the payment of temporary workshop hands, which has been sanctioned as a tentative measure, the stock of repairable instruments on hand is steadily increasing.

The annexation of Upper Burma, and the consequent extension of public works, such as surveys, roads, railways, &c., have perceptibly increased the demands on this office. The Military Department, too, are largely increasing their demands for survey and scientific instruments.

356. The new building intended for the future accommodation of this office has now happily been commenced; and there is a reasonable prospect of its being ready for occupation early in 1888. Thus one great desideratum, roomy workshops, and adequate space for storing the large stock of serviceable and repairable instruments, will have been attained.

357. Year by year efforts are being made to gradually add to the capabilities of the workshop, and to render the establishment more independent of outside assistance in performing its work. A few years ago, a circular dividing machine, by Troughton and Simms, was procured from Madras, where it had been lying useless for several years, and set to work. This enabled the workshop to re-graduate a large number of theodolites, which otherwise must have been either condemned as unserviceable, or sent to England at very considerable expense to be repaired. Till last year, all aneroid barometers had to be sent to the Meteorological Department to be tested, and compared with a standard barometer. By importing a machine from England this office is now in a position to do this work itself very satisfactorily. Before long, it is to be hoped that this office will be able to undertake gilding and chronometer repairing, and thus considerably reduce the cost of these operations.

358. During the year under review 36,969 instruments, valued at R1,91,183, have been added to the serviceable stock; and 37,391 serviceable instruments,

* The Officer in charge reports that Mr. B. M. Wilson, who has the charge of all Revenue maps, has discharged his duties satisfactorily, while Mr. H. R. Vallis, the Map Curator, and Mr. S. Hazrah, his assistant, have rendered especially good service.

valued at R1,83,519, have been issued on indent; showing a net increase of R7,664 in the value of the serviceable stock in hand at the close of the twelve months.

359. The following statement shows the sources from which the supplies of serviceable instruments were received:—

Source of receipt.	No.	Value.
		R
From England on indent	4,742	47,324
By purchase in local market	10,343	8,715
Manufactured in workshop	9,545	23,450
Returned to Store by public officers	2,580	19,461
From other manufacturing offices	4,722	668
From "repairable" stock after repair	4,998	89,485
From other sources	39	2,080
GRAND TOTAL . . .	36,969	1,91,183

360. The repairable stock was increased by 5,192 instruments valued at R66,472, which is a slight falling off on last year, for which the number was 6,320 valued at R69,860. The total issues from the repairable stock amounted to 5,044 instruments valued at R60,793, showing that the value of repairable stock in hand had increased during the twelve months by R5,679. Of the above-mentioned issues 4,998 instruments valued at R60,012 were repaired in the workshop at a cost of R29,473 and transferred to serviceable stock at an enhanced value of R89,485.

361. Table A (page cxxxvii of the appendix) exhibits the debits against various departments on account of issues of instruments on indent, and for repairs executed for them by this office; and the credits to the same for instruments returned by them into store, either in a serviceable or repairable condition. The value of issues and repairs executed has increased from R1,81,175 in 1885-86 to R1,87,377 in 1886-87. The credits for instruments returned have diminished from R93,630 in 1885-86 to R87,253 in 1886-87. The cash sales have risen in value from R3,767 last year to R6,893. On the whole, the value of issues over receipts amounts to R1,07,017 as against R91,322 in 1885-86; so there will be a net increase of R15,695 in the credits to the Government of India under the head of "Revenue Receipts from Survey of India" over the preceding year.

362. In 1885-86, 16,151 instruments were purchased in the local market for R13,467. Under this heading there is a considerable decrease, only 10,343 instruments having been purchased for R8,715 in 1886-87. The details will be found in Table B (page cxxxviii of the appendix).

363. As regards instruments manufactured in the workshops, their number is smaller than in the previous year, but their aggregate value is greater. The figures are given below:—

	No.	Value.
		R
1885-86	13,453	21,453
1886-87	9,545	23,450

The class and value of these instruments are shown in Table C (page cxxxix of the appendix).

The number of principal instruments repaired in the workshops is 2,172, against 1,593 during the previous year. The total number of instruments repaired is 2,491. (*vide* Table D page cxli of the appendix).

364. The next statement (page cxlii of the appendix) is the "Profit and Loss account of the workshop." This exhibits a decided advance on the corresponding statement for 1885-86. The total value of work turned out is R67,405, being an increase of R6,493 in the value of the work done during the twelve months. The value of work done for public officers is less than in 1885-86; but work done for repairable stock and manufactures shows a marked increase. The workshop profit is R7,845, being more than double the amount for the previous year—R3,887.

365. As noted in the opening paragraph, the work of this office is very heavy and shows a marked tendency to increase. The increased number of instruments passing through the hands of this office causes a corresponding increase in the labours of the clerical staff, and also in the superintendence of the workshops. It is now many years since the clerical staff of this office was fixed at its present strength, and it will now be advisable to slightly increase the number of clerks. As regards the European superintendence of the workshop, it has been found that when short leave has been granted to either the Mathematical Instrument-maker or to his Assistant, that the duties of superintending such a large workshop are too onerous for one man. It must be borne in mind that native workmen joining this office require very careful training to begin with, and very close supervision, even after they have become efficient workmen, to prevent them scamping their work, or rapidly deteriorating. This supervision has to be carried on in a very trying climate. The ordinary appliances, too, which are available in most offices, for mitigating the rigour of the climate, cannot well be made available in a workshop.*

II.—TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

366. This office is divided into the following sections:—

(1) Correspondence, Accounts, and Stores.
(2) Computing.
(3) Type printing.
(4) Drawing and Compiling.
(5) Photozincography.
(6) Solar photography.
(7) Miscellaneous, Meteorology, &c.

The most important operations of the Trigonometrical Survey have been the execution of chains of triangles over the continent of India and extending beyond its limits; the determinations of azimuth from celestial observations at many of the stations of the triangulation; the observation of astronomical latitudes; the determination of differences of longitude by the aid of the electric telegraph; and the determination of sea-level at many places on the coasts of India and Burma, from which main lines of spirit-levelling are run over the country to form a basis for canal, railway and other operations. The principal work of this office is the final reduction and pub-

Personnel.

Colonel C. T. Haig, R.E., Deputy Surveyor General in charge Trigonometrical Branch.
Mr. W. H. Cole, M.A., Deputy Superintendent, 3rd grade, in charge of the Office.
Mr. J. Eccles, M.A., Assistant Superintendent, 1st grade.

(1) Correspondence, Accounts, and Stores.

Mr. C. H. McA'Fee, Surveyor, 3rd grade.
Mr. F. A. D'Rozario, Head Clerk.
Babu Mizaji Lall, and 4 other Native Writers.

(2) Computing.

Mr. C. Wood, Surveyor, 1st grade.
„ H. W. Peychers, Surveyor, 3rd grade.
Babu Ganga Pershad, Computer.
„ Cally Mohan Ghose, Computer.
Babu Cally Coomar Chatterji, Computer.
And 15 other Computers.

(3) Type Printing.

Mr. B. V. Hughes, Printer.
17 Compositors and Apprentices.

(4) Drawing and Compiling.

Mr. A. J. Wilson, Surveyor, 1st 1st grade.
Mr. G. W. E. Atkinson, Surveyor, 1st grade.
Mr. N. C. Gwynne, Surveyor, 3rd grade (joined 11th October 1886).

Drawing and Compiling—continued.

Mr. T. H. Rendell, Surveyor, 4th grade (joined 4th November 1886).
Mr. G. D. Cusson, Assistant Surveyor, 1st grade (joined 1st October 1886; transferred 1st September 1887).
Mr. H. Sindon and 6 other Draftsmen.
24 Assistant Draftsmen, Apprentice Draftsmen and Colourists.

(5) Photozincography.

Mr. C. G. Ollenbach, Zincographer.
„ R. W. Foster, Photographer.
1 Assistant Photographer, 2 Native Draftsmen, 1 Assistant Draftsman, and 1 Mapkeeper.

(6) Solar Photography.

Sergeant B. Rowland, R.E., Solar Photographer (services replaced at disposal of Military Department on 28th October 1886).
Mr. C. F. Guthrie, Assistant Solar Photographer (transferred from Photo-zinco. section on 1st October 1886).

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* Colonel Macdonald reports very favourably of Mr. Bolton's abilities and efficient management of the workshops, and brings his services prominently to notice; Mr. Marshall's skill and industry are highly commended; Messrs. Gray and Compagnac are reported to be very painstaking and industrious; and the clerical establishment generally are commended for their efficiency.

lication of the triangulation in all parts of India, including both the principal and secondary operations of the Great Trigonometrical Survey. Most of the publications being necessarily of a technical nature, and the office being located at a considerable distance from Calcutta, it has been found a great advantage that it possesses small printing, drawing, and photozincographic establishments, without which the accuracy of the technical details could not have been well maintained. The office has also a depôt of instruments (chiefly of the higher class) and stores attached to it, appertaining to the Great Trigonometrical Survey, of which it was the head-quarters. Among the instruments are, besides several large theodolites, the Colby compensation bars and microscopes for the measurement of base-lines.

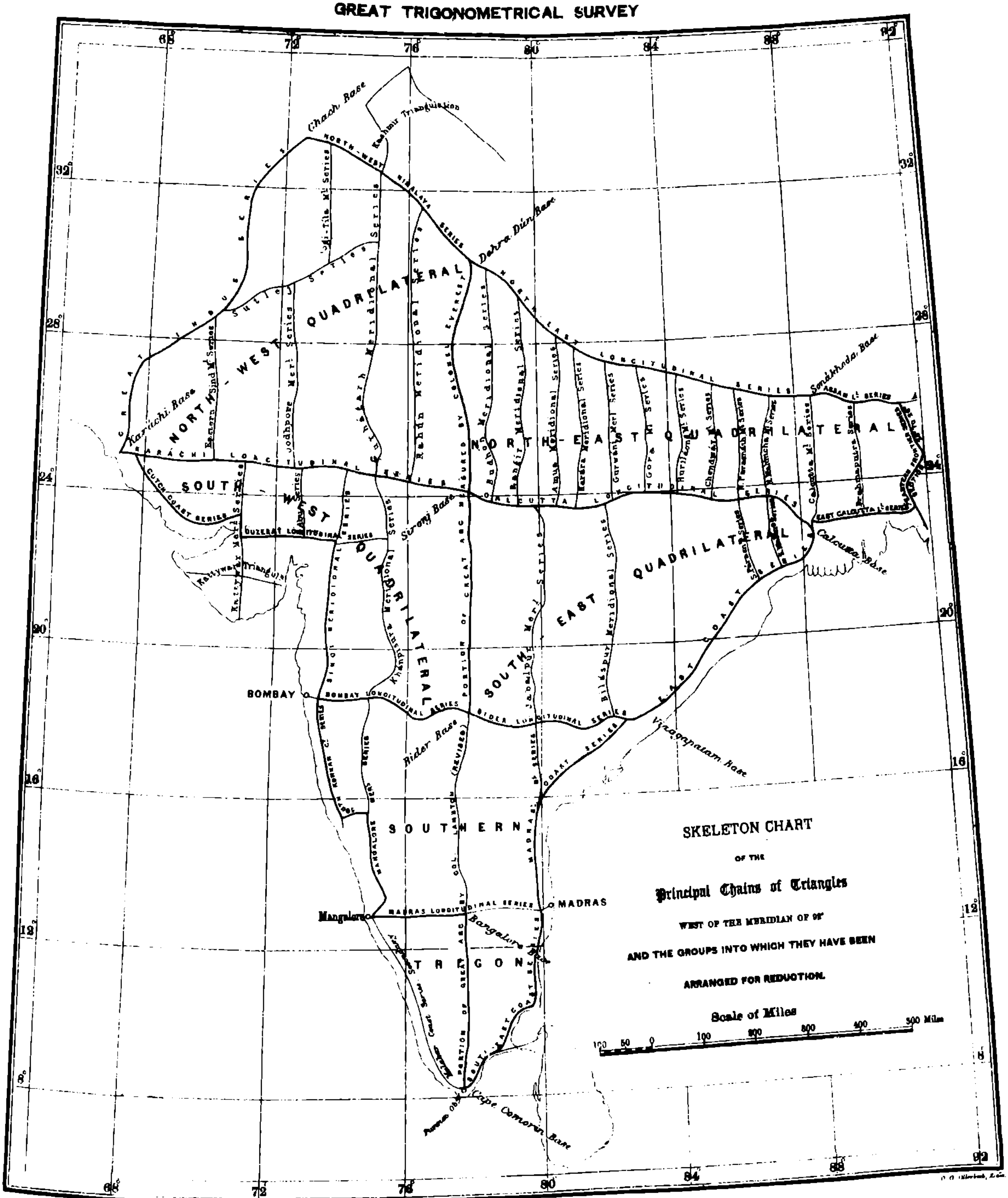
367. (1) CORRESPONDENCE, ACCOUNTS, STORES SECTION.—In connection with this section it may be mentioned that this office usually equips officers and others proceeding beyond the frontier with efficient surveying instruments. The work in connection with the protection of survey stations has continued to be carried on as usual. During the year 886 stations have been repaired by district officers at a cost of R3,431. Of the 328 districts from which reports are due, those for 46 were not received.

368. (2) COMPUTING SECTION.—The chains of triangles, although executed with the best instruments available and with the utmost care and precision, were still, like all human undertakings, imperfect; and their imperfections appeared when a chain closed on a measured base-line or one chain met another, by small discrepancies showing themselves in the length of side and in the co-ordinates of the stations. The first great undertaking of the Computing Section was the rendering into one harmonious whole the principal triangulation of India between the meridians of 67° and 92° by the most approved mathematical processes, *i.e.*, by "the method of least squares." The triangulation was too extensive to render it possible to manipulate the whole at once, and moreover at the time the reduction was commenced, *i.e.*, about the year 1867, several chains still remained to be executed and two base-lines to be measured. The triangulation was accordingly divided up into five large sections (see diagram), designated the North-West, North-East, South-West, and South-East Quadrilaterals, and the Southern Trigon. During the past year the work of reduction and publication of the various operations have continued to proceed steadily under the able superintendence of Mr. Cole assisted by Mr. Eccles.

369. At the commencement of the year under report the whole of the reductions of the principal triangulation stood complete with the exception of a few details of the South-West Quadrilateral. These details are now disposed of, and the entire *principal* triangulation of India has been rendered consistent *inter se*, so that the correct length of every base-line is reproduced by the triangulation from any other base-line, and no circuit, however chosen, shews any closing error.

The results of the preceding calculations have been published as follows:— The North-West Quadrilateral in Volumes II, III, IV, and IV A of the Operations of the Survey; the South-East Quadrilateral in Volume VI, and the North-East Quadrilateral in Volumes VII and VIII. Of these Volume IVA was published during the year under review, and considerable progress has been made with the printing of the results of the remaining two large sections of the triangulation. In connection, however, with the principal triangulation, a great deal of subsidiary or *secondary* triangulation is always executed, chiefly with minor theodolites, for the purpose of fixing the positions of important towns, of conspicuous buildings, &c., to afford data for the topographical delineation of the country. This triangulation has also to be rendered consistent with the principal triangulation, and though much yet remains to be disposed of, a very large quantity has been finally reduced. All that appertains to the North-West and South-East Quadrilaterals is finished and the results have been published in Synoptical Volumes; one, *viz.*, Volume VIIA, containing the results of the Jodhpore and East Sind Meridional Series of the North-West Quadrilateral, having been completed and published during the year. Of the North-East Quadrilateral only the secondary triangulation of two series remains unpublished, *viz.*, that of the North-East Longitudinal Series and the Assam Longitudinal Series. The former has not yet been taken in hand owing to the field operations not being complete; the latter, which will include the work as far east as the extreme north-east frontier, is in hand and a good deal of time has been devoted to it during the year; it is hoped that the calcu-

GREAT TRIGONOMETRICAL SURVEY



Bābu Ram, Photo.

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dūn January 1888.

lations will be finished during the next twelve months. The printing of the Synoptical Volume has been commenced. Up to the present time 23 Synoptical Volumes have been published containing the data of 33 series of triangles suitably arranged for the use of detail and other surveyors. The Southern Trigon embraces almost the whole of Colonel Lambton's net-work of triangulation, which is now treated as secondary, besides the secondary triangulation connected with each series. Much of Colonel Lambton's triangulation has been reduced to final terms during the year, and the whole of the secondary triangulation appertaining to one of the series, the South Konkan Meridional, is practically disposed of. The secondary triangulation of the South-West Quadrilateral has not yet been taken in hand.

370. The final reduction of the Astronomical latitudes was undertaken in 1879, and by the commencement of the year under report all the observations from Lambton's time to 1884-85 had been reduced and considerable progress had been made with the preparation of the results for the press. The progress since made has been the completion of the press copy, the writing of the explanatory chapters and the printing of more than 140 pages of the results and 30 pages of the chapters. Assistance has also been rendered to the officer in charge of the Astronomical Parties in the preliminary reduction of the observations of 1885-86. The electro-telegraphic longitude operations, which are carried out by Astronomical Parties Nos. 1 and 2, are reduced year by year by those parties aided by a pair of computers lent by this office during the recess season. The results when ready for the press are made over to this office to be printed. One volume of the results, *viz.*, Volume IX of the operations, &c., was published in 1883; a second volume, which will be number X, is nearly complete, and contains the operations up to season 1883-84 inclusive, and it is expected that it will be in the hands of the binder within the next two months. Subsequent operations are reserved for a third volume. The results of spirit-levelling operations, carried out by the Tidal Party, are sent to this office for publication. During the year, pamphlets Nos. 2 and 3 of Levels in the Bombay Presidency and Nizam's Dominions (revised), and No. 1 Madras Presidency, embracing the whole of the results from Bombay to Bider, Bangalore, Kárwár, Madras, and Beypore, have been completed and issued; and another pamphlet, containing the work executed in 1885-86 from Madras *viâ* Negapatam and Pámban to near Cape Comorin, has just passed through the press and will shortly be published.

The edition of the Auxiliary Tables to facilitate the calculations of the Survey Department, published in 1868, having been exhausted, a new edition was taken in hand in 1885; this has now been completed and copies are in course of issue. The book has been considerably enlarged and now contains over two hundred pages. It is anticipated that it will prove very useful.

It is necessary to state that all proofs are carefully read in the Computing Office, as it would be unsafe to entrust their comparison to men who are not thoroughly acquainted with the details of the calculations from which the results have been obtained.

371. (3) TYPE PRINTING SECTION.—The out-turn of this section has been steadily increasing for the last four years, and has more than doubled since 1883-84.

372. (4) DRAWING AND COMPILING SECTION.—This section has been principally occupied in assisting Major Gore in the compilation and drawing of trans-frontier maps, a work of considerable magnitude, required by the Government of India. The regular work of the office has accordingly been a good deal in abeyance. The following may, however, be particularised: a set of charts shewing the principal peaks of the Himalayan ranges was prepared for the Australian Geographical Society: two sheets of Levels in the Punjab and a new edition of one in the North-Western Provinces have been published. A map of M—H's route to illustrate a report on his explorations was compiled and published. A map of Mr. Carey's explorations was compiled from Mr. Dalgleish's survey of the route, and a tracing was supplied to Mr. Carey to illustrate a report to be read before the Royal Geographical Society, London. Other explorations were also plotted and a good deal of work of a minor character performed.

373. (5) PHOTOZINCOGRAPHIC SECTION.—The details of the work performed by this section are given in tabular form in the appendix. Considerable assistance has been rendered to the Forest Department and some to the

Foreign Office and the Quartermaster General's Department. The out-turn compares favourably with the expenditure.

374. (6) SOLAR PHOTOGRAPHY.—Photographs of the sun have been taken daily throughout the year for the Solar Physics Committee, South Kensington, except when the sun was invisible. In all sixty-three days were lost.

375. (7) METEOROLOGY.—The usual tabulated results of the meteorological observations are given in the appendix, where also will be found an account of the improvements introduced for the better supervision of some of the earth thermometers and the prevention of convection currents.

376. (8) EXPLORATIONS.—Besides the publication of the report on M— H's explorations, and the compilation of the account and map of explorer R. N. and his assistant's work in Bhutan, which are treated of in detail in Part II of this Report, the astronomical observations by Mr. Dalgleish taken in Eastern Turkestan and Mongolia, were examined and reduced, and his route survey (about 3,000 miles in length) was primarily adjusted.*

LIST OF MAPS AND CHARTS PUBLISHED DURING THE YEAR 1886-87.

Title of Map.	Scale.	Number of Sheets.	Remarks.
	In. M.		
General Maps.			
Skeleton Map of Afghanistan and Punjab Frontier	1=32	1	
Do. of the Baluchistan and Sind Frontier	1=32	1	
Do. of the Burma and Assam Frontier	1=32	1	
Contour map of India (reduced)	1=64	2	
Skeleton Map of Punjab and surrounding countries	1=32	1	(With additions to December 1886.)
Atlas Sheets.			
Quarter sheets Nos. 8S.W., 32N.E., and S.E., 38S.E., and S.W., 39S.W., 40N.E., 49S.E., 67S.W., 15S.W., 18S.E., 20S.E., 50 N. E.	1=4	13	
Sheets Nos. 28 and 50	1=4	2	
Provincial Maps.			
Preliminary map of Upper Burma 1887 (1st and 2nd edition) reduced from the ¼" reconnaissance sheets	1=16	1	
Rajputana Agency	1=16	2	
Divisional Maps.			
The Presidency Division, comprising the districts of Moorshidabad, Nuddea, Jessore, Khoolna, 24-Purgunnahs and Sundarbans	1=8	1	
District Maps.			
District Bannu	1=4	1	
Do. Cachar with corrections to 1887	1=4	1	
Do. Hoshangabad	1=4	1	
Do. Jessore	1=4	1	
Do. Nuddea	1=4	1	
Do. Peshawar	1=4	1	
Do. Shajahanpur	1=2	2	
Do. Sonthal Pergunnahs	1=4	1	
Standard Maps.			
Andaman Islands.			
Sheets Nos. 1, 5, 6, 7, 9 and 10	1=2	6	
Do. 6, 7 and 16	4=1	3	
Assam.			
Sheets Nos. 57, 68, 69, 70, 80 and 81 District Cachar	1=1	6	Preliminary Edition.
Bengal.			
Sheets Nos. 293, 294, 295, 296, 315, 316, 338 and 339 District Jalpaiguri	1=1	8	

* Mr. Cole reports favourably of his Assistants, making prominent mention of Messrs. Wood, Wilson, McA'Fee, Ollenbach and Hughes, who stand at the head of the various sections, and of Messrs. Atkinson and Peychers. He also mentions the intelligent interest taken in their work by Babus Ganga Pershad, Shivnath Saha, Shoshi Bhushan, and Mizaji Lal.

Title of Map.	Scale.	Number of Sheets.	Remarks.
STANDARD MAPS—*contd.*			
Bombay.	I. M.		
Sheets Nos. $81\frac{\text{S.E.}}{1}$, $\frac{\text{S.E.}}{2}$, $\frac{\text{S.E.}}{3}$, $\frac{\text{S.E.}}{4}$, $133\frac{\text{S.E.}}{1}$, $\frac{\text{S.E.}}{2}$, $\frac{\text{S.E.}}{3}$, $\frac{\text{S.E.}}{4}$, $134\frac{\text{N.E.}}{1}$, $\frac{\text{N.E.}}{2}$, $\frac{\text{N.E.}}{3}$, $\frac{\text{N.E.}}{4}$, $\frac{\text{S.E.}}{1}$, $\frac{\text{S.E.}}{2}$, $\frac{\text{S.E.}}{3}$, $\frac{\text{S.E.}}{4}$, and $159\frac{\text{S.W.}}{3}$, (Preliminary Edition), District Thana	4=1	17	
Sheets Nos. 133, 135, 136, 141, 161, 167, 169, 170, 171, 203, 238, 239, and 270, Districts Thana, Satara, Ratnagiri, Kolhapur, Kolaba, Surat, Nasik, Sholapur and South Maratha Agency	1=1	13	
Burma (N. E. Trans-Frontier Series).			
Sheets Nos. 15 N. E., 15 S. E., 23 N. W. and 23 S. W. . .	1=4	4	Compiled from Reconnaissances.
Burma (S. E. Trans-Frontier Series).			
Sheets Nos. 1 N. E., 1 S. E., 2 N. E., 2 S. E., 3 N. E., 4 N.W., 4 S. W., 5 N. W., 5 S. W. and 6 N. W. . . .	1=4	10	Compiled from Reconnaissances.
Burma (Lower).			
Sheets Nos. $77\frac{\text{N.E.}}{4}$, $92\frac{\text{S.E.}}{3}$, $\frac{\text{S.E.}}{4}$, $93\frac{\text{N.E.}}{1}$, $\frac{\text{N.E.}}{2}$, $\frac{\text{N.E.}}{3}$, $\frac{\text{N.E.}}{4}$, $\frac{\text{S.E.}}{1}$, $\frac{\text{S.E.}}{2}$, $\frac{\text{S.E.}}{3}$, $\frac{\text{S.E.}}{4}$, $94\frac{\text{N.E.}}{2}$, $\frac{\text{N.E.}}{4}$, $\frac{\text{S.E.}}{2}$, $110\frac{\text{N.W.}}{1}$, $\frac{\text{N.W.}}{3}$, and $\frac{\text{S.W.}}{1}$, Districts Tharrawaddy, Prome, Tounghoo and Shwegyin	4=1	17	
Sheets Nos. 74, 77, 92, 93, 140, 180, 182, 184, 185 Districts Prome, Henzada, Tharrawaddy, Bassein . .	1=1	9	
Sheets Nos. 94N.E., N.W., S.E., S.W., 106N.E., N.W., S.E., S.W., 115N.E., N.W., S.E., S.W., 123S.E., S.W., 124S.E., S.W., N.E., N.W., Districts Tharrawaddy, Hanthawaddy, Pegu, Shwegyin.	2=1	18	
Central India and Rajputana.			
Sheets Nos. 219, 252, 400 (2nd edition) and 401, Natives States of Gwalior and Bickaneer, and Districts Hissar and Jhansi	1=1	4	
Cutch.			
Sheets Nos. 54, 55, 56, and 69, Parts of Cutch, Morvi, Thar, Parkar, N. Gujarat, Pranthal, and Great Ran . . .	1=1	4	
Gujarat.			
Sheets Nos. $41\frac{\text{N.E.}}{1}$, $\frac{\text{N.E.}}{3}$, $\frac{\text{N.W.}}{3}$, $\frac{\text{N.W.}}{4}$, $\frac{\text{S.W.}}{1}$, $\frac{\text{S.W.}}{2}$, $\frac{\text{S.W.}}{3}$, $\frac{\text{S.W.}}{4}$, $42\frac{\text{N.W.}}{3}$, $158\frac{\text{N.E.}}{2}$, $\frac{\text{N.E.}}{4}$, $\frac{\text{S.E.}}{2}$, and 190 (Section 9), Districts Nassik, Panch Mahals, and Rewa Kantha States.	4=1	13	
Sheets Nos. 133 and 159, District Surat	2=1	2	
Hyderabad.			
Sheets Nos. 201, 210, 211, 218, 219, 221, 223, 224, 225 .	1=1	9	
Sheets Nos. (202, 203, 212, 213) (204, 205, 214, 215, and 222) (208, 209, 216 and 217), Kamamet Circar . . .	1=2	3	
Kathiawar.			
Sheet No. 79 (2nd edition). Parts of Halar, Kathiawar and Gohelvad	1=1	1	
Mysore.			
Sheets Nos. 11 (2nd edition), 19 (2nd edition), 20, 21, 23 (2nd edition), 24 (3rd edition), 25, 27, 28, 29, 30 (2nd edition), 43, 44, 45, 46, 47, 48, 50 and 57 (2nd edition), 65, 66, and 70 Districts Bangalore, Kadur, Kolar, Mysore, Shimoga and Tumkur	1=1	23	

Title of Map.	Scale.	Number of Sheets.	Remarks.
Standard Maps—*concld.*	I. M.		
Nepal Boundary.			
Sheets Nos. 13A, 14 to 43. Districts Bhaugulpore, Durbhanga, Mozufferpore and Chumparun	4=1	31	
Sheets Nos. 44 and 45 (2nd edition). District Chumparun .	1=1	2	
Northern Trans-Frontier Series.			
Sheets Nos. 20 and 21, part of Tibet	1=8	2	
North-Eastern Trans-Frontier Series.			
Sheets Nos. 5 and 6, parts of Tibet, Sikkim and Bhutan .	1=8	2	
Sheets Nos. 7 $\frac{\text{N.W.}}{1}$ and part of 6 $\frac{\text{S.W.}}{3}$, 7 $\frac{\text{N.W.}}{3}$ Sikkim .	1=2	2	
North-West Provinces.			
Sheets Nos. 56 B, 194, 208 (Preliminary Edition), 209 and 217 (Preliminary Edition), Districts Ballia, Sarun, Ghazipur, Jalaun and parts of Gwalior and Datia Native States.	1=1	5	
Oudh.			
Sheets Nos. 86, 87, 119, 122, 132, 133, and 134, Districts Kheri, Sitapur, Bahraich, Rae Bareli, Unao, Hardoi, Lucknow, Bara Banki	1=1	7	
Punjab.			
Sheets Nos. 243, 244, 250, 257, 258, 259 and 260, Districts Hissar, Jullundur and Bickaneer, Patiala and Kapurthala Native States	1=1	7	
Plans of Cities, Cantonments, &c.			
City, Cantonment, and Environs of Bangalore . . .	12=1	13	
City and Environs of Baroda	1=200ft.	16	
City, Cantonment and Environs of Bhuj	12=1	7	
City and Environs of Dungarpur	6=1	1	
Government Cattle Farm, Karnal	16=1	4	
Cantonment of Kherwara	12=1	2	
Do. and Environs of Ranikhet	6=1	1	
Simla, Revision Survey Sheets, Nos. 1, 2, 3, 4, 6, 7, 8, 12, and 13	24=1	9	
Hooghly River Survey.			
Sheets Nos. 1J, 1L, 1M, 1N, 1O, 1P	16=1	6	
Do. 2A, 2B, 2E, 2F, 2G, 2H 2I, 2J, 2K . . .	16=1	9	
Do. 3E, 3H	16=1	2	
Do. 4H, 4I, 4J, 4K, 4L, 4M, 4N, 4O, 4P . .	16=1	9	
Do. 5E, 5J, 5K, 5L, 5O, 5P, 5 Q	16=1	7	
Do. 1, 2, 3, 5, and 8	3=1	5	
Do. 5, 6, 7, 8 and 9	6=1	5	
Index Maps.			
Standard Maps of Bengal	...	1	
Do. do. Bombay	...	2	
Do. do. do.	...	1	
Do. do. Burma	...	1	
Do. do. Central Provinces	...	1	
Do. do. Madras	...	2	
Do. do. North-Western Provinces . . .	...	1	
Do. do. Punjab and Hill States . . .	...	1	
Do. do. Sind	...	1	
Survey operations in Ajmere	...	1	
Do. do. in Akyab	...	1	
Do. do. in Bilaspur	...	1	
Do. do. on the Hooghly River	...	1	
Do. do. in Kamrup and Darrang . . .	...	1	
Do. do. in Mysore	...	1	
Do. do. in Punjab	...	1	
Do. do. in Seoni and Chhindwara	...	1	
Do. do. in Saugor and Narsinghpur . . .	...	1	

Title of Maps.	Scale.	Number of Sheets.	Remarks.
Index Maps—*contd.*	I. M.		
India, showing progress of Imperial Surveys to 1st October 1886	1=128	1	To illustrate the General Report for 1885-86.
Chart to the Great Trigonometrical Survey of India	1=96	1	
Indian Atlas, showing Sheets published to October 1886	...	1	
Do. do. State of Engraving ditto	...	1	
Survey operations in Andaman Islands	...	1	
Do. do. Basti	...	1	
Do. do. Baluchistan	...	1	
Do. do. Burma	...	1	
Do. do. Cutch	...	1	
Do. do. Deccan and Konkan	...	1	
Do. do. Gorakhpur	...	1	
Do. do. Gujarat	...	1	
Do. do. Jubbulpore and Damoh	...	1	
Do. do. South Maratha	...	1	
Do. do. Mirzapur	...	1	
Do. do. Mozufferpore	...	1	
Do. do. Raipur	...	1	
Do. do. Rajputana	...	1	
Do. do. Sambalpur	...	1	
Statistical Maps.			
India, shewing Canals	1=32	6	
Ditto shewing Railways open to traffic, under construction and under survey on 31st March 1887	1=96	1	
India, shewing Density of population	1=80	1	
Miscellaneous Maps, &c.			
Boundary between Garo Hills and Mymensingh extending from the Nitai river to the Moishkhali river	2=1	2	
Jacobabad to Chaman and adjoining country. (Being an extract from Sheets Nos. 21, 22, 29 and 30 of the N. W. Trans-Frontier Series, Preliminary Edition)	1=16	1	
Panoramic Profile of the hill ranges seen from Cheena (height 8,568 feet) near Naini Tal	...	1	
Stereographic Projection of the Northern Celestial Hemisphere on the plane of the equinoctial	...	1	
Triangulation Charts.			
Andaman Survey	1=4	2	
Mysore Survey, Degree Sheets Nos. 9, 11, 12, 13, 14 and 15	1=4	6	
Level Charts.			
Levels in the N.-W. Provinces. Sheet No. 6 (second edition) Parts of Meerut, Bijnour, Muzaffarnagar, Moradabad, Kumaun, Garhwal and Tarai	1=2	1	

APPENDIX.

EXTRACTS

FROM

REPORTS BY EXECUTIVE OFFICERS.

Extract from the Narrative Report of MR. E. C. RYALL, *in charge No. 24 Party,—Season 1886-87.*

COAST TRIANGULATION.

The entire length of the coast line triangulated was 170 miles northwards from Madras, and nine beacons were fixed and erected on it, exclusive of Madras, Pulicat, and Armugham Light-houses. Including these they run in straight line intervals as follows :—

	Miles.
Madras Light-house	...
Ennur (Ennore) Beacon	10
Pulicat Light-house	13
Pulanjeríkuppam Beacon	15
Palm-tree	14
Palm-tree	$1\frac{1}{2}$
Armugham Light-house	9
Kottapatam Beacon	$16\frac{1}{2}$
Kistnapatam Beacon	$15\frac{1}{2}$
Pennér Beacon	$19\frac{1}{2}$
Wuturpallepalem Beacon	$17\frac{1}{8}$
Ramapatnam Beacon	$15\frac{1}{8}$

The coast from Madras up to Masulipatam to an average distance of twelve miles inland is extremely flat, and consequently very much covered with lakes and swamps. In the neighbourhood of the coast itself there are a series of creeks and backwaters, which are connected with each other by canals. These creeks and backwaters, so connected form the well known Buckingham Canal. The largest lake, or more properly speaking swamp lake, is that of Pulicat—an expanse of water 35 miles in length north and south, with an average width of 6 miles, the greatest width being 11 miles. It receives the drainage of a comparatively small area, and is chiefly fed by the high tides of the sea, the inlet being to the south of the small town of Coromandel.

Further inland for about 10 miles or up to 22 miles from the coast the ground is broken up into scattered hillocks seldom rising over 150 feet, consisting of rocks of the metamorphic series, chiefly quartz resting on granite. The granite seldom shows itself except at elevations over 400 feet. Beds of laterite occur all along the coast, they are in general deeply covered over with sand and alluvial deposits.

The chief rivers are the Kalangi draining into the Pulicat lake, the Swarnamukhi, the Vuppateru, the Pennér (Paner), the Mannér, the Pálur, the Museru, the Gundlakamma, and the Kistna; the largest of these in order of size are the Kistna, the Pálur and the Pennér. The Kistna alone brings down with it rich alluvial soil. By the remaining rivers, which drain into the Nellore district, sand and gravel chiefly are brought down, rendering the soil very poor. The cocoanut, the palmyra and the casuarina (of all of which there are numerous and dense plantations) are the chief sources of profit to the inhabitants. The casuarina is comparatively speaking of modern introduction. All along the coast line extensive patches of these plantations are to be seen, and they were no mean obstacles to the triangulation. The casuarina is said to arrive at full maturity in ten years; the trees seldom reach 40 inches in girth and are on an average only about 24 inches, but they frequently attain to a height of 70 feet and sometimes more.

There are no ports between Madras and Masulipatam. Not even native vessels of small draught can enter into any of the mouths of the abovementioned rivers. The Buckingham canal is the only highway for traffic of a heavy nature, and this has to be continually dredged to allow the passage of vessels of 3½ feet draught.

The belt of country, almost 20 miles in width, is devoid of masonry structures except in a few places; mud-houses, sometimes tiled, and huts, constitute the chief abodes of the people.

Extract from the Narrative Report of MR. A. M. LAWSON, *in charge No. 10 Party, —Season 1886-87.*

SOUTH MARATHA COUNTRY.

Sheet 243.
General description.

Sheet 243 was mostly surveyed last season, but has been finished and drawn this season. It comprises a portion of the Sávantvádi State, the villages of the Chief of Hira, and the western part of the Belgaum *taluka*. The Sahyádri hills cross the sheet, with a very irregular outline, from north to south, and from the western face of the main range spurs break away, with deep densely wooded gorges between. To the east of the Sahyádris, the hills are in detached ranges, generally stretching north-east, and having peaks with bold and varied outline, some of which rise to a height of 3,400 feet, and some are surmounted with strong natural forts famous in Maratha history.

Forts.

Párgad (2,419 feet), a fort on the Belgaum-Sávantvádi frontier, is built on a peaked hill scarped on all sides, and surrounded by deep thickly wooded ravines. It was one of the forts held by Shivaji at the time of his death, and is now occupied as a police outpost.

Kálánindhigad (3,333 feet), a ruined fort on the Ram Ghat road, is situated on the highest point of one of the Sahyádri spurs.

Gandarvagad (3,226 feet). The site of this fort is on a range of hills 20 miles west of Belgaum. It was built in 1724 by Nág Sávant, the second son of the great Phond Sávant, and has been the scene of many captures and recaptures. The fort defences have almost disappeared and the site is now a hamlet occupied by peaceful cultivators.

Mahipálgad (3,269 feet). This fort stands on the north-east corner of a considerable plateau 10 miles west of Belgaum. The walls with round towers on the angles and sides are still standing, and inside there is a large well and several inhabited houses. The fort belonged to Chintámanrao, the Sángli Chief. At his death in 1680 Shivaji is said to have held Mahipálgad. There are some rock-cut caves and temples on the eastern face of the plateau.

Roads.

Two metalled roads cross the sheet from east to west. The Ram Ghat road was the old military route between Belgaum and Vengurla, but while the approaches to the Rám pass above and below are well kept roads, the pass is now impassable for loaded carts. There is still, however, a considerable amount of bullock traffic, salt and saltfish being taken from the coast and grain from inland. The travellers' bungalows on the route are kept in repair. The bungalow at Ram Ghat (in Sávantvádi limits) is beautifully situated on the edge of a densely wooded gorge overlooking Goa territory, with the sea in the distance; and as large game is abundant in the neighbourhood, it is a favourite resort for those fond of sport.

The new road from Belgaum to Vengurla by way of the Amboli pass was opened in 1871, and is a first-class road metalled and bridged throughout. During the fair season, when the port of Vengurla is open, the cart traffic is immense. There are travellers' bungalows along the route, and at Amboli on the crest of the Ghats the Raja of Sávantvádi has built a summer residence. There are several other houses built and some under construction, and it is hoped that from the rare wildness and beauty of the scenery around Amboli and the comparatively cool climate it will become a favourite sanatarium for Belgaum as well as for Sávantvádi.

In addition to the above, two other unmetalled roads form lines of communication between the Amboli pass road and the Rám pass road. The first from Amboli follows the crest of the Sahyádri hills passing through Chowkoli and meeting the Rám pass road near the Rám pass bungalow. The other leaves the Amboli road at Sirgaon and passing Chandgad and Hira joins the Rám pass road near Patna.

Rivers.

The rivers draining to the west are, from the nature of the country, mere mountain torrents, the only exception being the Tilári, rising some distance inland near the village of Tudiya at an elevation of 2,600 feet; it flows west draining the Dhamna and Máhálungi hills on either side. The force of its current has cut back through the face of the Ghats forming what is known as the Tilári Gorge. At Kedra where it enters Sávantvádi the elevation of its bed is 478 feet. Crossing the old military road near Ghotagevadi it leaves the sheet. During the rainy season the Tilári becomes a mighty torrent difficult and dangerous to cross, and so sudden are its freshets that no year passes without loss of life from drowning. The other rivers draining north-east from the Sahyádri hills leave the sheet before they become of much importance. The Ghatprabha rising near Chowkoli flows north-east for about 40 miles, leaving the sheet at Uchalli. The Támraparni has its source in the hills north of the Rám pass and flowing north-east between the Gandharvagad and Mahipálgad hills falls into the Ghatprabha at Yartenhati, 6 miles north of the limits of the sheet.

Villages.

There are no villages of much importance in Sheet 243, but Chandgad may be mentioned, it being the head-quarters of the sub-division of that name; besides revenue and police offices, it has a post office and school.

Hira, the residence of the Chief of that name, has a weekly market.

Sheets 305 and 306 comprise parts of the Belgaum, Dhárwár and Kaládgi collectorates and part of the Rámdurg and Torgal *jagirs*.

Sheets 305 and 306. General description.

The Manoli hills—a flat-topped range—separated by the Malprabha river from the Mudkavi hills, cross Sheet 305 from west to east as far as Soriban, where a spur turns north. The southern face of the hills is steep and more or less scarped, the flat tops being overgrown with thorny jungle and strewed with loose angular stones. The hills have generally a gentle slope on the northern face.

There are other detached groups and isolated hills, notably the Yeláma group, which extends into Sheet 306. The group takes its name from the shrine of the goddess Yeláma, which is held in great veneration throughout the Bombay Karnátak, and is visited yearly by about one hundred thousand pilgrims. The shrine is built in the bed of the Sarasvati, a small stream, which runs north from the hills into the Malprabha. The priests who officiate at the temple are Lingáyats, and live on the hill. One quarter-anna is levied from every pilgrim for the use of the temple, but in addition to the fee almost every pilgrim gives clothes, cash and ornaments. Of these the money gifts, which are estimated to bring in about R10,000 yearly, belong to the priests. The clothes and ornaments are presented to the goddess and become temple property.

Parasgad fort stands on the south-west edge of the Yeláma plateau. The walls are built of stone, but are in ruins and most of the bastions are out of repair. There is a hollow in the western face of the rock, with a spring which is esteemed sacred by the people, and an underground cave. Parasgad is said to have been built by Shivaji in 1674.

Rivers.

The Malprabha enters the south-west corner of Sheet 305, at the village of Yengi, and flowing east about 10 miles, turns abruptly to the north, passing the village of Ganial, where it rushes violently through a gorge in the Manoli hills. The gorge, which is about 300 feet deep, includes an upper or northern half, not more than 50 yards wide, and a lower half which is broader, and with lower banks. During floods, the water rises 30 to 40 feet in the gorge, and rushes with mighty force, forming pot-holes of great size and depth, which at every new-moon, in the fair season when the water is low, are visited by numbers of Hindu devotees. The gorge is known by the name of the Naul Tirth or Peacock's Pool. The local story is that a peacock hard pressed by pursuers, and too weary to fly over the chain of hills, rested on a large rock, and called piteously. The river heard its cry, clove the hills, and the peacock escaped. Emerging from the gorge, the Malprabha passes Manoli, then north-east to Torgal where turning east it passes Rámdurg, and flowing through a gap between the Manoli and Mudkavi hills, continues its course south-east until it leaves the sheet. The only other rivers of importance are the Bennihalla and Tuparihala. The Bennihalla enters Sheet 306 from the south and flowing north for 3 miles, then turns north-east passing Navalgund, continuing this course until it leaves the sheet. The Tuparihala rising in the hills near Kittur enters Sheet 306 on the west and flowing east by Betgeri falls into the Bennihalla near Navalgund.

Roads.

Sheets 305 and 306 are well provided with roads. The principal lines of communication are the Belgaum-Kaládgi road which crosses the north-west corner of Sheet 305 and the Gokák-Nargund road which meets the Hubli-Bijápur road at Nargund. Another road runs south from Nargund by Navalgund, meeting the Hubli-Gadag road at Annigiri. There are several other sections of road some of which are under construction.

The chief towns and places of interest falling within Sheets 305 and 306 are—

The fortified town of Torgal, beautifully situated on the left bank of the Malprabha, where the river flows between the Torgal and Manoli hills. The fortifications are said to have been built by Adil Shah, one of the Bijápur Kings. The Chief of Torgal resides in a small fort inside the village. Here is a police station, a post office and a school. Torgal is connected by a well made road with Ramdurg and Soriban on the east and with Katkol on the west.

Rámdurg, a large town on the left bank of the Malprabha, has five schools, a court-house, police station and post office. There is also a temple of Venkatesh where an annual fair is held in the month of April. The Chief of Rámdurg resides in a small fort to the west of the town.

Manoli, on the left bank of the Malprabha, has a post office and weekly market. A ruined fort stands on a peninsula round which the river winds. It was here that Colonel Wellesley defeated the freebooter Dhundia Vagh in July 1800, driving 5,000 of his men into the Malprabha where they were drowned.

Saundatti, the head-quarters of Parasgad subdivision, lies 6 miles south of Manoli. Besides revenue and police offices, it has a dispensary, sub-judge's court, post office, a collector's bungalow, two schools and a ruined fort, on a small isolated hillock to the west of the town.

Nargund, on the Hubli-Bijápur road, is the head-quarters of the Nargund petty division. The town lies at the foot of a steep hill on which stands the ruined fort of Nargund. In 1858 Bába Sáheb, the Brahman Chief of Nargund, raised the standard of revolt against the British Government, and on the 29th of May surprised the Political Agent, Mr. Manson, at night, when asleep in the village of Soriban, killed him, cut off his head, and fastened it over the gate of Nargund fort. The Chief was subsequently executed at Belgaum and his State forfeited to the British Government.

Navalgund is a municipal town and the head-quarters of the subdivision of that name. There are revenue and police offices, dispensary, post office and schools.

Extract from the Narrative Report of COLONEL H. C. B. TANNER, *in charge No. 18 Party, —Season 1886-87.*

HIMALAYAS, PUNJAB.

The 4-inch work was contoured by means of the clinometer at 500 feet intervals in the low tracts and 1,000 feet in the higher mountains. The field sections were shaded in with 33·3 feet vertical intervals between the lines, but this was found to give results too close and confused, and the fair maps have been drawn with 50 feet intervals. This gives a clear topographical map on which only a few small features less than 50 feet high are omitted.

We show on the sheets the following items :—

(1) *Bhoja** or *kothi* boundaries without the boundary marks but with tri-junctions of included *mauzas* and *phatis*.
(2) Forest Department blocks with forest cairns.
(3) The approximate limits of cultivation and of forest lands.
(4) All the chief lines of communication.
(5) All villages and hamlets with their names.

The demarcation of *kothis, bhojas* and forest blocks as a rule are good, but owing to the absence of fairly correct *shajra*† maps or of the usual *mujmilli*, which is always furnished by the Settlement Department for the guidance of surveyors, our men had great difficulty in shewing the correct boundaries.

This was more specially the case in Seoráj, where there were either no forest maps at all, or else those that were used by the surveyors were found to be of such bad quality that practically they were of no use whatever, and our men had to trust solely to the word of the Forest menials who sometimes omitted to point out all the boundary pillars.

The triangulation has been carried out in the usual manner, and it is only necessary to note here that the localities in which the operations were conducted are disconnected from each other, and thus a loss of power has ensued. Most of the stations of the old North-West Himalaya triangulation were found.

The bar subtense method has again been followed. In Morni the revenue survey village by village polygon system was wrongly adopted, and loss of time and labour has been the result. Where a system of triangulation extends over a country to be traversed the main traverses should run in a nearly direct line between suitable trigonometrical points, and sub-traverses should then be based on the stations of the main traverses. This system gives simple results which can readily be computed. It has been followed in Shahpur Kandi and Pálampur, and the Morni work which was first computed on the polygon system ignoring triangulation stations, has been recomputed in the proper way.

In Morni all the *bhoja* and *mauza*‡ tri-junctions have been fixed by traverse. The country is highly mountainous and it is thought that the Settlement Department will

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* A *Kothi*, or, in the Morni State, a *Bhoja*, is a collection of several village lands under a single *Mukia* or headman who is responsible to Government for the revenue of the *kothi* ; it is therefore somewhat similar to an *ilaka* in other parts of India.

† A *Shajra* is a village map on which is recorded every individual holding of land in the village.

‡ A *Mauza* includes an area within convenient and generally natural limits and all the habitations therein.

be unable, except to a limited extent, to base their settlement maps upon these fixed points. In consultation with Colonel Wace, Financial Commissioner, it has been arranged that in future, only such open ground as seems capable of being accurately mapped on the 40-*kadam* scale (27·68 inches = 1 mile), shall be traversed by the Himalaya Party. This will curtail the traverse operations to a very appreciable extent, for the surveyors will in future omit all traverse work in regions which are mountainous and will fix tri-junctions only in those tracts where we may reasonably expect that settlement maps may be easily based upon them.

The 4-inch = 1 mile survey will be taken up in Shahpur Kandi and Pálampur, and later in the field season the Seoráj survey will be continued. Sheets Nos. 290 and 313 N, W. and S. W. will also be completed up to margin on the 2-inch scale. These sheets contain partly British and partly Native States land. It has been arranged with the Punjab authorities that the 2-inch survey shall embrace a topographical delineation of the general run of village boundaries. Limits of cultivation are not required, but masses of forest will be shewn. Traversing will be continued in Pálampur and in the open parts of Kulu. Besides this, the fixing of Himalayan peaks from the tower stations in Pilibhit and Sháhjahánpur will be carried out by two trained Sub-Surveyors.

Three soldier surveyors joined the party from Roorkee at the commencement of the field season. They have become efficient plane-tablers and have executed route surveys in the Himalayas. Two of the men have done remarkably well in route surveying and the third fairly. They have all learnt the use of the theodolite and aneroid. They are now about to commence a plane-table survey of a tract on the ¼-inch scale, basing their map on two or at most three plotted points, after which they will be instructed in the use of the sextant and artificial horizon for latitude observations. The subject of the instruction of these men is now under reference and a final scheme may soon be looked for. It is proposed that the whole course, including half a year at Roorkee, shall not exceed two years' duration.

The Morni traverses have been plotted on 161 sheets on the scale of 40-*kadams* (27·68-inch = 1 mile) to an inch by pupils attached to the office of the Himalaya Party by the Director of Settlements. They have also made tracings of the Morni sheets for the Settlement Officer, Umballa, to serve as an index to his work now about to commence in Morni or Kotáha.

Extract from the Narrative Report of COLONEL W. F. BADGLEY, *in charge No. 19 Party,—Season 1886-87.*

MADURA DISTRICT, MADRAS.

The area plane-tabled consists of a block of hills from 4,000 to above 8,000 feet high, including the south-west corner of the Palnis and parts of Madura and Travancore. It is for the most part bare but exceedingly rugged, some of the precipices being tremendous—such that a body falling with a slight impetus, would touch nothing for a quarter of a mile. The difficulty of surveying this country was therefore not so much in sketching what was travelled over as in getting from place to place; and this was increased by the laziness of the coolies who twice failed to come into camp, leaving me on the first occasion with neither food nor shelter. Towards the plain of Madura these hills present a precipitous ridge and a steep slope cut into gorges. The south edge of the Palnis here has the appearance of a wall 6,700 feet above the plain with a slope cut into ridges ending in the plain at only 3½ miles from the top. In the other parts the ridge still has a precipitous front, but is more irregular, varying in height from 8,600 to 4,600 above sea-level and showing some fine points. The Travancore boundary runs through this country southward to the south-west corner of the Palni hills, and then west, south and south-east along the watershed of this ridge. To the west of the ridge, that is in Travancore, the ground falls in steps from 8,600 to 4,000 feet above sea-level, forming small irregular plateaux and valleys.

The hills are nearly all grass-covered at top, generally with forest (locally called *sholei*) on the sides. Misapuli, the highest, is a point at the side of a table-topped hill about the middle of the work, and is 8,654 feet above the sea-level.

There are four small villages and a migratory village of hillmen in the area topographically surveyed, and there are also five cinchona plantations with resident planters.

There are three passes from the plain to the plateau. One of these is directly north of Bodináyákanúr. This in its upper part is very steep, looking from below like a wall of rock, and men walking along the path on the face of it seem as though they must fall off. The path is secure enough when one is on it, but it is as rugged as a watercourse and in the wooded parts is obstructed with branches of trees and undergrowth. The distance to the top of this pass from Bodináyákanúr is about 10 miles, but, on account of its steepness, the top is usually reached on the second day. It is only practicable for men on foot.

The Kotagudi pass is north-west of Bodináyákanúr, whence to the Travancore boundary is about 15 miles. The road for the last three miles is very steep but open. At a mile from the top it divides, the right-hand path going to the Vátarvádi villages, the left to two cinchona gardens. Goods are carried by cattle, ponies and donkeys, but the pass is not suitable for riding. The Kotagudi valley, through which the road runs, is very much shut in, and on that account is so very unhealthy, that the people in the neighbourhood say, that any one not born in the pass who drinks the water or sleeps there at night gets fever in three days.

To the west of Bodináyákanúr and about 7 miles thence to the ridge which forms the Travancore boundary, is a pass, for the improvement of which Government has made a small grant, and something seems to be doing towards spending the money. This is the easiest of the passes, the top being little more than 3,000 feet above the plain at the foot and the direct distance from top to foot 2 miles, which becomes 3 by the winding of the road. It is passable for horses, doolies and any baggage animals except laden elephants. At about a mile to the west of the top the road branches, the right branch going to cinchona gardens about Devikolam, the left to Chandanpáre, where the Raja of Travancore has a customs-house during the cardamom season. There are also small custom posts kept up in this and the Kotagudi pass, where dues are taken for Travancore on salt, cardamoms, and cinchona bark. Carts can go to the foot of the north and east passes and to about three miles up the Kotagudi valley. There are other paths, besides those mentioned above, crossing the hills in various directions, and a bridle path from Kodai Kánal winds along the south edge of the Palni hills.

There are no rivers but there are numerous small streams, some of which join to form a stream called here the Periyár, but it is only a branch of that river which rises 50 miles further south, and being joined by this stream, turns westward to fall into the sea north of Cochin.

Omitting the garden coolies, who are most of them semi-resident, coming when wanted from the villages in the plains, there are very few inhabitants in this bit of country. The corner of the Palnis has none. Bodináyákanúr owns the hamlet Kotagudi with 15 houses and about 70 inhabitants. There are three villages of altogether 46 houses and 230 inhabitants in the Vátarvádi valley, and the migratory village of hillmen consists of 10 houses and about 40 persons. Approximately the population is 340 persons old and young, or 2 to the square mile, and they are physically a poor lot.

They have no particular customs to speak of, nor is there anything of archæological interest, except a few upright (perhaps) memorial stones, which the present inhabitants can tell nothing about.

Of natural exports there are none except a little honey and wax, and the fire-wood which the villagers cut for themselves. The cardamoms grow, both wild and semi-wild, in the country immediately to the south in cleared patches in the forest. Elephants, tigers, leopards, bison, sambur and ibex are found in these hills. The forests which are infested with leeches abound in Rhododendrons and tree-ferns.

The grass on the hills is mostly spear grass two feet high. This is very dry from January to March and is then burnt, and as there is generally a pretty strong wind blowing, camping is rather risky work at that time. The burnt stubble also makes a nasty camping place, the ashes worry one's eyes and a dewy morning walk leaves one with legs like a chimney-sweep's.

Of forests, there are none left in this corner of the Palni plateau. In the rest of Madura, that is, the slope towards the eastern plain, about a third of the area is forest, the more accessible slopes being bare. In Travancore about a third of the area is forest. The hillmen used to clear and burn this in patches for cultivation, but they are now forbidden to cultivate any but the grassland, as the forest land has become saleable for cinchona cultivation, and the forest is being rapidly destroyed where the aspect is favourable for that cultivation.

Cinchona bark is the only cultivated export, and is as yet a new production. The people grow only enough grain to feed themselves and to pay their taxes. The gardens are supplied with food from the Madura district, and as the load which the miserable donkeys and ponies can bring up is very small, the cost of the supplies is high; at the beginning of the year, rice selling at 12 seers in Bodináyákanúr, cost the planters a rupee for five seers.

The hillmen keep buffaloes, which they graze on the hills, and in the neighbourhood of these people milk can be bought; otherwise nothing is to be had. All food must be brought from the plains. The Vátarvádi people keep cows but graze them in the Wynaad in the dry weather.

The climate of the hills is pleasant in the winter and apparently salubrious, but in spite of precautions I and most of my men got fever. This I attribute to the water which those in camp must drink from the streams that are at hand. These streams usually have wooded courses and the water is often of a suspicious brown colour. In the winter months, a continuous strong wind blows, which often brings clouds to the mountain tops, which interfere much with surveying. The wind also is often so furious as to prevent work, and twice it wrecked my umbrella and once tore to pieces my *kalasis'* tent. In the spring it blows from the north-east and is very dry and cold, peeling the skin off one's face and hands in flakes. I only know of the climate in the summer from hearsay and was informed that then the wind is equally strong and feels even colder, as it drives a cold stinging rain before it. There is frost on the hills in winter, and in February I found the thermometer at 8,000 feet showed min. 35°, max. 69°, sun, 82.°; at 4,000, min. 50°, max. 80°, sun, 100°; and on the plain below min. 75°, max. 95°, sun, 110°.

The only carriage for these hills is coolies. Mr. Mills tried ponies but gave them up after one trial. The coolies were procured from Bodináyákanúr. They were lazy and insubordinate, could or would only carry half a load for half an ordinary march, and were difficult to get at 8 annas a day. In fact, no man thereabouts will work at all, if he can help it as long as he has a wife or family to support him.

Extracts from the Narrative Report of LIEUTENANT-COLONEL G. STRAHAN, R.E., *in charge No. 21 Party,—Season 1886-87.*

NICOBAR ISLANDS.

Modifications of usual procedure.

As the survey was to be confined to one season, it followed that the usual procedure under which the first season of a new survey is spent in triangulating and preparing for the subsequent work of the detail surveyors, must be abandoned; and it became necessary to devise some system by which the detail work could be carried on without previous triangulation and be subsequently fitted on to it, so to speak, after the computations had been completed in recess quarters. Computation in the field, sufficiently approximate, could not be undertaken without loss of valuable time, every day of which was precious, partly because there were no elements of latitude, longitude or azimuth on which to base them, except such as could be measured off from the charts (confessedly very inaccurate) with compasses, and partly because the weather was so wet and cloudy for several weeks after our arrival at the settlement that astronomical observations to determine these elements were impossible.

It will contribute to the methodical arrangement of this report if I explain here the system I adopted, before proceeding to the detailed account of the share taken by each member of the party in carrying it out.

Requirements of survey.

It appeared that the requirements of the survey were four in number, *viz.,—first,* an accurate survey of the coast lines of each of the principal islands; *second,* correct determination of the position of the Nicobar group on the earth's surface including their relative positions *inter se; third,* as much topographical detail of the interiors as could be secured; and *fourth,* an enlarged plan of the settlement itself and its environs in detail, carefully contoured on the same principle as that employed by Captain Hobday at Port Blair. I will take up each of these requirements in order.

Coast traverses.

First—An accurate survey of the coast lines of the principal islands. This was accomplished by what may be called "the subtense bar method," introduced into the Survey Department by Colonel Tanner. When first beginning this system of traversing, I felt somewhat in the dark as to what reliance could be placed on its accuracy, and I therefore commenced on the comparatively small island of Nankauri, which is about 26 miles round. This traverse closed absolutely without visible error on the scale of 1 inch to 1 mile. There was no doubt something of a happy chance about this, as most of the other circuits do show appreciable error. Thus the Little Nicobar, 43 miles round, has a closing error of ·25 mile. The Great Nicobar, 120 miles in perimeter, has one of ·51 mile. On the other hand, Kar Nicobar, 30 miles round, closes within ·06 mile.

Closing of circuits.

Provision was made for adjusting these errors by fixing points in the circuits either astronomically or by triangulation; the errors were judiciously distributed and the traverses fitted on to these fixed points. I have little doubt that the circuits would have closed well in every instance under more favourable circumstances, but it must be remembered that in many cases the plane-table and the theodolite had to be set up in most awkward positions—frequently in the sea with spray dashing over them, or on slippery and uneven rocks, the subtense bar being often partially obscured by the spray of the never-ending swell on these coasts.

Building of observatory.

The second requirement, *viz.*, the correct determination of the situation of the islands of the Nicobar group on the earth's surface, necessitated astronomical observations of latitude, longitude and azimuth, and also a network of triangulation emanating from a measured base. At the settlement of Kamorta I erected a wooden observatory over a large masonry platform which was intended to serve as a permanent mark or zero on which the elements of the survey depend. In order to secure the platform from injury and to identify it in future, it has been placed under the care of the Settlement Officer, and a stone slab bearing the following inscription let into the masonry: "G. T. S. The position of this stone was found from observations made by Lieutenant-Colonel G. Strahan, R.E, in 1887, to be N. Latitude $8^\circ\ 2'\ 21''\cdot03$ and E. Longitude $93^\circ\ 31'\ 55''\cdot05$."

Latitude observations.

At this point an astronomical latitude was carefully measured by the method of circum-meridian altitudes. An equal number of stars north and south of the zenith were employed, and an equal number (or very nearly so) of observations face right and face left secured. To avoid the loss of time involved in changing face between every two observations of a star as it crossed the meridian, I made all the observations on each star as it passed without changing face at all, then reversed the instrument and observed the next star on that face throughout, and so on. I found in this way that I could get much more work into a given time without sacrificing any principle, which is a most important consideration in such a climate as that of the Nicobars, where cloudless skies are few and far between. I had no difficulty in securing ten intersections of a star including the reading of four verniers for each intersection in 9 or 10 minutes, thus for the most part obtaining observations within 5 minutes of the meridian either before or after, saving thereby an appreciable amount of labour in the subsequent reductions. Only Nautical Almanac stars were observed. The instrument used at this station, and at all others where the latitude was observed, was a 14″ theodolite by Troughton and Simms.

The longitude of the observatory at Kamorta was determined differentially from Chatham Island, Port Blair, by chronometers. For this purpose I obtained from the Mathematical Instrument Office in Calcutta two excellent transit instruments by Troughton and Simms of about 30″ focus of almost identically the same pattern, and six chronometers, in addition to which the three chronometers of H.M. I.M.S. *Kwangtung* were placed at my disposal. Of these nine chronometers six gave good results, two indifferent, and one was broken at the outset, and consequently took no part in the proceedings. The longitude depends therefore on eight chronometers which were carried three times between the stations, *viz.*, twice from Chatham Island to Kamorta and once from Kamorta to Chatham Island. The weak point of chronometric determinations of longitude is well known to be the uncertainty of their rate during transport from one station to another. In this particular case the voyage though a short one was somewhat too long to admit of transits being observed on one night at one station, and on the next night at the other: one night always intervened. Of the eight chronometers employed, seven solar ones remained always undisturbed in padded boxes on board the ship in as nearly an uniform temperature as possible. The eighth, a sidereal one, was used in the observatories and carried backward and forward as occasion required, comparisons being made with the others either before or after work (or both). The sidereal chronometer was selected for comparison merely for convenience, as its ½-second beats would be synchronous with the ½-second beats of a solar chronometer, about once in every three minutes.

Longitude of Kamorta and instruments employed.

The method of proceeding was as follows. Transits of eight or ten stars were observed at (say) Chatham Island for two or three nights in succession. Hence the correction of the sidereal chronometer at certain epochs was deduced, as well as its rate from night to night. By means of its rate, its correction at any other epoch could be obtained. In order to determine the corrections and rates of the seven solar chronometers which remained on board the ship, the correction of the sidereal one was computed for the seven epochs at which the comparisons had been made; hence the true sidereal time of comparison was known, and from this follows by a short computation the true mean time, and hence the corrections and rates of the mean time chronometers are obtained. On reaching the other station Kamorta a similar process was carried out; and the rate of each chronometer during the voyage, which enters directly into the longitude, was assumed to be the mean of those found at the first and last stations. The deduction of the longitude then follows very simply, thus :—

Method of determining longitude.

Let $\tau_1 =$ chronometer time of observation at 1st station.
$\tau_2 =$ „ „ 2nd „
$T = \tau_2 - \tau_1$
$\alpha_1 =$ chronometer correction at time τ_1 at 1st station,
$\alpha_2 =$ „ „ τ_2 2nd „
$m =$ mean daily rate correction.
$\omega =$ longitude of 1st station — longitude of 2nd station.

Then $\omega = \alpha_1 - \alpha_2 + mT$, each chronometer furnishing a separate value on each voyage. It had been originally intended that there should be two voyages at least in each direction, but the weather was so uniformly unfavourable and time so pressing, that I had to be content with two from Chatham Island to Kamorta, and one from Kamorta to Chatham Island. There are therefore in all twenty-four independent values of this difference of longitude, the probable error of the mean being $\pm 0{\cdot}11$ of a second of a time. The two little transit instruments proved to be very handy and serviceable, and very stable in their adjustments. The chronometers employed were the following :—

No. 391 solar, by McCabe from M.I.O., rate very steady.
„ 466 „ „ „ „ indifferent.
„ 1601 „ Cummins „ „ very steady.
„ 2684 „ Fletcher „ „ fair.
„ 1509 sidereal, Arnold and Frodsham from M.I.O., rate indifferent.
„ 228 solar, Shepherd H.M.S. Kwangtung, rate very good.
„ 522 „ Baker „ „ „ „
„ 1032 „ McCabe „ „ „ fair.

The longitude of the Chatham Island Observatory was taken at 92°-42′44″·00 which is the value obtained from 41 lunar culminations and 180 lunar zenith distances by Mr. Nicholson of the G. T. Survey in 1861.

An azimuth was measured at the Kamorta Observatory by the usual method of observations to a circumpolar star at elongation. As the triangulation is not of large extent, nor of extreme refinement such as is aimed at in geodetic operations, it was considered that observations to Polaris at one elongation would give sufficiently good results.

Azimuth observations.

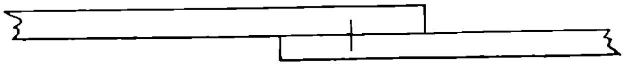
The observatory at Kamorta is connected by triangulation with the base-line, the measurement of which I will now proceed to describe. A suitable site was very difficult to obtain: the locality ultimately decided on is situated about four miles north of the settlement of Kamorta, on some low undulating hills which are free from jungle. They are however much cut up by swamps, the crossing of which entailed considerable labour in the preparation of the base-line. Its length is approximately 1,000 yards, the eastern extremity being 55 feet higher than the western. The measurement was made under great

Selection of Base-line.

difficulties, very heavy rain fell during the first day and converted the ground into a black quagmire ankle deep, and smelling horribly of decaying vegetation. As the rain is almost incessant at that time of year (November and December) it was no use waiting, and we had to make the best of it, but the inevitable fever prostrated a number of men in consequence.

First measurement of Base-line.

The process of measurement was carried out with well-seasoned bars of teak, $10\frac{1}{2}$ feet in length and 3 inches square in section. These bars were carefully planed and squared: a length of 10 feet taken off from an iron standard supplied by the Survey Office in Dehra was laid off on each bar, the extremities of the 10-foot length being marked by a finely cut transverse line. The measurement was effected by bringing into coincidence the transverse cut of the preceding end of one bar with that of the following end of the next one, the bars being placed alongside of one another thus :—

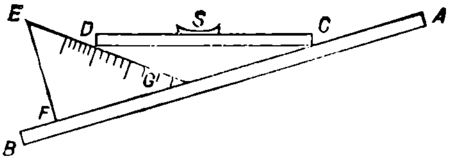


The alignment was given by a 7″ theodolite. The base was measured twice, the process being somewhat different on the two occasions. During the first measurement each bar was individually levelled by means of blocks of wood and small wedges placed under the ends until a spirit-level laid upon it showed the horizontality to have been secured. This was found to be a very tedious and inconvenient proceeding, on such soft and swampy ground, especially as the undulations are considerable. Moreover, during the process of wedging there was an appreciable risk of disturbing bars previously adjusted.

Second measurement and improvements introduced.

During the second measurement the following plan was adopted with great success, the time occupied being reduced from seven hours to four, while at the same time the accuracy was in all probability increased. It occurred to me that if some simple apparatus could be devised by which I could, instead of levelling each bar, measure its inclination, so as to be enabled to compute the amount to be deducted from each in obtaining the true length of the base, that all wedging up might be dispensed with and the bars placed sufficiently level by eye alone. For this purpose, I constructed a large wedge of teak about $2\frac{1}{2}$ feet in length and $1\frac{1}{2}$ inches thick carefully smoothed and planed, and also a teak rod 6 feet long and $1\frac{1}{2}$ inches square in section, on which at the middle of its length was mounted a spirit-level with its axis parallel to the rod. This rod, bearing the spirit-level, was laid longitudinally along the upper surface of a measuring bar when placed in position, and one end of the rod was gradually raised by the insertion of the wedge beneath it until the spirit-level showed it to be horizontal. The end of the rod resting on the wedge then pointed to a number on a scale on the edge of the wedge which was so contrived that that number represented the length in thousandths of a foot to be deducted from the length of that particular bar due to its dislevelment.

In the diagram, AB is the measuring bar, CD the rod supporting the spirit-level S which



is levelled by the insertion of the wedge EFG, on the edge of which is a scale so divided that at the point D where the rod touches it, is a number corresponding to the deduction to be made for that particular inclination of AB. This scale is obviously not one of equal parts, but still the dividing of it presents no practical difficulty. It may be as well to mention here that the angle of the wedge, on which the size of the scale divisions partly depends, must be greater than any angle at which the measuring bars are likely to be placed, but with this proviso the smaller it is the better, as the scale divisions will increase in magnitude as the angle diminishes. The angle of the wedge actually used was made without any definite design, and when subsequently measured turned out to be 16° 36′ and answered its purpose well.

Graduation of wedge scale for Base-line.

The graduation of the scale is based on the following principles; if a bar of length a be placed at some definite inclination θ to the horizon, then its projection on the horizontal plane is shorter than itself by the quantity a versin. θ: in other words if this bar be used as a measuring instrument at this inclination we must subtract this quantity a versin. θ from its length. The scale was divided to show thousandths of a foot and by estimation ten-thousandths.

Now suppose the angle of inclination θ to be such that n thousandths of a foot have to be deducted to obtain the value of the projection on the horizontal plane. Also let the length of the measuring bar be a, the length of the rod carrying the spirit-level be b and the angle of the wedge α.

Then we have $n = a$ versin. θ

and in the triangle CGD, $\text{GD} = \dfrac{\text{CD}}{\text{Sin. }\alpha}\ \text{Sin. }\theta = \dfrac{b\ \text{Sin. }\theta}{\text{Sin. }\alpha}$

from which two equations the value of GD, *i.e.*, the point at which the number n should be placed, is determined. This being done for successive values of n, the scale may be constructed. In the present instance CD= 6

$$AB=10$$

$$EGF=16^\circ\ 36'$$

whence we have $10 \text{ versin. } \theta = \cdot 001\ n$

or $\text{versin. } \theta = \cdot 0001\ n$

and GD (in inches) $=252\cdot 02 \text{ Sin. } \theta$

The values of θ are tabulated for $n=1$, $n=2$, $n=3$, &c., whence the corresponding values of GD are obtained.

Remarks on measurement of Base.

This wedge contrivance is obviously open to some theoretical objections such as flexure of the measuring bar, or of the rod supporting the spirit level which would prevent the true inclination to the horizon being measured, as the spirit level would give different indications according to its position on the bar. The level itself was firmly fixed once for all on the rod, so that no subsequent adjustment was possible, and this condition of things might at once be objected to by a surveyor in search of extreme theoretical accuracy. It is only necessary to point out that considerable inclinations of the bar produce very minute corrections to its length, to prove that such objections are of little or no weight where extreme refinement is not aimed at. Thus it requires a dislevelment of a 10-foot bar to the extent of 49′ before the deduction on account of slope amounts to $\frac{1}{1000}$ of a foot, and a level if carefully adjusted could never be in error to such an extent as 49′. Notwithstanding such theoretical objections as these, the method was found extremely convenient in practice and well adapted for a topographical survey. Five bars, constituting one set, were placed simultaneously; the whole length of the base required 59 sets, 4 bars and a fraction. By the first measurement the length of the base was found to be 2,994·770 feet and by the second (which is probably the more accurate, and to which double weight has been assigned) 2,994·595. The final adopted value is 2,994·653.

I will now proceed to the narrative of how these several operations were carried out and the part taken in them by the various members of the party.

Preliminary preparations and voyage to Kamorta.

One assistant, Mr. D. Campbell, was sent down to the Nicobars by the mail steamer of October 22nd to make arrangements for the supply of convicts, masons, building materials, base-line bars, &c., and also to select and prepare a site for the base-line. The rest of the party followed in the mail steamer of November 19th. We were delayed two days by encountering a cyclone in the Bay of Bengal, but reached Port Blair without mishap on the 24th idem. The Chief Commissioner, Colonel Cadell, being in England on leave, I discussed with his successor, Colonel Wimberley, the requirements of the survey, and the best means of carrying them out. Two of the Indian Marine steamers, *viz.*, the *Kwangtung* and the *Nankauri*, with all their boats were placed at my disposal, as well as a batch of convicts, who would be required for various kinds of manual labour. On the following morning we again embarked and reached our destination, Kamorta, on the morning of the 26th November. I found Mr. Campbell had not suffered from the almost incessant rain which generally falls at this time of year, but his work of selecting and preparing a base, and building stations had been considerably retarded. By December 4th the ground had partly dried, and the first measurement was made, the intermediate days having been employed in unpacking and adjusting instruments, mounting plane tables, testing compasses, preparing base-line bars and trestles, &c., &c.

Prosecution of the work.

After December 4th heavy rain again set in and it was impossible to proceed with the verificatory measurement. I therefore with the assistance of Mr. Keating commenced the traverse of the coast of the island of Nankauri. On the 11th I went to the island of Bompoka, and having selected a station there returned the next day to Kamorta. I may as well mention here once for all that I was forced to give up any idea of clearing hill tops of jungle to serve as stations. The forest is so dense, and the hills so difficult to approach, that each clearing would have occupied several weeks, and I had neither men nor time for such work. Fortunately I found a few bare hill tops on Bompoka, from which most of the other islands of the central group are visible, and here I planted a station which subsequently proved of the greatest value. By December 13th the swamps had sufficiently dried up to enable me to carry out the second measurement of the base. On the 15th I left Kamorta for the island of Kar Nicobar with Mr. Keating to start him on the coast traverse there, as he had already gained some experience in this work whilst working with me on the coast of Nankauri. I left him there on the 17th idem and then steamed round the island of Batti Malv to ascertain if it were possible to land on it as it would be necessary to fix its position by astronomical observations. Not being successful I returned to Kamorta, and finding the observatory which I had ordered to be built there nearly ready, I took out and adjusted the transit instrument, measured its wire intervals and value of level scale. On the following day I completed the circuit of Nankauri, which had been left unfinished, at the same time instructing Mr. Campbell in the subtense bar method of traverse. From December 28th to January 5th I was engaged in observing transits at Kamorta and Port Blair with a view of determining their difference of longitude, but was much hindered by bad weather. On January 6th I took Mr. Campbell to the island of Tilanchong to work the coast line traverse and left him there, and returned to Kamorta. On the 9th I inspected Mr. Keating. The rest of the month was occupied partly in observations for latitude at Kamorta, and partly in traversing the coast line of the island, which proved an extremely difficult job. It was rarely possible to land at all from the boats direct; the only practicable method was to anchor the boat just outside the surf and then

Difficulties encountered.

either wade or swim ashore. Except just when a heavy roller came in, the water was only about 4 feet deep, and the men could stagger along, but the surf went often completely over their heads, much to the detriment of the instruments and plane tables. This process had often to be repeated 10 or 12 times a day, and for days together not one of the party ever had a dry thread on them. Five times during the season my boat was completely capsized in the breakers, but fortunately on no occasion was there any loss of life. The coasts being very dangerous owing to want of reliable charts, much time was lost in rowing ashore from the ship in the morning and out again in the evening after work, as she was always obliged to keep out at a safe distance, the currents and tide rips being very strong and the swell generally very heavy.

Proceedings at southern group.

After completing this I started for the southern group comprising the islands of Great and Little Nicobar, Kondul and several small uninhabited ones. The Little Nicobar coast traverse was allotted to Mr. Keating and the great Nicobar to Messrs. Campbell and Senior. I intended to observe for latitude at convenient intervals along the shore as a check on their traverses, and to utilize my ships the *Kwangtung* and *Nankauri* in moving their camps along the coast as the traverses proceeded, no land carriage being available, and this course I found a very convenient one and economical of time. The weather was horrible, scarcely a day passed without heavy rain, and my observations were much hindered in consequence. I eventually succeeded in getting five latitudes, *viz.*, one on the west coast, one on the south, one on the east, and two on the north. I then laid out some triangulation in St. George's Channel which divides the Great and Little Nicobars, leaving Mr. Keating to measure a short base with the chain to ensure our obtaining correctly the breadth of the channel and the relative situation of the two islands. It now became necessary to return once more to Kamorta as the monthly mail would arrive on the following day, February 17th, and much office work and correspondence had to be brought up. I was engaged from that time till March 4th in making another voyage to Port Blair and back, for chronometric difference of longitude: on the 5th I inspected Mr. Campbell at Tilanchong, and tried unsuccessfully to find Mr. Keating on Teressa. The next day I succeeded in landing on the island of Batti Malv and observed the sun for latitude, and proceeded afterwards to Kar Nicobar, which I reached in time to secure star observations for latitude the same night. They were continued the next night as far as clouds would permit.

Proceedings at Little Andaman.

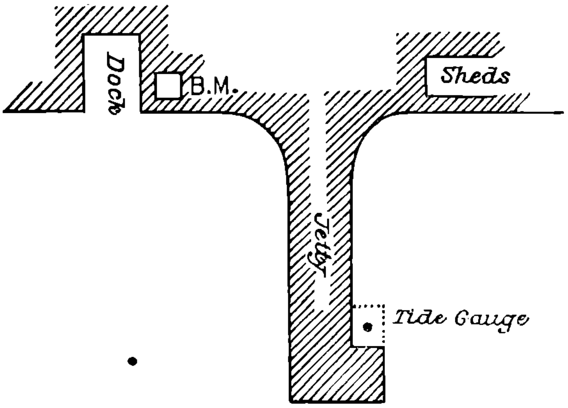
During my previous visit to Port Blair I had arranged with Colonel Cadell, the Chief Commissioner, who had returned from leave, to meet him on March 8th, at the south end of the Little Andaman to fix the latitude there and to partly overhaul a traverse of the island which had been made by Mr. Portman, one of the settlement officers at Port Blair, and which disagreed so grossly with the published charts of the island that some examination into the matter was most important. A traverse of the northern part of the island had been commenced by Mr. Keating in the previous season starting from an intersected point of the Andaman triangulation, which certainly showed that the Little Andaman is incorrectly placed on the existing charts. Mr. Portman's traverse seemed to indicate that the error in the south was considerably less. In order to elucidate this point I measured one latitude at the extreme north and another at the extreme south of the island. The former agreed very fairly well with the intersected point alluded to, showing the error of the chart to be no less than $+4' \ 50''$. The latter proved the error at the southern extremity to be $+1' \ 50''$. The traverses were corrected accordingly and a fair outline of the island secured. Whilst I was engaged on this, Mr. Senior revised a portion of Mr. Portman's traverse. Surveying on the Little Andaman is by no means unattended with danger, owing to the hostility of the savages. It was supposed that through the exertions of Mr. Portman, the Settlement Officer, that they had been pacified; it seems, however, that this is not really the case, as Mr. Murray, the Chief Engineer of the *Kwangtung*, was attacked, while walking along the beach, by one of them, and dangerously wounded by a blow from an axe on the back of his head. The assault was utterly unprovoked, and it was impossible to guess at the savage's motive in committing it. Fortunately the others showed no intention of joining in the attack and the man was secured without difficulty and taken off to Port Blair.

Hostility of Natives.

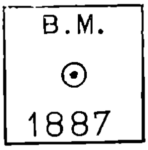
The remainder of the season was taken up in observing two azimuths, one at Kamorta and the other on the northern coast of the Great Nicobar; also in observing at some of the stations of the main triangulation, in arranging for recording the rise and fall of the tide at Nankauri at intervals of 15 minutes day and night for 33 days, in inspection, and in a third and final voyage for obtaining the difference of longitude of Kamorta and Port Blair. The observations were brought to a close at Port Blair on 19th April.

Description of tidal apparatus.

The means by which the tidal record was obtained were as follows. A graduated pole was planted vertically near the end of the Kamorta jetty in shallow water, and secured by guy ropes. The scale on it was laid off from a steel tape which had been previously compared with a standard bar. For convenience of reading, the feet were alternately black with white graduations and white with black graduations. A strong mark was made at every three inches, and smaller ones denoted the single inches, the halves and quarters were estimated. A hedge of cocoanut stalks and leaves was built round the pole, forming an enclosure about 25 feet square to keep off the swell, but not sufficiently thick to retard the rise or fall of the tide within it. The clock used was compared and set every morning at 8 A.M., with a very reliable one at the bungalow of Mr. Man, the Settlement Officer, which in its turn was set weekly to true time by a chronometer regulated by means of transit observations at the Kamorta observato ry. The tide gauge zero is 9′ 7″ below the surface of a masonry bench-mark near the land end of the jetty, which bench-mark serves for the zero of heights for the Nicobar survey, its height above mean sea level being assumed provisionally at 6 feet. The record was kept by two convicts sent down from Port Blair for only that purpose, *viz.*, Abdul Rahmán, No. 5405, and Mehar Bux, No. 5213, under the superintendence of Sub-Surveyors Harlal Singh and Ali Nawáz Khán. It gives the height of the water at every 15 minutes day and night for 33 days, *viz.*, from March 12 to April 13, both inclusive. Arrangements have been made with the Settlement Officer, Mr. Man, for resetting the graduated pole if required at any future time, so as to preserve exactly the same zero it had during these observations. The position of the tide gauge and bench-mark are shown in this diagram.



The stone on the bench-mark is thus inscribed :—



Difficulties of the survey.

The survey of the Nicobar Islands certainly presented exceptional difficulties. There is no mode of carriage except by boat or by coolies (which must be provided by the survey party) along the sea beach, which, however, is so rough and steep in many places as to be impassable. Supplies are nowhere to be obtained, there are no villages worthy of the name, nothing but a few isolated huts on the shore from which the natives generally fled in terror on our approach. The forests on most of the islands are hopelessly impenetrable and the lowlands so cut up by swamps as to be inaccessible. It unfortunately happens that the groups of islands are in many cases at such distances from each other, that the shores are concealed from each other by the curvature of the earth, while the inaccessible hill tops are still visible, and this necessitated more astronomical work than would otherwise have been required, as in many instances the triangulation could not be extended from one to the other.

River scenery, &c.

The scenery, especially of the Great and Little Nicobars, is of indescribable beauty. There are several rivers in the former island which are navigable by rowing boats for some miles, notably the Galatea river on the south coast up which Mr. Campbell penetrated nearly twenty miles. Its course is very tortuous, the banks are fringed with tree-ferns, canes, bamboos and tropical vegetation of infinite variety, through which occasional glimpses are obtained of high mountains in the interior clothed with dense forest to their very summits, and generally cloud-capped. The stream is deep and sluggish with steep muddy banks and contains abundance of fish. The country through which it runs is almost uninhabited, a few huts appear here and there tenanted by an inland tribe of savages called "Shom Pen," of whom very little is known except that they are in such an utter state of barbarism as to be held in contempt even by the Nicobarese inhabiting the coasts. On most of the islands the forest grows luxuriantly close down to the beach and indeed is in many places washed by the sea at high water. Mangroves, except on the island of Kamorta, are not very plentiful, and in this respect these islands differ widely from the Andaman group, where the creeks are fringed with mangroves mile after mile. The sea beach consists largely of coral, and those who have never seen living coral washed by water of such marvellous purity as the Nicobar seas, can form no idea of the wonderful beauty of the forms and colours displayed by it. Shells too of every shape and hue abound on these coasts, many of them being, I believe, highly prized by conchologists.

Climate.

The climate is most pleasant to one's feelings, being very equable day and night, summer and winter, like most tropical islands, but unfortunately its character for unhealthiness is only too well established. Fever, especially among newcomers, is always prevalent: at times I had 70 per cent. of my men laid up with it, and very very few of the establishment have been altogether free from it. It does not seem to be of a very fatal type, for, with the exception of Sub-Surveyor Harlal Singh, there have been no casualties; but it is most difficult to shake off its effects, and many of my men have been more or less incapacitated from it during the whole recess.

Rainfall.

The rainfall, which averages about 100 inches, is pretty evenly distributed throughout the year. December and January are reckoned the driest months, but during the past season we rarely had more than one or two days free from rain even at that time, and while I was at the Great Nicobar, showers, and very heavy showers too, were of almost daily occurrence. The thermometer stands pretty steadily between 80 and 85 in the shade and hardly varies day or night. The temperature of the sea-water is about 81.

Inhabitants.

The inhabitants of these islands are allied to the Malays. They are very strong, thickly built men, not much if at all inferior to Europeans in physique, of a reddish brown colour, and in every way totally distinct from their near neighbours the Andamanese. The latter are intensely black with woolly hair, and are among the tiniest races of the globe, very few of the men reaching 5 feet in height. The chief characteristic of the Nicobarese savages is unconquerable laziness, which is perhaps not very much to be wondered at. As far as their limited intelligence goes, they have everything they can ever want close at hand. If hungry they have only to eat the pandanus fruit hanging ready to their hand or knock down a cocoanut, and if thirsty drink its milk. Famines, droughts and wars are things unknown to them; their wants are few and simple and easily supplied. They have no money and hardly care to accept it as a gift, having no use for it. Small services are generally paid for in rum or castor-oil, which they mix together and drink eagerly, or in scarlet cloth which they prize more than anything else. Beads and looking-glasses generally so dear to the savage mind they set no value on. They are a peaceable well-disposed race, and it is to be regretted that they are fast dying out, except on the island of Kar Nicobar, where the population is said to be increasing. They appear to have a really wonderful talent for learning languages. Wherever they come in contact with Europeans or with Indian convicts located at Kamorta, they quickly pick up a certain amount of both languages, besides knowing one or two of the Nicobarese languages of which there are six or seven. They are very fond of taking English names, and I found amongst them men answering to the names of Dandy Jem, Sweet William, Adam Bede, Captain London, and other absurdities of which they are extremely proud. They are somewhat fastidious in their head gear and prefer a discarded cocked hat or *sola topi* to anything of their own manufacture. They are grossly superstitious and worship evil spirits to keep them at a distance as far at least as they can be said to worship anything. Christianity has made absolutely no progress among them. It is currently reported that some 15 Danish missionaries spent twenty years among them without making a single convert. I found it utterly impossible to utilize them in any way for survey work, their incorrigible laziness rendered it hopeless to get them to do anything in the way of carrying loads or pointing out paths. Once or twice I found them useful as pilots but for nothing else whatever. On Christmas Day the Settlement Officer organized some sports in which some Nicobarese together with my *khalasis*, some Sikh Police, Madras Sepoys and lascar crew of the *Kwangtung* engaged, and I found that the savages held their own very well. They were beaten in running by some up-country men, but in the tug of war they pulled over all the teams except the Sikh Police. In putting the shot one Nicobarese was far ahead of all competitors, but for the most part they seemed too apathetic to take much interest in what they evidently considered useless exertion.

It is impossible to help feeling a good deal of interest in such genuine savages as these people are, and it was with much pleasure I listened to the accounts given of them by Mr. Man, the Settlement Officer at Kamorta, who is a distinguished anthropologist, and has studied their habits and language thoroughly, and is now engaged on a book on the subject, which will shortly be published, the interest of which I should be sorry to forestall in any way by adding too much to this report.

Conclusion.

In conclusion, I have only to add that I am much indebted to Colonel Cadell and the various officers under his command for the ready assistance they have afforded me in carrying out this survey, the conditions of which are so different from those usually met with in India,—without their aid the difficulties would have been almost insuperable. More especially I have to acknowledge my thanks to Mr. Man at Kamorta for the ready way in which all the resources of his limited establishment were placed at our disposal. His knowledge of the Nicobarese language has enabled me to give much information in our maps which would have been otherwise quite unattainable.

Extract from the Narrative Report of LIEUTENANT-COLONEL S. H. COWAN, *in charge No. 4 Party,—Season 1886-87.*

BASTI DISTRICT.

LIST OF PAPERS WHICH CONSTITUTE A COMPLETE *MISL* OR VILLAGE RECORD.

Received from the Settlement Office.	Prepared by Survey Establishment in the Field.	Prepared by Survey Establishment in Office.	EXPLANATORY REMARKS.
Khewat, or Hissa Kashi.	...	...	List of proprietors with detail of their respective shares in the village.
Intikhab .	...	...	Abstract showing occupant of each field at last settlement 12 years ago and last year.
	Khewatbadar slip	...	Only prepared when local inquiry shows that corrections are required in the *khewat*.
	Khasra . .	...	Written by the *amin* or *muharrir* in Urdu; areas and page totals, &c., entered in office.
	Jamabandi slips .	...	Written by the *patwári* in Nagri at the same time as the *amin* makes the corresponding entries in the *khasra*.
	Fardhawála .	...	Kept by *amin* to show the number of first entry of each *zamindar* and tenant to which subsequent entries are referred, &c., &c.
	Dispute lists .	...	One in Urdu by the *amin* and one in Nagri by the *patwári* to make sure that all claims are duly recorded.
		Trace maps .	One in Urdu on which the various classes of soils are shown by colour and one in Nagri for *patwári*.
		Milán khasra .	Abstract of *khasra* showing details of cultivated area, irrigated and dry, area fit for cultivation, barren area, &c.
		Serial lists of Fields.	Partly prepared in the field by *patwáris*, but generally re-written in office.
		Book Jamabandi	The slips copied into a book after regular arrangement, and entry of areas, &c.
		Terij . .	Abstract of holdings.
		Statement No. 1 (Urdu).	Detailed area statement showing separately assessable lands of various classes, non-assessable, &c.
		" " 2	Soil statement, areas of various kinds of soil.
		" " 3	Statement of holdings showing separately *sír*, *khúdkasht*, occupancy, tenant-at-will, and areas.
		" " 5	Statement of areas under different crops.
		" " 6	Caste statement, number of fields and areas cultivated by different castes.
		" " 7	Showing classes of soil distributed under the different tenures of the cultivators.
		" " 9	Agricultural statistics, number of ploughs, cattle, wells, &c.
		Village statement (English).	Giving the above 7 statements on one large page.
		Statistical Index (English).	In four pages, giving the same in one line for each village with total for each *tappa*.

Extract from the Narrative Report of LIEUTENANT-COLONEL J. E. SANDEMAN, S.C., *in charge No. 5 Party,—Season 1886-87.*

GORAKHPUR DISTRICT.

(1) Statistics of areas and population of Padrauna Tahsil compiled from survey records.
(2) Archæological notes on Buddhist remains.
(3) List of illustrations. (*These have not been reproduced.*)

(1) STATISTICS OF AREAS AND POPULATION.

The Padrauna *tahsil*, the survey of which is now completed, consists of only one *pargana*, Sidhua-Jobna. The names of the 22 *tappas* which it contains, their area and the total number of *mauzahs* in the *pargana* are given below :—

Number of Mauzahs.	Names of Tappas.	Parganas.	Area in acres.	
	Bank Jogni . . .	Pargana Sidhua-Jobna.	33,105·60	
	Bansi Chirgora . . .		43,554·62	
	Batsara		101,879·16	
	Bhalua		13,963·28	
	Bhatahi Badraon . .		16,755·63	
	Chaura Bargaon . .		47,533·38	
	Dandupur		15,129·47	
	Dhuria Bijaipur . . .		18,766·89	
	Haveli		40,809·15	
	Jhankaul		13,356·22	
	Khan		16,134·12	
	Mainpur		27,175·08	
	Malsil Saraini . . .		27,511·01	
	Naugaon		18,928·34	
	Pakri Gangrani . .		9,520·77	
	Papaur		41,164·27	
	Parwarpar . . .		43,577·82	
	Pirthipur		7,043·45	
	Rampur Dhab . . .		18,086·81	
	Rampur Rogha . . .		13,514·62	
	Sandi		15,789·71	
	Sapahi Kuchia . . .		10,260·36	
1,364	. . . . . .	. . .	5,93,559·76	= 927·49 square miles.

The total amount of cultivation and of irrigated and dry cultivation in the *tahsil* is as follows :—

	IRRIGATED		TOTAL.		Total cultivation.
	From wells.	From other sources.	Wet.	Dry.	
	Acres.	Acres.	Acres.	Acres.	Acres.
Sidhua-Jobna	17,126	33,251	50,377	361,584	411,961

The small amount of irrigation is due to the large tract of *bahát* soil, which is cretaceous and retains moisture and does not therefore require irrigation.

The areas of land cultivated by proprietors and tenants in the *tahsil* are as follows :—

	Sir and Khudkásht.	Tenant's land.
	Acres.	Acres.
Sidhua-Jobna	55,774	356,186

The numbers of, and the areas cultivated by, occupancy tenants and tenants-at-will are given below :—

	OCCUPANCY TENANTS.		TENANTS-AT-WILL.	
	No.	Acres.	No.	Acres.
Sidhua-Jobna	93,380	201,102	93,215	147,482

The number of rent-free tenants and the areas cultivated by them are—

	Number.	Acres.
	3,001	7,094

The number of ex-proprietory tenants and areas cultivated by them—

	Number.	Acres.
	148	508

The average sizes of the three kinds of holdings are—

	Acres.
Occupancy-tenants	2·15
Tenants-at-law	1·58
Ex-proprietory tenants	3·43

The culturable and barren areas are as follows:—

Culturable.

	Fallow.	Groves.	Grass.	Bush.	Total.
	Acres.	Acres.	Acres.	Acres.	Acres.
	88,645	11,452	10,822	25,329	136,248

Barren.

	Sites.	Water.	Otherwise barren	Total.
	Acres.	Acres.	Acres.	Acres.
	9,372	17,970	18,008	45,350

The cultivated areas under the various soils are as follows—

	Dóras (loam).	Matyár (clay).	Balúa (sand)	Bahát (cretaceous soil).	Kachhár (lands inundated in the rains).
	Acres.	Acres.	Acres.	Acres.	Acres.
	66,881	27,192	2,700	303,632	11,556

It will be noticed that *bahát* soil, which requires no irrigation and which is well suited to the growth of indigo and sugar, is nearly three times the area of the remaining soils.

The conventional tracts, as divided for assessment purposes, and to which the rates of rent often conform, have the following areas:

	Goend (home lands).	Manjhár (middle tracts).	Pálu (out lying).
	Acres.	Acres.	Acres.
	66,288	163,068	182,604

Thus the *goend* tracts are about 16 per cent. of the whole.

The following is an abstract of the agricultural statistics:—

Wells. Masonry.	Wells. Earthen.	Total.	Ploughs. 2 bullocks.	Ploughs. 4 bullocks.	Total.	Plough cattle.	Other cattle.	Sheep and goats.	Horses.	Village sites.
6,661	1,244	7,905	55,188	41	55,229	114,618	179,797	72,673	3,325	4,828

There are 5·21 sites of villages in each square mile.

The following are the areas under some of the principal crops in the autumn and spring harvests:—

Kharif.	Acres.
Rice (Aghani and Bhadain)	117,154
Kodo	48,304
Arhar, with jowár and bájra	37,961
Til	202
Makai	38,667
Jowár	3,199
Urd, moth	778
Garden food crops	1,505
Other food crops	14,265
Total food crops of the kharif harvest	262,035
Sugarcane	28,480
Cotton	3,727
Indigo	5,072
Garden non-food crops	11,328
Other non-food crops	2,235
Land prepared for sugarcane	18,346
Land prepared for indigo	4,098
Total non-food crops in the kharif harvest	73,286
Rabi.	
Wheat	61,058
Barley	35,257
Gojai, wheat and barley	42,952
Gram	3,011
Kirao (pulse)	35,616
Potatoes	622
Masúr	13,223
Garden food-crops	564
Other food-crops	326
Total food crops in the rabi harvest	192,629
Opium	6,334
Tobacco	89
Tisi	33,623
Garden non-food crops	1,462
Other non-food crops	956
Total non-food crops in the rabi harvest	42,464

The double-cropped area is = 158·454 acres.

The numbers of cultivators of each caste and the areas cultivated by them are given below:—

	Number.	Acres.
Mahomedan	5,341	11,847
Brahman	25,368	63,544
Rájputs, Thákurs or Chhatris	8,391	27,522
Banya	6,279	11,127
Káyath	2,952	8,494
Chamár or Dusád	18,095	28,917
Ahir	19,512	35,470
Koeri	21,231	49,716
Kurmi	14,386	36,245
Kahár, Mallah or Gondh	7,834	12,303
Dhobi	3,022	4,053
Teli	5,818	9,654
Juláha	14,102	23,958
Nanera	5,437	9,952
Barai	1,127	2,290
Kalwár	3,596	6,708
Nái	3,238	4,475
Bharbuja	41	68
Darzi	413	584
Dhánuk or Dhom	96	61
Christian	140	7,210
Blacksmith and carpenter	5,815	9,912
Goldsmith	1,001	1,233
Other castes	28,058	46,617
TOTAL	201,293	411,960

Beyond giving the above statistics I abstain from making further remarks on the *tahsil*, as it has been fully described at the previous settlement and in the "North-Western Provinces Gazetteer."

(2) ARCHÆOLOGICAL NOTES ON BUDDHIST REMAINS.

The Padrauna *tahsil* has been a Subdivision since 1868.

The head-quarters of the Joint Magistrate are at Kasia, which has been identified as the ancient Kusinágara, and it is remarkable for its Buddhist remains, the most famous of which I have ventured to illustrate by sketches taken by myself and one Ramnarain Bhagat, an old man who is a resident of the Salímpur *pargana*, and whom I discovered going about making his living by taking sketches of indigo factories.

I have affixed an explanatory index to the sketches. The ruins are situated on the western banks of the Ramabhar Tál.

The oblong mound 30 feet high on which the ruined *stupa* and memorial temple are situated is 600 feet long and 200 to 300 feet wide. The conical mound of solid brickwork now overgrown with bushes and trees is 50 feet high. The colossal statue 20 feet long rests within the restored temple where it was originally discovered in fragments.

The other sculpture is situated under a tree a few hundred yards from the temple, it is 10½ feet high and 4¾ broad, the figure is colossal. It is defective as to an arm (if I recollect rightly) which the artist has thought proper to supply. It will explain the interest which attaches to the sketches, which as such have little merit, if I give a brief account of the rise of Buddhism and also short extracts from the account of the discovery and excavation of the ruins. For the facts regarding the former I have had to refer to Monier-Williams and others, and for the latter to Vol. XVIII, Archæological Survey Report 1876-77.

Buddha was born at Kapilavastu in the Basti district. Buddha means "the perfectly enlightened one." The family name was Gautama and the father was king of the Sakyas, an Aryan tribe inhabiting the country on the banks of the Rohini, the modern Kohána. Prince Gautama, commonly known as Sakya-Muni (the lion-hearted sage), among reverential Buddhists, was born about 543 B.C.*

He was early married, but there is little record of his youth till his 29th year, when he suddenly left his home to devote himself to a religious life, after having seen a series of visions, abandoning his wife and only son, his home and wealth. The motive for his flight is said to have been love and pity for humanity which caused him to proclaim his doctrine to the world.

Gautama died about 500 B.C.*

Buddhism spread with great rapidity. King Asoka, who reigned about 250 B.C. decreed it the state religion of his kingdom Magadha (Behar). His edicts, enjoining *dharma*, the practice of universal benevolence, are written on stone pillars and are found scattered in many places, and there is more than one such in the Gorakhpur district.

Buddha's teachings were committed to memory by his disciples and thus handed down until at last they were put in writing.

The number of living Buddhists is estimated at 470,000,000, outnumbering the followers of the various Christian churches.

I have called the sketches "Scenes from the Buddhist Holy Land," because not only was the "Great Law Giver" born at Kapila and died at Kusinagara, but many of his wanderings were in these parts, the inhabitants of which were the first to be converted to the new faith.

Buddhism has no theology, but is rather a system of "duty, morality, and benevolence without real deity, prayer or priest."

At a few fanatical centres of Brahmanism Buddhism was in time exterminated by force, but it is probable that generally speaking the two became gradually blended.

In the seventh century A.D. the Chinese traveller, Hwen Tsang, found the two flourishing amicably side by side. The following are a few extracts from the Archæological Survey Report regarding the discovery of the ruins:—

. . . .

"As I was actually in search of the famous colossal statue of the Nirvána of Buddha mentioned by Hwen Tsang, it struck me that I might possibly have the good fortune to hit upon some remnant of the famous statue. I ordered a shaft to be sunk perpendicularly downwards into the centre of the mound. After digging to the depth of 10 feet I came upon what appeared to be the upper part of the thigh of a colossal recumbent statue of stone, but which had apparently been repaired with plaster."

. . . .

"The statue was lying in a ruined chamber which was about 30 feet in length by nearly 12 feet in breadth."

. . . .

"The stone, of which the statue was formed, was sandstone of a mixed colour, mostly dark and clay colour."

. . . .

"The total length of the statue was about 20 feet and of the pedestal 24 feet, breadth $5\frac{1}{3}$ feet."

"The thickness of the walls of the temple on a level with the floor was nearly 10 feet."

. . . .

"The dimensions of the temple outside were about 47 feet 8 inches by 32 feet. But there was, besides, an outer chamber on the west side, which was about 35 feet 10 inches in length by about 15 feet in breadth outside, with walls about 5 feet thick."

. . . .

"I also entirely repaired and restored the *singhásan* or throne."

. . . .

"Affixed to the western side of the *singhásan* I found three sculptures, displaying three human figures, each carved in a shallow curved niche cut into a solid block of stone. The left-hand figure was that of a woman with long hair, in a posture of grief, and stooping or crouching forwards, with her hands resting on the ground, which I took to be a figure of Yasodhara, the wife of Buddha. The right-hand figure might be that of either a male or female and was in a sitting position, with the head resting on the right hand, as if in sorrow. I took this to be the figure of Rahula, the son of Buddha. The central figure was that of a man sitting in a squatting position, with his back turned to the spectator, and his face hidden from him, and turned towards the great statue of the Nirvána. On the lower part of the stone of this latter sculpture I was so fortunate as to find an inscription, in two lines, in characters of probably about the second century of the Christian era."

. . . .

"But in the inner door of the temple itself I made an interesting discovery. In two hollows, one on each side at the lower part of the doorway, I found the ancient cup-shaped iron pivot hinges of the former doors and adhering to the hinges I found some fragments of black charred wood, which showed that the doors had been destroyed by fire, and as numerous human bones and various charred substances were found in the outer chamber, as well as in both doorways, it was evident that Buddhism had here been annihilated by fire and sword." . . . . . .

"But the temple which I repaired was not the original or most ancient temple . . . for I discovered that the present temple was closely surrounded on three sides by the ruined remains of the base of

* Accounts give different dates.

another brick wall which extended from the front along the sides to within 6 feet of the back of the present temple."

. . . . "Besides the flight of steps leading up to the door of the present temple, I also discovered another lower and more ancient flight of steps running down from the west side of the great plinth in front of the temple. These ancient steps were lower than and about 10 feet distant to the west of the steps of the present temple." . . . .

"Close adjoining to the east side I excavated a row of small *stûpas*, five in number and of various diameters" . . . .

"At the greatest depth reached in the excavations I found a red *terra cotta* figure of Buddha, standing with his right hand raised in the attitude of teaching . . . to the east of the great *stûpa* I found a metal bell with a portion of a thin iron rod attached to it" . . . .

"I also found an ancient well at the depth of 10 feet below the surface of the mound, this ancient well was originally square below . . There is now good water in the well and people draw from it" . .

"It is plain that the present ruined pillar cannot be the one built by Asoka . . . It cannot even be a secondary *stûpa* which was reconstructed upon the remains of the Asoka *stûpa*, but I believe that the present *stûpa* represents a third structure which was reconstructed upon the same site and upon the ruined remains of the two former successive structures." . . . .

"In the other ruined *stûpa* which is situated some distance to the east, are found huge square bricks which must at least be as old as the period of Asoka, if not older, some being 1 foot 4 inches square by 4½ inches in thickness" . . . "it was erected on the spot where Buddha's body was burned."

Kasia (the ancient Kusinagara) was visited in the fifth and seventh centuries by the Chinese pilgrims Fa Hain and Hwen Tsang respectively. The latter says that Budhha died half a mile from the city, which General Cunningham identifies as the spot where the colossal statue is found. The mound where the cremation took place is also identified from the description of the Chinese.

Mounds of bricks are scattered all over the *pargana*. Ancient remains, many of them Jain, are found at other places, such as Padrauna, Saraia (Tappa Haveli), Satiaon and Fazal Nagar (Tappa Jhankaul). Mr. Carleyle, who made the excavations at Kasia, identifies this last named place as the city of Páwa, where Buddha is said to have rested and drank water or bathed before proceeding to Kusinágara on his last journey. No doubt reverential Buddhists would attach great importance to the right identification of such a "sacred" spot.

At the village of Lohangri (Tappa Sapahi Kuchia) are the foundations of an enormous building which can only have been the palace of a King or a huge Buddhist monastery.

When Mr. Edwin Arnold, the author of the beautiful poem the "Light of Asia" visited India two years ago, I wrote to invite him to pay a visit to the death place of Buddha, but he was unable to come, I regret to say. It would have been interesting to visit these scenes in the company of such an enthusiast.

(3) List of Illustrations.

Scenes from the "Buddhist Holy Land."

No. 1. A sketch of the ruins of the memorial *stûpa* built on the spot where Buddha Gautama died or "attained Nirvána." Also of the restored temple, of great antiquity, within which the colossal statue of Buddha was discovered. The cottage on the left of the picture is modern and is in ruins, and has been built on the foundations of an ancient building.

No. 2. A sketch of the ruined *stûpa* built in the third century B.C. on the spot where the body of Buddha was burnt. It is situated on the west bank of the Ramabhar lake. The ruins are close to Kasia, the ancient Kusinágara.

No. 3. View from the platform of the ruined *stûpa* and of the restored temple within which the colossal statue was found and where it now rests.

No. 4. A pen-and-ink drawing of the colossal statue by Ramnarain Bhagat, a resident of the Gorakhpur district.

No. 5. A pen-and-ink drawing of the black stone statue of Buddha seated under the Bodhi tree, and which rests where it was found within a few hundred yards of the *stûpa*. It is also drawn by Ramnarain.

Extract from the Narrative Report of Lieutenant S. G. Burrard, R.E., *in charge Nos. 22 and 23 Parties (Astronomical),—Season 1886-87.*

Latitude Operations.

As the Jubbulpore Meridional Series on which I was operating passes through the mountainous districts of the Central Provinces, and throughout its entire length contains no single plain station, I had much difficulty in selecting stations which would be apparently free from deflection of the plumb-line. The following stations were finally selected for the season's work :—Sarandi Pat, Lingmára, Sitápár, Bhimsain, Rájuli, Diwai, Ankora and Burgpaili, but (owing to my recall in March to carry out the experiments with the Transit Instruments) observations were only taken at the first five.

Zenith Sector No. 2 was used in preference to the sister instrument No. 1, owing to the large (N—S) equation shown by the latter when last employed in 1871-72.

The parties moved from Mussoorie to Dehra on October 8th for practice with Zenith Sector No. 1, and on November 5th started for Nágpur. Owing to the delay of the baggage in transit, the difficulty of obtaining new *khalásis* and *kahárs*, and the time consumed in bringing No. 2 Zenith Sector from Poona, work was not begun till November 25th. Having received orders to thoroughly overhaul the instrument before moving out into the districts, I built a latitude pillar at Nágpur and observed for latitude on eight different nights, taking 248 observations: some harassing peculiarities were constantly to be met with in manipulating the instrument, but on working out the results I found them too accordant for anything to be radically wrong, and consequently reported the instrument in good working order.

Whilst at Nágpur, I determined the values of the division scales of the vertical axis and transit axis levels, as also of all the spare levels with the parties. With the exception of the spare levels, these values had been determined before by Colonels Campbell and Heaviside, but both officers had thrown doubt on the correctness of their results. The instrument I used in these determinations was a bubble-tester from the Mathematical Instrument Office, and I found it to give excellent results.

Leaving Nágpur on December 8th I passed Seoni on December 15th, and reached Sarandí Pat, 160 miles from Nágpur, on December 19th. Owing to the pillar being unfinished, observations for latitude were not commenced till 23rd, they were completed on the 31st, and the parties set out for Lingmára the following day and arrived on January 7th: the observations here extending over six nights were completed on January 13th. Sitápár, the third station of observation, was reached on January 18th and work commenced the same night. I was much troubled at this station by clouds, but considered sufficient observations had been taken by January 23rd. I set out from Sitápár for Bhimsain on the following day, but was delayed for ten days at Sákoli, a *tahsil* town *en route*, owing to a disturbance between my *khalásis* and the police.

After setting up the instrument at Bhimsain on February 10th, and levelling it accurately, the steel spanner (used for clamping and unclamping the base-plate screw) unfortunately broke: I was therefore unable to adjust my level, and had to accept whatever error the instrument chose to show. Day by day this error increased until after work on the fourth night, the bubbles passed the 70th division of their scales: in finding the values of these scales at Nágpur, I had noticed that the uniform curvature of the tubes ceased about the 75th division on either side of the centre point: it was useless therefore to continue work, and only four nights' observations have been taken at Bhimsain: moreover, no reversal of the instrument in azimuth was carried out, as it cannot be done without disturbing the level. In spite of the absence of this reversal, the comparative fewness of the observations and the large inclination of the vertical axis, the probable error of the final value of co-latitude was as small as at others, due no doubt to the extremely favourable nights on which observations were taken. The spanner of No. 1 Zenith Sector forwarded from Dehra Dún reached me at Rájuli, my fifth station, where work was commenced on February 24th and concluded on March 1st, and I then marched for the railway terminus at Warora, and left the Central Provinces for Dehra Dún on the 12th March.

Method of observing.

The method followed throughout the season in taking the observations was practically the same as had been adopted by Colonels Herschel, Campbell and Heaviside when observing with the same instrument. The programme for a night's work was made to contain from 32 to 36 stars, and in drawing it up the following conditions were fulfilled:—

(1) All stars were to be selected from the latest Greenwich catalogue.
(2) No star was to be considered trustworthy unless its north polar distance was determined by at least six observations.
(3) 13° was to be the maximum zenith distance allowable.
(4) The number of north stars was to be equal to the number of south.
(5) The mean north zenith distance was not to differ from the mean south by ½°.
(6) Stars of an 8° zenith distance and more were to be paired.

I commenced at Nágpur by observing every star on four nights: on computing out the results I found that the probable error of co-latitude, as given by a single star observed four times, was $\pm 0''{\cdot}40$, whilst the probable error of the mean of the four zenith distances was only $\pm 0''{\cdot}18$. Starting with these data, the following probable errors admitted of easy deduction:—

P. E. of a single zenith distance observation $= \pm 0''{\cdot}360$,
P. E. of an N. P. D. computed from the Greenwich Catalogue $= \pm 0''{\cdot}357$.

The object of my observations being the determination of astronomical co-latitudes, and not merely of zenith distances, it became apparent that the accuracy of the results was as much affected by errors in N. P. D. as by all errors of observation combined, and consequently I deemed it advisable to increase the number of zenith distance observations and the number of stars observed simultaneously. An observer has four nights to devote to each station; with the above computed data as a basis, he can calculate the probable error of the result of his four nights' work, and from this he can see whether it is more advantageous

(1) to observe the same 40 stars on each of the four nights;
(2) to observe 40 stars on the first two nights and 40 fresh ones on the last two;
(3) to observe 40 fresh stars every night.

In each of the three cases the number of observations taken on the whole and the amount of work carried out would be the same. By utilising the results of an immense number of observations, I was able to make the following calculations :—

Probable Error of a co-latitude, deduced from	40	stars, each observed	four times	$= \pm 0''\cdot063$.
" " " " "	80	" " "	twice	$= \pm 0\ \cdot049$.
" " " " "	160	" " "	once	$= \pm 0\ \cdot039$.

The result therefore attained by observing 40 fresh stars on each of the four nights will be very much better than by observing 80 stars twice each. It is, moreover, easy of proof, that but slight advantage accrues at all from taking a third zenith distance observation *per* star, and that a fourth such observation is absolutely waste of time.

I had however reasons to suspect that the zenith distance of any star would vary according to whether it was observed with the azimuthal stud north or south and whether it was taken from east to west or from west to east. With this contingency in view I thought it best to observe each star on two nights, with azimuthal stud north on one night and south on the other; if on the first occasion it was taken from east to west, on the second I took it from west to east and *vice versâ.*

For the purpose of investigating the presence of these suspected instrumental errors the latitude at each station has been computed firstly from observations taken with the azimuthal stud north, and secondly from observations taken with the azimuthal stud south. If large differences had been found, it would have been necessary to apply a correction to the final value of latitude at Bhímsain, where (as mentioned before) no reversal of the instrument took place. But the mean value of these differences being only $0''\cdot019$, a quantity less than half the average probable error, we must conclude that the position of the azimuthal stud exercises no appreciable effect on the observations and that any correction for absence of reversal would be superfluous.

For similar reasons the stars have also been grouped, according to whether they were observed E. to W. or W. to E. and the values of latitudes computed in the two cases. It is an extraordinary fact, that on an average throughout the season any star observed W. to E. will give the latitude of the place half a second larger than the same star observed E. to W. Thus the latitude of any station derived from stars observed only W. to E. will be $0''\cdot25$ in excess of the true value, whilst the latitude derived from stars observed E. to W. will be the same amount in defect of the true value. Now the symbols E and W have relation only to the cardinal points, and do not refer to any particular position of the instrument: as far as the instrument itself is concerned, and without any reference to exterior objects the *same* process in changing from *E. to W. with stud north* is gone through as when changing from *W. to E. with stud south.* To gain further information, I combined all observations taken E. to W. with stud north and all observations taken W. to E. with stud south: the resulting latitudes differed from the true values in the mean by only $0''\cdot07$. Similarly I collected together all observations taken W. to E. with stud north and all taken E. to W. with stud south: the results derived from these also differed from the final mean values by $0''\cdot07$. These facts only help to intensify the perplexity of the E. to W. and W. to E. differences; these symbols in reality only indicate the position of the instrument with reference to the Observatory tent, and I am quite at a loss to assign a cause for the discrepancies brought to light.

After the discovery of the E. to W. and W. to E. differences, it will never be possible for the latitude of a place to be determined from stars only observed once each: the probable error of such a result would be $0''\cdot15$, and therefore although as I have shewn the P. E. of a co-latitude determined from 160 different stars each observed once is less than that of 40 stars each observed four times or of 80 stars each observed twice, yet, having regard to the necessity of observing each star E. to W. and also W. to E. the best possible arrangement would seem to be that of 80 stars observed on two nights each.

Defects in instrument.

The necessity of always determining a zenith distance by at least two observations greatly influences the improvements required in the instrument: the mean of two zenith distances is a much more reliable measure than the N. P. D. of the star given by the Greenwich Catalogue. It is of but little advantage to possess an instrument which gives highly accurate values of zenith distance if the N. P. D.'s are unreliable. Provided therefore the necessity of observing every star *both* E. to W. and W. to E. is fully recognised, Zenith Sector No. 2 as it stands at present is more than qualified to answer its purpose. The only improvement that I should like to see carried out, is the permanent attachment of the level tubes to the brass pivots: and this I recommend not with the object of attaining greater accuracy, but simply to relieve the observer of an ever-existing source of anxiety during the field season.

An observer working with Zenith Sector No. 2 is caused much annoyance by uncontrollable changes in the relative readings of the microscopes; it is of importance that the readings of the microscopes B, C, D, should be each some 10 divisions in excess of that of A, and at the commencement of a night's work the micrometer heads were invariably adjusted to attain this object. However, through some defect in the instrument, a constant relationship was not maintained, and numberless hindrances ensued in consequence. Suppose at starting the micrometers of the 4 microscopes are adjusted to read respectively

30, 40, 40, 40: after a very few observations they are found reading 30, 40, 30, 30 or perhaps 30, 40, 50, 50, and after a few more they will have reverted again to 30, 40, 40, 40. I wasted hours in futile attempts to trace the cause of this phenomenon, and it was only towards the close of the field season I satisfactorily discovered what it was. I can unhesitatingly state now that the black counterpoise does not always act with the same pressure, and consequently does not always raise the sectors the same amount with reference to the alidade. This irregularity of pressure must be due either to (1) the levers having longitudinal play and the relative lengths of their arms being thus able to vary; or (2) to the wear of the bearings in the front wall of the cradle, enabling the levers to find two different points as *fulcra;* or (3) to a fault in the relieving wheels, to which the short arms of the levers are attached.

This defect may without doubt be attributed to the serious accident that befell this instrument at Voi in 1872. I have mentioned it thus briefly, as it was a source of great uneasiness in the field, so much so that I considered it expedient to devote 6 nights to each station instead of 4. Having now computed out the final values of co-latitude, I find that it has no visible effect on the results; and if only future observers are fore-warned of the phenomenon, it will always he perfectly harmless.

The irregular readings of the levels caused me much uneasiness in the field; but when they were computed and exhaustively treated, the results arrived at were satisfactory as may be seen from the following table:—

STATION.	λ True values of latitude obtained by employing both levels.	λ_a Values of latitude obtained by employing *a* level only.	λ_b Values of latitude obtained by employing *b* level only.	$d\lambda_a = \lambda - \lambda_a$	$d\lambda_b = \lambda - \lambda_b$
Sarandí Pat . .	22°12′50″·706±·047	22°12′50″·750±·049	22°12′50″·660±·047	—″·044	+″·046
Lingmára . .	21°42′55″·409±·053	21°42′55″·457±·054	21°42′55″·360±·054	—·048	+·049
Sítápár . .	21°24′43″·868±·046	21°24′43″·884±·047	21°24′43″·851±·049	—·016	+·017
Bhímsain . .	20°57′28″·595±·045	20°57′28″·485±·048	20°57′28″·704±·045	+·110	—·109
Rájulí . . .	20°12′51″·293±·037	20°12′51″·276±·039	20°12′51″·310±·038	+·017	—·017
Means .	±·046	±·047	±·047	+·004	—·003

The mean values of $d\lambda_a$ and $d\lambda_b$ are absolutely insignificant; the mean probable errors of λ_a and λ_b are the same, and only 0″·001 in excess of the probable error of λ. The relative worths of the two levels are therefore so nearly equal, that probable errors do not afford sufficiently minute data for comparison: all we learn by their means is that it is better to employ the readings of both levels than those of either one separately, but that even then the advantage gained is so insignificant as to be barely visible. Now if one level was decidedly superior to the other, it would of course be advantageous to entirely reject the readings of the inferior, and the fact that both levels combined give better results than either separately, is a clear indication of perfect equality.

Final results.

The final results of the observations are as follows:—

STATION.	Number of stars observed.	Number of observations.	(N—S) equation.	λ_0 Astronomical Latitude.	λ_0 Geodetic Latitude.	$\lambda_0 - \lambda_0$ = Apparent attraction of plumb-line.
Sarandí Pat. .	53	183	+″·380	22°12′50″·706±·047	22°12′55″·61	—4″·90 North.
Lingmára . .	68	182	+·102	21°42′55″·409±·053	21°43′ 3″·07	—7″·66 „
Sítápár . .	66	166	—·186	21°24′43″·868±·046	21°24′50″·54	—6″·67 „
Bhímsain . .	68	134	+·282	20°57′28″·595±·045	20°57′35″·96	—7″·37 „
Rájulí . . .	88	174	+·448	20°12′51″·293±·037	20°12′55″·45	—4″·16 „

The mean (N—S) equation for the season is +0″·205; this is unusually small, and considering that errors in refraction directly tend to produce this equation, I think we may safely assume that Zenith Sector No. 2 is wholly free from the great defect that renders the sister instrument useless.

After the harassing phenomena so frequently met with in the manipulation of the microscopes and levels, I was much surprised at the accuracy of the results finally shewn up by the probable errors; the comparative magnitude of the probable error at Lingmára is due to one refractory star, No. 590, the value of co-latitude derived from which was 1″·78 in excess of the final mean.

The differences between the astronomical and geodetic latitudes shew how impossible it is to even roughly estimate the probable deflection of the plumb-line from the view of the country round or from the study of maps. At Sarandí Pat I expected a very large northerly attraction, whilst at Bhímsain and Rájulí I saw no reason for supposing a deflection in either direction. At Lingmára and Sítápár the view pointed to northerly attraction, but both stations appeared suitable for latitude observations and very superior to Sarandí Pat.

Electro-Telegraphic Longitude Operations.

These operations consisted of the determination on 16 different nights of the difference of longitude between two stations in Dehra Dún, built on the same meridian and 17 yards apart. The work was purely experimental, its object being to localise the source of the large circuit errors that obtained in the season 1885-86. Mr Eccles and myself were the observers, and the Transit Instruments employed were those that have always been used on this work. The numerous theories that had been broached as to the cause of these errors, formed the basis for our programme, which was so arranged that all the questions hitherto mooted were expected to receive their answers from our results. The various conjectures that had been made may be briefly summed up as follows:—

(1) That our method of determining collimation was erroneous, in that the readings of a collimator cross are sensibly different when taken with uninterrupted vision, and when view is obtained through the aperture in the cube of the telescope, whereas we assume them to be the same.

(2) That the velocity of an electric current from A station to B is not the same as from B to A, whereas our method of reduction is based on the hypothesis that it is.

(3) That personal equation is liable to large and sudden variations from night to night.

(4) That there exist certain natural phenomena, of whose presence and laws we are ignorant, but whose influence on our results is considerable.

(5) (*a*) That the telescopes possess constant residuals which should be allowed for in the computations, but which have never been determined.

(*b*) That the telescopes are so defective in construction that the line of collimation in each possesses the power of moving $0^s{\cdot}25$ either to the east or west at any time of the day and night without giving any indication of the fact.

Readings of a Collimator Cross.

The experiments on the suspected change of reading of a collimator cross were carried out by Mr. Eccles. The telescope was first placed in position and in intersecting the cross of the northern with the vertical wire of the southern collimator, view was obtained through the aperture in the cube; with these conditions holding, four readings were taken and recorded. The telescope was then removed and four readings obtained with uninterrupted vision. This process was repeated four times in each pivot position of both telescopes, and ample data was thus afforded for the required comparison. In spite of the large and constant difference found at Greenwich the only conclusion to be drawn from Mr. Eccles' results is that the north collimator readings are not in any way affected by the interposition of a telescope.

Velocity of Electricity.

The experiments made with the purpose of discovering the time taken by an electric current in traversing the distance from A station to B, and that taken by the same current in returning from B to A are fully described elsewhere in this Report. It will suffice to state here that conjecture No. (2) was found to be directly contradicted by the results, but that the circuit errors of 1885-86 were not sensibly improved by the application to each arc of the newly deduced correction for "electric rate."

Method of Observation.

The first two conjectures being, therefore, proved insufficient to account for the unexplained phenomena, a programme of star observations was accordingly drawn up, so that the confirmation or confutation of the remaining three was reasonably considered to be assured.

From the experimental arc of May 1886 we knew that, though the difference of longitude between the two stations at Dehra Dún was actually $0^s{\cdot}000$, yet by observation it was $0^s{\cdot}180$. The present observations had now to decide whether that erroneous (*i.e.*, observed) value was due to inconstancy of personal equation, to unknown telescopic errors, or to some physical cause; the programme was, therefore, made to contain certain judicious interchanges, between the two stations, of telescopes and observers, by which means a localisation of the cause of error would, it was thought, be probably much facilitated. If the *observers* could change both their stations and telescopes without any effect on the results being exhibited, the theory of variable personality would have to be abandoned: if on the other hand the *telescopes* were interchanged between the two stations and no difference of result ensued, the absence of instrumental defects would be established, if finally it was found that *whatever* arrangement of telescopes and observers was adopted, the value of Δ L *never* varied, there would remain but the one conclusion that for some unknown reason and in spite of meridional identity, stars do not apparently transit simultaneously at the two stations.

The work was divided into four arcs, to each arc were devoted four nights, and on each night 40 stars were observed. With two telescopes four combinations of pivot positions are possible, and we so arranged that on no two nights of any one arc, the same combination should prevail. Of the 40 stars observed nightly, 32 were taken for the determination of the difference of longitude, and the remaining 8 for personal equation.

During the first arc Mr. Eccles observed at the northern station with telescope No. 2, and I at the southern with telescope No 1. We then changed stations leaving telescopes standing: between the 2nd and 3rd arcs we moved back to our original stations, this time taking our telescopes with us; and between the 3rd and 4th we again changed over, leaving as in the first instance all equipment behind.

Results.

The results of the observations taken on the first night of the first arc are unfortunately so discrepant and erratic and moreover so clearly indicate want of skill on the part of the observers, that I have considered it necessary to reject that night's work *in toto* and consequently the final value of ΔL as given by the first arc, being derived from the results of three nights' work only, is not entitled theoretically to the same weight as are the values of the other arcs.

The observations of the last 15 nights, though of no high order of merit, would easily bear comparison with those taken on the arcs of 1885-86. I give this as my deliberate opinion, after having closely examined the two side by side, though their relative value, important as it is to establish, does not in the absence of a recognised standard of excellence admit of mathematical demonstration.

The results of the observations were as follows :—

Arc.	Observer and Telescope.		Difference of Longitude.
	Northern Station.	Southern Station.	
No. 1.	Eccles with Telescope No. 2.	Burrard with Telescope No. 1.	$+0^{s}{\cdot}048$
Interchange of observers only.			
No. 2.	Burrard with Telescope No. 2.	Eccles with Telescope No. 1.	$+0^{s}{\cdot}051$
Interchange of both Telescopes and Observers.			
No 3.	Eccles with Telescope No. 1.	Burrard with Telescope No. 2.	$+0^{s}{\cdot}092$
Interchange of observers only.			
No. 4.	Burrard with Telescope No. 1.	Eccles with Telescope No. 2.	$+0^{s}{\cdot}075$

Variability of personal equation.

Between the 1st and 2nd arcs as also between the 3rd and 4th the observers changed stations leaving telescopes standing and other conditions in *statu quo*. The effect of the change was in the first instance to *increase* the value of ΔL by $0^{s}{\cdot}003$, and in the second to *decrease* it by $0^{s}{\cdot}017$, the mean difference caused being $0^{s}{\cdot}007$. Now as the circuit errors amount to three-tenths of a second, it is useless to pay any regard to such quantities as $0^{s}{\cdot}007$, and if it were not for other considerations we might by the light of this result at once discard all theories based on the unsteadiness of personal equation. There are however two facts directly bearing on this question and which cannot be overlooked: one is that in December 1885, when the first interchange of observers was carried out, the result with Strahan at Agra and Heaviside at Amritsar differed from the result with Heaviside at Agra and Strahan at Amritsar by no less than $0^{s}{\cdot}081$; and the other is, that although the values of all the four arcs are in remarkable accordance, yet the nightly values of ΔL from which these final means are derived frequently differ from the latter by $0^{s}{\cdot}15$. These two facts, though in nowise tending to establish mutability of personal equation, suffice to raise one's suspicion that the quantity $0^{s}{\cdot}007$ must be fortuitous and due to cancelment of errors; and in spite of all the precautions taken in drawing up the programme if another distinct source of information had not been available, the question of variable personality might still have remained unsolved.

We had always during the Dehra Dún experiments made a practice of observing 40 stars *per* night instead of the customary 32, the nightly number on regular longitude work: the additional 8 were set apart for the determination of personal equation, a separate value of which therefore exists for every date on which observations were taken. We are thus able to make a direct comparison between the simultaneous variations of personal equation and difference of longitude and thence decide whether the latter is a function of the former.

Table I* has been constructed for the purpose of illustrating this comparison: the

* Table I has been incorporated in the graphical illustration facing page 61 in Part II, where it appears as Diagram No. 1.

chain-dotted line indicates both the true value of ΔL and the mean adopted value of Personal Equation: the thick curve shows the nightly variations of ΔL, and the thin curve those of personal equation: the latter has been so drawn that it would become, if nightly values of personal equation were employed in the Reductions instead of a General Mean, the Zero line of ΔL, and the nightly value of Difference of Longitude under those conditions, would always be the distance between the two curves.

Although a slight mutual attraction between the two curves is undeniably detectable, yet the aberrations of the thin are confined to such insignificant limits when compared to those of the thick, that any attempt to prove the latter to be due to the former cannot but fail. The question as to the possibility of large and sudden changes occurring in the absolute personal equation of any observer has, in my opinion, been conclusively answered in the negative, and no theory based on personal peculiarities can well be advanced again to account for the existence of the circuit errors.

Unknown physical influences.

There is a decided tendency, whatever arrangement of observers and telescopes be adopted, for the value of ΔL to be positive, in other words for the north station to be shewn west of the south. Every possible combination between the stations, telescopes, and observers was made during these experiments, and a positive value was the invariable outcome. The experimental arc of May 1886 coincided in its arrangement of telescopes and observers, with the single exception that Major Strahan was observing instead of Mr. Eccles, with the first arc of this season, and its result was $+0^{s}\cdot180$.

The thick curve in Table I shews such a marked bias for the positive side of the zero line, that I cannot but believe in the existence of some unknown physical influence. I have made several attempts to classify the various sources of error *without* including natural phenomena among them. A classification which has any claim to credit must contain sufficient data to enable the result of every single observation, however wild, to be satisfactorily explained, and I have no hesitation in saying that it is absolutely impossible by any system of errors to account for all the discrepancies in our work, *unless* we admit the presence of some secret physical force. Hereafter in this report each arc is shown to be affected by a positive error of $0^{s}\cdot014$ owing to the unequal resistances offered to currents by the two chronographs, and as the mean value of the 4 arcs is $+0^{s}\cdot066 \pm \cdot007$, it may be assumed that the difference ($0\cdot066 - 0\cdot014 = +0^{s}\cdot052$) is a fairly accurate estimate of the constant error attributable to extraneous sources. It is worthy of remark that a natural phenomenon, if its effects remain invariable, though it produces an error in every arc, does not exercise any pernicious influence on the circuits. The experimental arc of 1886 rather goes to prove that the phenomenon discussed above is by no means an unchanging agent, and that consequently the error generated is a function both of the locality and season, in which the observations were taken.

Instrumental errors.

The presence of a pivot error in either telescope has been emphatically denied by the results of these observations; a small telescopic residual, independent of pivot position, does however exist: whether entirely confined to one of the telescopes or partially due to both, we have no means of deciding. All we know is that the interchange of telescopes had the effect of increasing the mean value of ΔL by $0^{s}\cdot033$. I deduce from it the axiom that with telescope No. 1 at the northern station the arc will be $0^{s}\cdot017$ too large and with telescope No. 2 the same amount too small.

Instrumental defects have been proved to be the main source of error; there is no clue as to where they exist, nor as to whether they are present in both telescopes or only in one. The maximum error in a single value of ΔL, that can arise from this cause is $0^{s}\cdot175$ from which we may assume that $0^{s}\cdot088$ is the maximum error in the time of transit of a star, that can arise from telescopic defects. It seldom happens that these extreme limits are reached in either telescope, and still more seldom that both telescopes exert their full powers of harm at one and the same time, but unfortunately the defects are so constituted, that the generated errors cannot be wholly classed as "accidental" in the usual acceptation of the term, and on this account their final effect may be unduly large. The telescopic errors are peculiar in that they remain constant throughout any one night, and affect every star on that night to an almost identical degree. It is a rare occurrence for two stars observed on one night to give results differing by $0^{s}\cdot15$, whilst the mean results of two whole consecutive nights frequently disagree by $0^{s}\cdot30$, occasionally by $0^{s}\cdot40$, and once on the Agra-Mooltan arc by $0^{s}\cdot52$. The telescopic errors however possess the property of vanishing, if observations are multiplied, and are therefore to a certain degree related to the "accidental" family; suppose for example on these experiments we take the value of ΔL to be equal to (telescope No. 1—telescope No. 2) throughout, in lieu of to (northern station—southern station), we then get a final result of $+0^{s}\cdot017$, whether the "station" correction of $+0^{s}\cdot052$ is applied or not, and it would be difficult to improve on this. I think it a fairly satisfactory proof that the instrumental errors, peculiar as they are, do cancel on the multiplication of observations. The increase in number should however be made not by observing more stars *per* night but by devoting more nights to each arc: difference of longitude has hitherto been determined by 180 observations, distributed equally over six nights; a better result would be indubitably obtained if 15 stars were observed on twelve nights, though the total number of observations would remain the same; and I feel pretty convinced that if 9 stars were observed on twenty consecutive nights for the determination of every arc, we should never hear of circuit errors again.

The several sources from which the circuit errors have been shown by the results of the Dehra Dún experiments to *most probably* proceed, are classified in the following table:—

Classification of errors.

Class.	Source.	Maximum possible error.	Remarks.
Telescopic.	(1) Inherent difference between the two telescopes.	$0^s{\cdot}017$	Constant in sign and amount.
	(2) Defects in telescope No. 1 . .	$\pm 0{\cdot}088$	Only to be eliminated by increasing the number of nights *per* arc.
	(3) Defects in telescope No. 2 . .	$\pm 0{\cdot}088$	Ditto ditto.
Not known.	Physical phenomena	$\pm 0{\cdot}052$	Probably due to atmospheric heterogeneity.
Electrical.	(1) Inequality of resistance offered to electric currents by the two chronographs.	$0{\cdot}014$	Always present and constant in sign and amount.
	(2) Relay adjustments . . .	$\pm 0{\cdot}010$	
	(3) Exceptional resistance offered to currents *locally* by bad connections, weak batteries, &c.	$\pm 0{\cdot}040$	This error seldom exceeds $0^s{\cdot}020$, but attained its maximum value on two, if not three, nights of the Agra-Mooltan arc.

The actual discovery of some particular instrumental defect cannot in reason be expected to ensue from mere star observations, and if the arguments are admitted, by which the several sources of error have in the above table been localized, the object of the experiments will, I consider, have been fully attained.

The Electrical Experiments.

Owing to the peculiar results that obtained on the Agra-Mooltan arc, suspicions were aroused that star-signals might not be recorded by electrical means as instantaneously as had hitherto been supposed. The object of these experiments was to gain information on this subject in general, of which but little or nothing was known, as well as to solve in detail the several questions that had been raised. As a rule, on any arc the results derived from observations with 'east' clock are $0^s{\cdot}06$ less than those of observations with 'west' clock: the difference is of course equal to the time that the current is retarded in traversing the distance from the east station to the west, and returning again from the west to the east; we have always *assumed* that the retardation of a current travelling from the east station to the west is the same as when returning from west to east, and that if the whole time occupied in both journeys is $0^s{\cdot}06$, that spent on each is $0^s{\cdot}03$. This assumption was based on the idea that the retardation was almost wholly due to the line wire traversed, which is necessarily the same in both cases, and not to local connections at all. On the appearance of the circuit errors all arbitrary assumptions were examined, and much doubt thrown on the basis of the electrical hypothesis. The questions mooted may be summed up as follows :—

(1) Is retardation due to length of line wire?
(2) Is it affected by a change in battery-power?
(3) Will an alteration in the relay adjustments affect it?
(4) Are the retardations in the two chronographs, caused by local connections, relays, and pen-coils, sufficiently insignificant to be considered equal?
(5) Would it be possible from electrical phenomena alone for the value of an arc of longitude to be outside the two values as given by the 'east' and 'west' clocks and not between them?

Method of observing.

In carrying out the experiments the following arrangements were made:—the two chronographs were set up in one room and worked throughout under the same conditions as hold in a regular arc. They were made in fact to represent the two terminals of an arc, and all connections were as usual. First A chronograph 'sent clock' to B by means of a line battery and line wire, and then B 'sent clock' to A. The pens, the relays and the sounder were all worked by the customary local batteries. The *raison d'être* of the experiments necessitated however one departure from rule—instead of each observer having a tappet to record signals on his own chronograph, one and the same tappet was made to work a pen of both chronographs simultaneously. This was effected by putting the tappet and a pen of both chronographs all into one circuit, worked by a local battery, so that whenever the circuit was broken by means of the tappet, the instant of its being done was recorded on both chronographs. During ordinary work one stud of the tappet is connected to the commutator board and the other taken direct to earth: in these experiments the commutator board of A chronograph was connected to one stud of the tappet, whilst the wire attached to the other instead of going direct to earth passed through B chronograph first. For the first half of the experiments the clock worked the A pen and the tappet the B pen of both chronographs, for the second half this arrangement was reversed.

Explanation of appended table of results.

An abstract of the results is given hereafter in tabular form. Column I gives the reference number of the observation as distinguished on the chronograph records: column II shews the number of cells on the line battery, and column III the chronograph that was "sending clock." In column IV are given the relay adjustments: T_A denotes the translating relay of A chronograph, and R_A the receiving relay: T_B and R_B are similarly the translating and receiving relays of B chronograph: the words "to inner extreme" mean that the adjusting screw of the relay was screwed inwards as far as possible without allowing the tongue to stick, and those "to outer extreme," that a contrary motion was imparted, until the tongue was immovable: the position of the name of the relay in the column shews when the re-adjustment took place. Columns V and VI give the readings of the tappet marks, as recorded respectively by the two chronographs: column VII is the difference of these two readings and is the retardation: if the sign is positive, B chronograph has been retarded, if negative, A. Column VIII is the change in retardation.

Assumed basis.

Before discussing the results at all we have to make one assumption: it is that when the tappet breaks its circuit, the signal on each chronograph is recorded simultaneously; in other words, that the retardation of the tappet current is constant throughout its progress. To justify this assumption we have the following facts:—(1) A pen of each chronograph was worked directly by the tappet; (2) with the exception of the pen coils, the whole length of wire was under 15 yards; (3) any retardation due from pen coils is eliminated by pen equation; (4) except the 15 yards of wire and the pen coils no other source of retardation existed.

It is important to note that when a tappet signal as read off from the A record is *earlier* than the same signal read off from the B, it is the A chronograph, and not the B, as might appear at first sight, that has been affected by retardation; the reason is that it is the clock current (traversing relays), and not the tappet current, which has to overcome the resistance: the tappet signals are recorded instantaneously, but those marking seconds from the clock are always late.

Effect of length of wire.

Length of the line wire has been found not to be, as was supposed, the *sole* cause of retardation, but on the contrary to have a wholly inappreciable effect; on a regular arc the line wire is from 500 to 1,000 miles, whilst in these experiments it could never have exceeded 10 yards: the retardations in the two cases are however identical

Effect of alterations in battery power.

The strength of the line battery was to start with 24 cells; between observations 4926 and 4927, *vide* Abstract of results, it was reduced to 12 cells, and it was subsequently altered to 2, 4, 12, and 24 cells again. We thus have five changes in the strength of the line battery to examine, all other conditions before and after remaining the same. The results point clearly to the following conclusions:—

(1) that with a very weak battery, when difficulty is experienced in working the pens at all, the retardation is greater by $0^s{\cdot}02$ than with a strong battery;

(2) that when once the battery is sufficiently strong to easily work the pens, no further increase in its strength will diminish the retardation.

As the current that runs from east to west is generated by the east battery, and the returning one by the west, these results are very welcome; if retardation had varied directly with battery weakness, it would have been necessary in order to secure an equality of retardation on the two opposite currents, to have worked with batteries of identical power. It has, however, been proved, that if both observers see their pens to be easily worked by the batteries, difference of strength will not be a source of error, and no trouble need be taken to minimise it.

Effect of re-adjustment of relays.

By referring to column VIII of the table we can see the effect on retardation of altering a relay adjustment. A change from outer to inner extreme *always* increases the value of this quantity, and a change from inner to outer *always* decreases it; the amount of the increase and decrease is generally $0^s{\cdot}01$, and on only four occasions greater than $0^s{\cdot}02$. The smallness of these numbers might lead one to doubt their reality, but the remarkable constancy in sign shews them to be absolutely reliable. It may, therefore, be considered established, that relay adjustments exercise an appreciable effect on retardation, but that however little the attention paid to them by the observer they could never cause in any arc an error larger than $0^s{\cdot}01$.

Absolute values of the retardations in the two chronographs.

We now come to the most important question of all, *viz.*, whether the retardations in the two chronographs are equal. The last paragraph pertained to the *variation* caused by re-adjustment of relays, whilst this has to deal with the *absolute value* of retardation, caused by the relays in their normal adjustment: in the present experiments the resistance of the line wire was *nil*, that of the pen-coils was eliminated by the application of the pen equation, and the retardation in the chronographs was consequently due to the relays alone. The amount of this retardation is given in column VII of the table where the sign + denotes that B chronograph is behind A, and the sign -- that A is behind B. When A 'sends clock,' the current passes through the relays T_A and R_B, to which the retardation of B is therefore due. A 'sent clock' on three different occasions, and 18 values in all are available. The retardation of B chronograph $= T_A + R_B = 0^s{\cdot}013 \pm {\cdot}004$. B 'sent clock' on four occasions and 19 values in all are available; the retardation of A chronograph $= T_B + R_A = 0^s{\cdot}041 \pm {\cdot}004$. The retardations in the two chronographs instead therefore of being equal are under ordinary conditions and with normal adjustments of relays respectively $0^s{\cdot}013$ and $0^s{\cdot}041$. This discrepancy causes an error in every arc of $\frac{{\cdot}041 - {\cdot}013}{2} = 0^s{\cdot}014$, the value of ΔL being that amount too large, when B chronograph is at the east station, and the same amount too small when B chronograph is at the west station.

Possible effect of retardation on an arc.

Referring now to question (5) let the true astronomical value of an arc of longitude be $0^m 5^s{\cdot}463$, and let A chronograph be at the eastern station. Suppose the electrical conditions to be ordinary, and the relay adjustments normal, then the value of ΔL by observations with east clock will be $0^m 5^s{\cdot}463 — 0^s{\cdot}013 = 0^m 5^s{\cdot}450$, and the value of the same by observations with west clock will be $0^m 5^s.463 + 0^s{\cdot}041 = 0^m 5^s{\cdot}504$. The resulting value of the arc, being the mean of these two, will equal $0^m 5^s{\cdot}477$ or $0^s{\cdot}014$ in excess of the true value. This error will always prevail under ordinary conditions.

We want now to find what the maximum error is that can be possibly caused in an arc by retardation: both on the Agra-Mooltan arc and during these experiments the sign of the retardation when A was 'sending clock' was negative occasionally. Taking the most unfavourable values possible from the table we get $T_A + R_B = -0^s{\cdot}02$, and $T_B + R_A = -0^s{\cdot}09$: then the value of the arc $0^m 5^s{\cdot}463$ by observations with east clock will be $0^m 5^s{\cdot}483$, and the value by observations with west clock will be $0^m 5^s{\cdot}553$: the resulting value obtained is $0^m 5^s{\cdot}518$, being $0^m 0^s{\cdot}055$ in error, and the true value lies *outside* the east and west results and not between them.

Final conclusions.

The final conclusions to be drawn from these experiments are: (1) that length of line wire has no effect on value of ΔL; (2) that strength of battery has also no effect, *provided* it is sufficiently strong to work the pens with ease; (3) that relay adjustments should be kept the same throughout any one arc and altered as slightly as possible from arc to arc, but however made they cannot cause an error larger than $0^s{\cdot}01$; (4) that every arc contains an error of $0^s{\cdot}014$ due solely to electrical differences between the two chronographs; (5) that an arc under very exceptional conditions, might be affected from the same cause by an error of $0^s{\cdot}055$, but never by a greater.

Abstract of Results of the Experiments on Retardation.

Reference No. of Observation.	Number of cells on line battery.	The sending chronograph.	Re-adjustments in Relays.	Reading by A chronograph, means of 5 signals.	Reading by B chronograph, means of 5 signals.	A—B= Retardation.	Change in Retardation.	REMARKS.
I	II	III	IV	V	VI	VII	VIII	IX
	24	B						Pen equation (Q) positive.
4921	,,	,,		0·60	0·65	—·05		
			T_B to outer extreme . .				·01	
4922	,,	,,	,,	·46	·50	—·04		
			R_A to outer extreme . .				·01	
4923	,,	,,	,,	·62	·65	—·03		
		A					·05	
4924	,,	,,	,,	·65	·63	+·02		
			R to outer extreme . .				·01	
4925	,,	,,	,,	·57	·54	+·03		
			T_A to outer extreme . .				·00	
4926	,,	,,	,,	·40	·37	+·03		
	12						·03	
4927	,,	,,	,,	·40	·40	+·00		
			T_A to inner extreme . .				·00	
4928	12	A	,,	0·25	0·25	+·00		
			R_B to inner extreme . .				·07	
4929	,,	,,	,,	·43	·36	+·07		
		B					·10	
4930	,,	,,	,,	·07	·10	—·03		
			T_B to inner extreme . .				·01	
4931	,,	,,	,,	·34	·38	—·04		

Abstract of Results of the Experiments on Retardation—contd.

Reference No. of Observation.	Number of cells on line battery.	The sending chronograph.	Re-adjustments in Relays.	Reading by A chronograph, means of 5 signals.	Reading by B chronograph, means of 5 signals.	A—B= Retardation.	Change in Retardation.	REMARKS.
I	II	III	IV	V	VI	VII	VIII	IX
	12	B	R_A to inner extreme . .				·04	
4932	,,	,,	,,	·50	·58	—·08		
	2						·01	
4933	,,	,,	,,	·07	·16	—·09		
		A					·13	
4934	,,	,,	,,	·42	·38	+·04		
	4						·06	Change from Q + to Q— 2 cells no longer sufficient on line battery.
4935	,,	,,	,,	·26	·28	—·02		
			T_A to outer extreme . .				·00	
4936	,,	,,	,,	·30	·32	—·02		
			R_B to outer extreme . .				·01	
4937	,,	,,	,,	·56	·57	—·01		
		B					·06	
4938	,,	,,	,,	·39	·46	—·07		
			T_B to outer extreme . .				·04	
4940	,,	,,	,,	·15	·18	—·03		
			R_A to outer extreme . .				·01	
4941	,,	,,	,,	·09	·13	—·04		
	12						·02	
4942	,,	,,	,,	·53	·55	—·02		
			R_A to inner extreme . .				·02	
4943	,,	,,	,,	·57	·61	—·04		
			R_A to outer extreme . .				·01	
4944	,,	,,	,,	·64	·69	—·05		
			T_B to inner extreme . .				·04	
4945	,,	,,	,,	·45	·54	—·09		
		A					·09	
4946	,,	,,	,,	·42	·42	+·00		
			R_B to inner extreme . .				·01	
4947	,,	,,	,,	·51	·50	+·01		
			R_B to outer extreme . .				·01	
4948	,,	,,	,,	·46	·46	+·00		
			T_A to inner extreme . .				·02	
4949	,,	,,	,,	·26	·24	+·02		
	24						·00	
4950	,,	,,	,,	·09	·07	+·02		
			R_B to inner extreme . .				·01	
4951	,,	,,	,,	·45	·44	+·01		
			R_B to outer extreme . .				·01	
4952	,,	,,	,,	·18	·16	+·02		
			T_A to outer extreme . .				·01	
4953	,,	,,	,,	·24	·23	+·01		
		B					·06	
4954	,,	,,	,,	·46	·51	—·05		
			T_B to outer extreme . .				·02	
4955	,,	,,	,,	·49	·52	—·03		
			T_B to inner extreme . .				·01	
4956	24	B	,,	·41	·45	—·04		
			R_A to outer extreme . .				·02	
4957	,,	,,	,,	·06	·08	—·02		
			R_A to inner extreme . .				·01	
4958	,,	,,	,,	·55	·58	—·03		

Extract from the Narrative Report of MAJOR J. HILL, *in charge No. 25 Party,— Season 1886-87.*

TIDAL OPERATIONS.

I now describe briefly the working of each observatory, commencing with those at Aden and Kurrachee and following the order of the stations round the coast.

Aden.—The self-registering tide gauge has worked very satisfactorily, no interruptions having occurred in its registrations during the first seven months of the survey year, and only four short and unimportant interruptions since then.

The self-registering aneroid by Adie has worked without a single interruption throughout the year. The self-registering aneroid by Légé has also worked continuously, but while it is merely being kept in reserve its diagram is not renewed.

The self-registering anemometer has only suffered one interruption. On the 16th February one of the cups was broken by the signal halliard of the flag-staff whilst the flags were being hoisted ; but the damage was repaired on the following day and the instrument set working again.

On the 4th April the observatory clerk reported that a distinct shock of earthquake was felt at the observatory at 3-50 P.M., and on the 11th April he reported that a second similar shock occurred at 8-15 A.M. The tidal curves however give no indication of any disturbance.

The Aden tidal observatory was not inspected during the year. The last inspection of it was made by me in August 1886.

Kurrachee.—Throughout the Survey year the self-registering tide gauge at this station has worked very satisfactorily, only one interruption worth noticing having taken place. That interruption was caused by the driving clock stopping on the 16th of November and being under repair until the 20th of the same month. It was repaired and cleaned by the harbour works fitter, and has worked very well ever since.

The self-registering aneroid also worked most satisfactorily, and there was no interruption of any importance in its registrations during the year ; it was cleaned in November by the harbour works fitter.

The self-registering anemometer has worked well. The harbour works fitter cleaned its clock in January and the rest of the apparatus in April.

I inspected the observatory towards the end of March accompanied by Sub-Surveyor Dhondu Venayek and found the instruments and everything else connected with the observatory clean and in perfect order. The last inspection was made as far back as November 1884 ; but frequent inspections of this observatory by the officer in charge of the tidal operations or by his tidal assistant are not necessary owing to the admirable arrangements of Mr. Price, the Port Engineer, who continues to watch over the working of the observatory with as great an interest as ever, and who has appointed an overseer to make daily visits to the observatory and to take periodical measurements for determination of zero, &c., and one of the harbour works fitters to do the necessary cleaning and repairing of the instruments.

Bhávnagar.—The registrations of the self-registering tide gauge at Bhávnagar have been satisfactory throughout the year. The cylinder was flushed out every fortnight ; on each of these occasions there is necessarily a short break in the registrations, lasting from two to four hours, which is supplied by interpolation when the gauge is re-started. The accidental interruptions were few and unimportant, except one which occurred on the 8th April, when the silvered wire between the pencil and the float broke at 9 P.M. It was renewed at 4 P.M. the following day. This interruption is unimportant in itself ; but if the wire were to break again before zero measurements are obtained, the registrations between the two breaks might then become vitiated.

The self-registering aneroid and anemometer have continued to work well, only a few unimportant interruptions having occurred in their registrations through the stoppage of their clocks.

I inspected the observatory during the week embracing the last days of November and the first days of December, accompanied by Sub-Surveyor Dhondu Venayek and the watchmaker of the party, and found the observatory remarkably well constructed and most conveniently adapted to its purposes. Everything was in good order and the clerk understood his duties. Thanks are due to Mr. Proctor Sims, the State Engineer, and his assistants, for the interest they continue to take in the working of the observatory.

The tides at Bhávnagar are remarkable in one respect : the water rises gradually to high-water, when a long pause of about an hour and twenty minutes occurs, after which the water sinks more rapidly than it rose. The top of the tidal curve is very level throughout the pause, and the practical effect of this peculiarity is that the water for about 40 minutes before and after every high-water may be considered to be at the same level as the height of high-water given in the Tide Tables. The tidal observatory stands on the right bank of the Kálubhár river about 4 miles above its mouth, in tidal waters. The river flows eastwards into the gulf, the shores of which extend north and south from the mouth of the river, and the peculiarity of the tides at the observatory would seem to be due to the presence of a long bank situated in the gulf close to the mouth of the river, following the direction of the coast line both to the north and south.

Bombay (*Apollo Bandar*).—There is neither aneroid barometer nor anemometer at this observatory; but the self-registering tide gauge, as usual, worked extremely well, in spite of the fact that some of its parts were nearly worn out and had to be renewed.

I inspected the observatory towards the end of November, when everything was going on satisfactorily. I was accompanied in my inspection by Sub-Surveyor Dhondu Venayek and the watchmaker of the party. The old float band had to be renewed and the bottom of the float had become so thin that I arranged with the Port Trust Engineer for having a new one made as soon as possible. The driving clock had also to be removed and sent to Messrs. Favre Leuba and Co. for repair, and while this was being done the Port Trust Engineer most kindly provided men to assist the observatory clerk in taking registrations every quarter of an hour day and night which were entered by hand on the tidal diagrams, thus securing continuous registrations. After completing these arrangements I went on to Bhávnagar to make the inspection of that observatory. On my return to Bombay early in December, I found the new float ready, so I left Dhondu Venayek to attach it in lieu of the old one and went to Poona for a couple of days to attend to work there. On returning I made my final inspection and left the tide gauge clean and in thoroughly good working order, with the exception of the clock which was still in Messrs. Favre Leuba's hands. Major Baird was at this time acting as Mint Master in Bombay, and a few days after my departure he obliged me by seeing the clock properly attached and the gauge re-started. After the attachment of the clock it required regulating for three days; but on the 21st December it was working accurately, and since then the automatic registrations have been uninterrupted. Warm thanks are due to Mr. Ormiston, the Port Trust Engineer, for his co-operation, without which the tidal registrations while the gauge was under repair would have been very imperfect, and to Major Baird for his assistance.

Mormugáo.—The tide gauge at this observatory worked uninterruptedly throughout the year. The pencil however failed to mark the diagram for a few hours consecutively on three occasions: but as it was possible to interpolate the omissions they have not caused any inconvenience, and the tidal registrations throughout the year may be considered to be very satisfactory.

The self-registering anemometer also worked well. There were only seven short interruptions to its registrations during the year, three of them caused by the stoppage of the driving clock, three by the neglect of the observatory clerk to gear the barrel and one by the direction pointer falling out.

The old self-registering aneroid by Adie modified by Légé has not been working satisfactorily owing to accidents which occurred both before and after the inspection of the observatory and will require thorough examination and probably repair at next inspection. The reserve aneroid by Légé and Co. was thoroughly put in order during the inspection, after which its working was found to be all that could be desired.

The observatory was inspected early in January by Mr. Belcham accompanied by the watchmaker of the party, when all the instruments were thoroughly cleaned and left in good working order. Mr. Good continued his kind supervision of the registrations until last May, since when they have been under the supervision of the Harbour Master.

Cochin.—The tidal registrations were perfect up to the 4th April, when an unexpected accumulation of sand formed near the observatory and embedded the rose of the communication pipe, thus preventing free access of the water in and out of the cylinder and rendering the registrations inaccurate. Captain Winckler, the Port Officer, tried his utmost to remove the sand and had the pipe extended further into the river, but the curves remained inaccurate and imperfect until the 26th May, when the accumulated sand through the action of the water was removed as unexpectedly as it had appeared, and free communication became restored. The curves have been correctly registered ever since without any interruption, and it is to be hoped that no similar interruption will occur again. Captain Winckler stated that in his experience of Cochin, extending over four years, no accumulation of sand which could have interfered with tidal observations had ever occurred before.

The self-registering aneroid barometer worked without any failures until the 19th January, but as the readings were noticed at the inspection to be considerably less than those of the mercurial barometer, the gold wire was renewed, after which the instrument worked well up to the 5th February when the observatory clerk found that the minute-hand of the driving clock would not move; he then unfortunately tampered with the instrument, with the result of damaging it so much that it has failed to work ever since, and arrangements for its repair cannot be made until next inspection. Readings of the standard mercurial barometer have however been taken throughout the year at 7 A.M., 10 A.M., 4 P.M., and 6 P.M. The anemometer registrations have been very good, only six interruptions lasting for a few hours at a time having taken place; they were all caused by the driving clock failing to work.

The observatory was inspected in January by Mr. Belcham, who was accompanied by the watchmaker of the party; and all the instruments were cleaned and left in good working order.

Captain Winckler deserves our thanks for his kind exertions to restore the gauge to working order, and for the care he continues to devote to the observatory.

Colombo.—The registrations of the tidal curves for the year under report were remarkably good. There were no stoppages of the clock nor failures from imperfect communication such as occurred last year through the pipe not having then been periodically cleaned. One short break, however, occurred on the 29th June, when the silvered wire between the pencil and float broke, but it was speedily renewed by the observatory clerk. The accident is similar to that which occurred at Bhávnagar on the 8th April and may prove an unfortunate one should the wire break again before there is an opportunity of taking zero measurements.

The anemometer and barometer readings at this port are supplied by the office of the Surveyor-General of Ceylon.

The observatory was inspected by Mr. Belcham in February when the tide gauge was cleaned in all its parts by the watchmaker of the party who accompanied him. The spare pendulum tide gauge clock which was left at the observatory in 1885 was also cleaned, and Mr. Belcham suggested to the Master Attendant that it would be as well if it were set up in his office and kept going instead of being allowed to remain packed up in the observatory.

Thanks are due to Captain Donnan, the Master Attendant, for the great interest he takes in supervising the working of the observatory.

Galle.—The tidal registrations at this station continued without a break until the 15th December when the iron float cylinder became so full of holes through corrosion as to be perfectly useless and to require removal; a new one was, however, very quickly prepared by the Master Attendant, considering the means at his disposal, and it was fixed in position on the 17th January. Since this gap of about a month in the tidal registrations only one unimportant stoppage of the clock for about 8 hours has occurred.

The old pattern self-registering aneroid by Adie worked continuously throughout the year; but for a period of about two months preceding the inspection the readings, owing to the spring being rusty, were more than a tenth of an inch greater than those of the standard mercurial barometer. The new pattern self-registering aneroid by Légé & Co. worked without interruption until the 11th January when the pencil marker began to stick against the diagram, thus preventing the barrel from revolving. Both instruments were put in order at the inspection and have since then worked without any failures.

The anemometrical observations were perfect throughout the year.

The observatory was inspected by Mr. Belcham early in February, when all the instruments were found to be very rusty, and the old float band so corroded that a new one had to be substituted for it. The several instruments were thoroughly cleaned and put into good working order by the watchmaker of the party before the end of the inspection.

The kindness of Captain Blyth, the Master Attendant, in so promptly supplying a new cylinder, thus enabling the interrupted observations to be resumed, together with the great interest he has always taken in superintending the working of the observatory, call for warm acknowledgment.

Negapatam.—This observatory stands close to the northern mouth of the Kadaveár backwater on piles driven into the sand, and when my last report was submitted there appeared to be evidence of a slight sinking of the structure causing it to lean a little in the direction of the sea. One of the piles on the side next the sea, to which the graduated staff is attached, seemed to have subsided more than the bed-plate by 0·1 foot. This was confirmed by some measurements taken about the same time by the Port Officer, which showed that there was no retardation of the flow of water in and out of the float box which at this observatory is the substitute for a cylinder.

For a couple of months after these measurements were taken the tidal registrations were uninterrupted and the difference between the readings of the pencil of the gauge and of the graduated staff remained constant. But early in November stormy weather set in, and on the 7th December the Port Officer reported that the sand that usually formed at that time of the year to the north of the tidal observatory had extended itself far into the backwater, and, owing to the boisterous weather, especially that which had prevailed for the last three days, it had suddenly formed itself round the observatory and embedded the cylinder to such an extent as to completely stop the working of the gauge. The sand was resisting his strenuous efforts to clear it away, and he therefore applied to me for help. On receipt of the report I sent Mr. Belcham to Negapatam and by the time of his arrival there on the 18th December he found the accumulation had been sufficiently cleared away to enable him to re-start the gauge. The interruption to the registrations lasted for eleven days, but since the gauge was re-started, the Port Officer has gone to great trouble in taking constant precautionary measures to prevent a re-accumulation of sand, and the tidal registrations have been uninterrupted and satisfactory.

The working of the self-registering aneroid and anemometer have been uninterrupted throughout the year.

The inspection of the observatory was made by Mr. Belcham accompanied by the watchmaker of the party in December at the time when he went to re-start the tide gauge. He found the float band of the tide gauge broken, and the silvered wire connecting the pencil and float very much worn; otherwise all the instruments were in good order, the gauge, however, was out of level, and had settled 0·24 feet. A new float band and silvered wire were attached and all the instruments cleaned and left in good working order. A new graduated staff was also fixed to the observatory in a more convenient position than the old one; but it was carried away on the night of the 21st September by cargo boats which came into collision with it, and another one will have to be erected in its place.

Thanks are due to Captain Dennison, the Port Officer, for his kind exertions during the interruption to the observations, and for the attention he bestows on the observatory.

Madras.—For the first time since this observatory was established, the tidal registrations have continued for a whole year without a single interruption.

The clock, as stated in my last annual report, was repaired in August 1886 by Messrs. Orr & Sons, who thought that the vibration of the pier while cargo was being loaded and unloaded might cause the clock to get out of order at any time; but fortunately no accident such as they anticipated has occurred.

The self-registering aneroid worked without failure until the 3rd June when it got out of order and was sent to Messrs. Orr & Sons for repair by the Port Officer. It was set up again on the 9th August since which time the registrations have been continuous. There is no anemometer at this station.

The inspection of the observatory was carried out in February by Mr. Belcham, when the tide gauge clock was found to be clean, but the other parts of the gauge had to be cleaned by the watchmaker of the party. The aneroid barometer was also cleaned at the same time.

Cocanada.—In my last annual report I mentioned that during the six months extending from the commencement of the tidal observations at this station to the date of that report, no interruptions had taken place in the registrations of the tidal curves. The working of the self-registering tide gauge has continued to be equally good up to the present time, and the tidal registrations since their commencement are without a single break.

The self-registering aneroid worked throughout the year with only one day's interruption; but up to the time of the inspection, the curves were almost straight lines and did not show diurnal variations corresponding to those of the mercurial barometer. The instrument was then adjusted and has since worked well.

The self-registering anemometer has worked very well; but at the inspection it was found that the faulty arrangement referred to in my last annual report was not, as I understood, confined to the direction given to the vane. The interior mechanism was found to be so contrived as to reverse on the diagrams all the directions of the wind, except north-west and south-east, the points to which the instrument was originally set, and the completed diagram will have to be corrected accordingly. A new endless screw having an opposite pitch to that of the one supplied by Messrs. Légé & Co., was made by the watchmaker of the party in Poona to bring the vane to its position of rest in the wind with a motion opposite to that in which it originally moved when the fans revolved. This screw was substituted for the old one at the inspection, and the instrument was reset, so that its readings at north and south should be correct. The vane now points to instead of from the quarter the wind blows; but the interior mechanism remains unchanged and now reverses all direction readings, except those of north and south, so that for this observatory it will now be necessary to correct the printed diagrams received from Messrs. Légé & Co., for use with their anemometors by interchanging the letters E and W wherever they occur at the head of the direction columns.

The inspection of the observatory was made in February by Mr. Belcham accompanied by the watchmaker of the party. He found everything in perfect order, thanks to the kind superintendence of Captain Baker, the Port Officer, who continues to take a great interest in all matters connected with the observatory.

Kidderpore.—The self-registering tide gauge at this observatory has worked very well throughout the year. Such few interruptions to its registrations as occurred were all due to the stoppage of the driving clock, and were quite unimportant.

The self-registering aneroid registrations have also been very satisfactory, only two unimportant interruptions to them having occurred before my inspection and none since then.

I mentioned in my last annual report that the self-registering anemometer had to be removed for repair by Lieutenant Petley, R.N., on the 11th September 1886. Its registrations were resumed on the 3rd October; but it became necessary to remove it again on the 23rd March last, as the building on which it stood had to be pulled down in the course of the dockyard alterations, and Lieutenant Petley had it set up at the tidal observatory. There were 19 interruptions to the registrations between these removals, equivalent to about 3 per mensem, a proportion which can hardly be considered satisfactory. Mr. Belcham visited the observatory in May and found that the direction gear of the anemometer had not been adjusted to the new position of the instrument, and that the diagrams for all the days as far back as the 23rd March required a constant correction; he also found the instrument not upright. He adjusted it correctly, and it has since been working well.

I made an inspection of the observatory in January, accompanied by Sub-Surveyor Dhondu Venayek, and found the instruments, with the exception of the anemometer, in a satisfactory condition. They were all cleaned and left in good working order. Bench-mark A had been removed by the workmen during the alterations in the dockyard, but this was not discovered until I made my inspection. I explained to the observatory clerk that if any bench-mark or anything else connected with the observatory was disturbed or injured, he was to report the circumstance at once to Lieutenant Petley.

Mr. Belcham arrived in Calcutta *en route* to Port Blair on the 5th March, and as he had to wait some days for the Port Blair steamer he employed his time in inspecting the Kidderpore observatory. He found all the instruments clean and in good order; the clock of the anemometer had however stopped several times since my inspection, and the watch-maker who accompanied him examined it carefully but without being able to discover the cause of its irregular working. Mr. Belcham had to go from Port Blair to Burma to establish a new tidal observatory at Akyab. On his return to Calcutta in May he made a second inspection of the Kidderpore observatory, and found the tide gauge and aneroid in perfect order; but the anemometer which had been removed to the tidal observatory since his last inspection had to be adjusted as already mentioned.

It was fortunate that he had this opportunity of revisiting the observatory, for since his last visit the Irrigation bench-mark which was the bench-mark of reference, and bench-mark B, had both been demolished. In order that the observatory might not be without a convenient bench-mark of reference, he laid down a new one on the granite coping of the eastern wall of the main dock towards its northern end, and connected it by levelling with the bed plate of the gauge and with an engraved circle on the same coping which was one of the points of the line of spirit-levels executed in 1882-83.

In consequence of the alterations that are being made in the Kidderpore docks, the observatory will have to be removed during the coming field season to a new site not far from its present one. After the piles of the new observatory have been sunk and the preliminary levels taken, the removal of the observatory ought not to occupy more than about a fortnight. The zero of the gauge in its future position will be identical with its present zero, and if the Port Commissioners can provide men to assist the observatory clerk in taking readings to a graduated staff while the gauge cannot work, there will be no break in the tidal observations.

I have again the pleasure to acknowledge Lieutenant Petley's unvarying interest in the tidal observations. His extensive experience of the Hooghly tides has enabled him to supply valuable information; and in all matters connected with the observatory we have always been able to rely on his ready help.

Hitherto the tidal predictions for Kidderpore during the times of the freshets have not been satisfactory. Major Baird, however, in correspondence with Mr. Roberts, has arranged a new plan for utilizing the available observations which he believes will have the effect of gradually improving the predictions until they become very correct; and it is hoped that a considerable improvement will be noticeable in the predictions contained in the forthcoming tables for 1888.

Chittagong.—The tidal registrations at this station have been excellent, no interruptions of any importance having occurred in the working of the gauge.

The interruptions to the self-registering aneroid and anemometer have been very few and unimportant, and the working of these instruments has been very satisfactory.

I made my inspection in January, accompanied by Sub-Surveyor Dhondu Venayek. The observatory was found in very good order. All the instruments were examined and cleaned and were left working well. Mr. Good, the Port Officer, kindly superintends the working of the observatory in which he takes great interest. Mr. Belcham when returning to Calcutta after establishing the Akyab tidal observatory, touched at Chittagong and while his steamer was in port he took the opportunity to visit the observatory where everything was found in good order.

Akyab.—On the 24th January I selected the site for the tidal observatory at this new station, every facility being afforded me through the kindness of Captain Fenn, the Port Officer, and Mr. Lackersteen, the Executive Engineer. On the following day I went on by steamer to Rangoon, where I arranged with the Secretary to Government in the Public Works Department for the erection of the observatory and the construction of an iron cylinder for it.

The observatory, the instruments for which, as already mentioned, were sent from Amherst, has been erected over the extreme bay at the north-west corner of the T head of the iron pier opposite the Port Office. It is well ventilated, and very neatly and substantially constructed. The cylinder for the float to work in is of wrought iron, 2 feet in internal diameter and 28 feet long; it consists of four lengths of 7 feet each, and is painted both within and without as a protection against rust, the inside being coloured white in order to facilitate the measurements for determination of zero. The bottom of the cylinder is 7 feet below low-water and is closed with a block of iron wood containing numerous perforations for the free ingress and egress of the water. A graduated staff 15 feet long for checking the height of the water in the cylinder is fixed to the north-west pile of the observatory, its zero being the same as that of the tide gauge.

The anemometer and the aneroid and mercurial barometers are all set up in the observatory.

The construction of the observatory was carried out by Mr. M. R. Lackersteen, the Executive Engineer, Arakan Division, who took the greatest interest in its erection; and we are under obligations to him for the speedy and substantial way in which the observatory has been erected; it is one of the best constructed tidal observatories that have yet been established.

Since the tidal registrations at this station were commenced on the 9th May the tide gauge clock stopped eight times owing to the oscillation caused by steamers coming alongside and leaving the pier; but the interruptions, which always occurred at night during the absence of the observatory clerk, never exceeded twelve hours, and the gaps in the registrations can easily be interpolated.

The self-registering aneroid and anemometer, with the exception of one interruption of about twelve hours to each, have worked continuously since they were set up.

Captain Fenn, the Port Officer, made himself acquainted with the details of the working of the instruments, and supervises the duties carried on by the observatory clerk. He very kindly lent the mercurial barometer in his office for the use of the observatory, as the one belonging to it had been damaged in transit from Amherst.

Mr. Belcham arrived at Akyab on the 8th April, and on the 13th the erection of the building was commenced. During its erection he remained at Akyab watching its progress and giving details for the internal fittings. On the 3rd May the observatory was completed sufficiently to start the trial registrations, and by the 9th the several instruments were at work after being cleaned and adjusted by the watchmaker of the party who accompanied him.

Elephant Point.—On the whole, the tidal registrations at this station may be considered to be very satisfactory. The observatory was for some time in an unsafe condition and part of the apparatus of the tide gauge was almost worn out. Under such circumstances it is matter for congratulation that there were but a few unimportant interruptions to the registrations. Seven of these were caused by the stoppage of the driving clock, two by the entanglement of the float in the box which at this observatory does duty for a float cylinder, and one by the fracture of the silvered wire connecting the pencil and float. The last mentioned accident was fortunately not repeated before the observatory was inspected and measurements taken for determination of zero, nor has it occurred since then. One other interruption occurred early in May when heavy rain came through the roof of the observatory, deluging the apparatus and causing the clock to stop and the pencil to stick. On this occasion the bed plate was found to be slightly out of level, but it was at once re-levelled by the observatory clerk.

The auxiliary instruments are set up at the telegraph station which is about a mile-and-a-quarter distant from the tidal observatory, and are looked after by Mr. Duckworth, the Telegraph Master.

The self-registering aneroid worked well until the 23rd May, when the driving clock got out of order, and the barrel ceased to revolve. From that date up to the 28th June readings were taken from the dial and entered in the daily reports, and the following day the instrument was sent to Rangoon for repair. It was returned on the 22nd August, and its readings since then have only once been interrupted.

As stated in my last annual report, I brought away the self-registering anemometer clock to have it repaired by the watchmaker of the party. It was refixed on the 3rd February, at the time of the inspection of the observatory, and has worked since then with only two stoppages. A break of eleven days, however, occurred in April in the registration of the anemometer, due probably to the barrel not having been properly geared to the clock by the lascar whom the Telegraph Master sends aloft to change the diagrams. With the exception of these interruptions the registrations of the instrument have been satisfactory.

Early in February I made an inspection of the observatory, accompanied by Sub-Surveyor Dhondu Venayek. On the first day of my inspection Mr. Reichenbach, the Port Engineer of Rangoon, accompanied me, as I wished to point out to him some alterations and repairs to the observatory which were urgently needed. He was very obliging and arranged to have everything that was necessary carried out without delay. He also promised to visit the observatory occasionally and test the relative levels of the bed-plate and the bench-mark of reference. The tide gauge was found not to require much cleaning and to be working satisfactorily; but the observatory and the clerk's house were both in very bad repair, and the piles of the former required new bracing in order to render the structure safe, the float box also required renewing. At the close of the inspection all the instruments were left thoroughly clean and in good working order.

At the end of March, Mr. Belcham before proceeding to Akyab, took the opportunity of inspecting the Elephant Point observatory. The float was then found so worn that water had penetrated into it, but not in sufficient quantity to alter the zero; the float band also was very much out of repair. The watchmaker who accompanied Mr. Belcham executed the necessary repairs, and all the instruments were left in serviceable condition. After finishing his inspection Mr. Belcham reported that Mr. Reichenbach had taken in hand the repairs to the observatory.

In my last annual report I mentioned that there was an uncertainty regarding the relative level of the bed-plate of the gauge and the bench-mark of reference at the Elephant Point observatory during the months of July and August 1885 which was likely to cause trouble in preparing for measurement the diagrams for those months. I am glad to say that with the kind assistance of Mr. Reichenbach the results of some levelling done by the former Port Engineer in September 1885 were found and given to me, and the contractor who then repaired the observatory informed me that the only movement given to the structure was a slight lateral one which did not involve taking down the gauge, and which could not have altered its level to any appreciable amount. I was therefore at last in a position to decide that the diagrams in question could be prepared for measurement in the usual way, and I am glad to be able to state that they were completed and read off during the present recess.

Rangoon (Latter Street Wharf).—The record of this station has been far from satisfactory throughout the year; there were many interruptions to the tidal registrations. The daily reports received up to date mention six interruptions through entanglements caused by the float box, eight through the stoppage of the driving clock of the gauge, seven through the float band slipping off the stud wheel, twenty-two through the pencil failing to mark, and two through the breaking of the silvered wire connecting the pencil and float. Of these mishaps the most unfortunate occurred in October 1886. The chain between the float and counterpoise weight had broken and become entangled with the float box on the 17th of that month, and on the evening of the same day the silvered wire connecting the pencil and float broke. On the following day the Port Trust overseer went to the observatory and proceeded to test the motion of the float band, with the result that the counterpoise weight got entangled at the bottom of the float box and the float band broke, and a new one had to be put on. Another unfortunate accident happened on the afternoon of the 28th December, when the float box which had been attached on the 16th June 1886 was carried away by a strong ebb tide, and half of the float chain was torn off and lost, the float band was also injured but not severed. Work was thus stopped until a new float box could be put up. This was done on the 18th January and the registrations were then resumed after having sustained an interruption lasting for three weeks. Had there been a graduated staff at this observatory, its registrations might have been taken at high and low water during the time the tide gauge was disabled; the break in the registrations would then have been less serious and the laborious calculations of the most probable values required for interpolation during the break described in my last annual report, would have been unnecessary. But there was no graduated staff at the observatory, and when I asked for the readings of the tide pole at Brooking Street Wharf, which would have answered my purpose, as its zero corresponds with that of the self-registering tide gauge, I was informed that no register was kept.

There have been only three failures in the self-registering aneroid registrations during the year, due in all instances to the stoppage of the clock. The instrument however appeared to have got out of adjustment when it was removed with the other instruments after the steamship *Zephyr* came into collision with the observatory, as mentioned in my last annual report, for when I made my inspection I found that the diurnal rise and fall were in most instances imperceptible on the diagrams, and that the aneroid and mercurial barometer readings, which agreed at my previous inspection, showed a considerable divergence. The aneroid was adjusted and has since worked well.

I mentioned in my last annual report that I brought away the self-registering anemometer clock for repair. It was refitted to the instrument when I made my inspection and the whole apparatus has worked remarkably well ever since. Its registrations have only once been interrupted through the clock being stopped by a shock given to the pier supporting the building on which the anemometer is placed.

My inspection of the Rangoon observatory, in which I was accompanied by Sub-Surveyor Dhondu Venayek, extended over the last four days of January and the 1st day of February. I found all the instruments tolerably clean and working steadily, with the exception of the anemometer which was not in use. The instruments including the anemometer were all cleaned and adjusted and left working well.

Mr. Belcham arrived on the 21st March in Rangoon from Port Blair *en route* to Akyab, but was detained for some days in Rangoon seeing about the float cylinder which was being made there by Messrs. Bulloch Brothers and Co. for the Akyab tidal observatory and which was not quite ready, when he also carried out other arrangements connected with the erection of that observatory. At the same time he employed himself very usefully in inspecting the Elephant Point and Rangoon tidal observatories. He found the instruments in the Rangoon observatory as I had left them in February, except that it had been necessary to renew the silvered wire of the gauge between the pencil and float on the 15th March. It broke then for the second time during the year; but as Mr. Belcham was fortunately present to take measurements for the determination of zero before another break occurred, the accident became unimportant. The watchmaker who accompanied Mr. Belcham cleaned the instruments, and substituted a new gold wire in the aneroid for the old wire which required renewal.

Mr. Reichenbach, who succeeded Mr. Jennings as Port Engineer at Rangoon, exercises supervision over the tidal observatories at Rangoon and Elephant Point. I explained to him what was required at both stations, and he very kindly promised to have everything done according to my instructions. Among other necessary improvements he has set up a graduated staff at the Rangoon observatory set to the same zero as the tide gauge, and I hope that before that observatory is again inspected an iron float cylinder to replace the float box may be ready for erection. Mr. Reichenbach also interested himself in my arrangements for establishing a standard bench-mark for Rangoon, which will be mentioned in their place. Mr. Darlington, the Vice-Chairman, Port Commissioners, was very kind in affording me every facility for making my inspections. He also took much interest in choosing a good site for the standard bench-mark, and as a block of stone suitable for it could not be obtained at Rangoon, he authorised me to order one in Bombay. I owe my thanks to both these gentlemen for their kind co-operation.

Port Blair.—The tidal registrations at this island station have not been as good as they might have been had more care been bestowed on their supervision. Actual breaks in them were not many. Half a dozen unimportant breaks were occasioned by the stopping of the driving clock of the tide gauge, and there was a break of five days' duration in May while a new cylinder was being put up in place of the cylinder that had been in use for about a year-and-a-half and which had worn or been eaten into holes in that time. Interruptions so occasioned were perhaps unavoidable; but in July a series of short interruptions due to the entanglement of the float twice or three times daily was allowed to continue for a week before the cause of the interruptions was removed; and during July and August no notice was taken of a marked discrepancy between the readings of the pencil of the gauge and the graduated staff, clearly indicating a retardation of the flow of water in and out of the cylinder through the obstruction of the inlet holes.

The daily reports sent to me, in which the comparisons between the readings of the gauge and graduated staff are entered, are signed by the Port Officer; but the discrepancy in question, which on the 22nd July actually amounted to one foot, does not appear to have attracted his attention. I wrote to him requesting that free communication might be restored; and the cylinder was accordingly cleaned, with the result that the pencil and staff readings became accordant again.

Nothing else requires notice, except that a slight shock of earthquake was reported to have been felt at the observatory at 2-50 P.M. on the 28th December; but it caused no disturbance in the tidal curve.

The self-registering aneroid and anemometer have worked without a single interruption throughout the year.

The observatory was inspected in March by Mr. Belcham who was accompanied by the watchmaker of the party. Considering that the instruments had not been cleaned since the last inspection, which was made more than two years previously, they were all in very fair order. He found, however, that the observatory clerk had made certain wrong entries in his daily reports. On the 29th November he had reported that the float band had merely been off the stud wheel for a few hours when in point of fact it had broken, and from that date onwards he had been entering identical readings of the float band and pencil instead of the true readings, which Mr. Belcham found to differ by about two inches. Mr. Belcham brought the matter to the notice of the Port Officer who promised to check the readings periodically and compare them with the readings of a graduated staff which Mr. Belcham was then erecting for the purpose of bringing to notice any obstruction of the inlet holes of the cylinder of the gauge sufficient to cause a difference between the level of the water within and without the cylinder; but the Port Officer appears to have let this obligation slip from his memory, and it is to be hoped he will exercise a stricter supervision over the observatory in the future. During the inspection the instruments were thoroughly cleaned and a new float band was fitted to the gauge, and when Mr. Belcham left Port Blair all the instruments were in good order and working well.

The accident which is likely to give most trouble is that which occurred at the Rangoon tidal observatory in October 1886, for it may possibly invalidate the tidal registrations extending back to the preceding July. A breakage of the silvered wire connecting the pencil and float of a tide gauge, followed by another before measurements for determination of zero are obtained, causes the values of the height of the water registered between the breaks to be less precise than they would otherwise have been. The daily records of the reading of the pencil and float band, made by the observatory clerk, are, as a rule, sufficiently accurate to enable the heights to be calculated nearly enough for our purpose; but that they are not invariably so is clear from what is mentioned above as having happened at Port Blair. A breakage of the float band occurring either at the time of the first or second breakage of the silvered wire complicates matters, and when it occurs at both times, as was the case at Rangoon, great doubt is thrown on the intervening height registrations. They may have to be rejected altogether, in which case very laborious calculations for filling the blank in the observations have to be made. Some of the new tide gauges are fitted with chains less liable to break than the silvered wires which in the older gauges connect the pencil and float: these chains should be substituted for the wires as occasion offers, and I have recently indented for a sufficient supply to enable them to be introduced at all the tidal observatories.

BENCH-MARKS.

The bench-mark at Rangoon which was built with the intention that it should be the standard bench-mark for that city, although altered as mentioned in my last annual report, seemed to me when I made my last inspection of it to be hardly worthy, either as regards its site or construction, of being the standard for so important a city as Rangoon. Mr. Darlington agreed with me and interested himself in the selection of a good site for a standard bench-mark, and authorized me to order the bench-mark stone in Bombay. I accordingly applied to Khan Bahadur Muncherjee Cowasjee Murzban, the Presidency Executive Engineer of Bombay, under whose superintendence the Bombay standard bench-mark had been erected, and after the sanction of the Bombay Government had been obtained he most kindly undertook to have a somewhat similar stone prepared for Rangoon. The stone which was despatched to Rangoon last month is a carefully dressed solid block weighing between 2 and 3 tons and measuring 3 feet by 3 feet by 3 feet 8 inches. It will be embedded 8 inches in a masonry plinth, the portion visible above the masonry being a 3 feet cube. Its top surface will be the plane of reference, and in each of its four vertical faces a space 1½ feet square and 1½ inches deep has been sunk to receive an inscribed metal plate, to be prepared in Rangoon. It will be erected by the Rangoon Port Engineer within the grassy enclosure near the flagstaff, opposite the Port Commissioners' office, and will be connected by double levelling with the tidal observatory at Latter Street Wharf. The bench-mark originally intended for a standard bench-mark will now become the bench-mark of reference for the tidal observatory.

During the year under report a pair of test bench-marks were laid down in connection with each of the tidal stations of Mormugáo, Kárwár, and Cochin. Five pairs had been laid down when my last annual report was written; so there are eight pairs of test bench-marks in existence at the present time.

One embedded and one inscribed bench-mark were laid down at the new tidal station of Akyab and connected with the observatory and with Colonel Heaviside's Longitude station, and in addition to them 44 embedded bench-marks, including the 6 test bench-marks mentioned in the preceding paragraph, 373 inscribed or minor bench-marks, and 1 Marine Survey bench-mark at Vipeen Island, Cochin, were connected in the course of last season's levelling operations. The bench-marks at the tidal stations were found undisturbed and in satisfactory condition, with the following exceptions:

At Kidderpore all the bench-marks in connection with the tidal observatory were removed in the course of the dockyard alterations; but a new bench-mark was laid down and connected with the bed-plate of the gauge as already mentioned.

At Rangoon bench-mark B was destroyed, and although bench-marks A and C were found intact; their positions render them very liable to damage. The bench-mark of reference however previously mentioned is so solidly built and its surface is so well protected, that no inconvenience would be felt if A and C were to disappear.

At Port Blair bench-mark C has been quite obliterated by the action of the sea.

At Kárwár bench-mark No. 99, entered at page 105 of Pamphlet of Spirit-levelled Heights No. 1, Madras Presidency, seasons 1869—85, was found to have sunk.

At Bhávnagar the bench-mark of reference is not of a sufficiently permanent kind. I therefore requested the Assistant to the State Engineer to have a proper one ready for connection at the next inspection of the observatory.

In my last annual report I mentioned that a bench-mark had been laid down at Tuticorin as a substitute for bench-mark No. 2 of the Pamphlet of Spirit-levelled Heights No. 1, Southern India. In June the Port Officer requested sanction to remove the latter as it interfered greatly with the traffic; and in reply I informed him that if he found it absolutely necessary to remove it, he might do so.

At Poona, bench-marks Nos. 115 and $\frac{1}{116}$ entered at page 14 of Pamphlet of Spirit-levelled Heights Nos. 2 and 3, Bombay Presidency, seasons 1877—80, revised edition, have been disturbed since their heights were originally determined. I have therefore arranged for obtaining new values of their heights, which, with the new value of bench-mark No. 99 at Kárwár, will shortly be issued in *addendum* slips for insertion in the Pamphlets to which they respectively refer.

Levelling Operations.

The operations of the last field season comprised the following lines of double levelling:—

Section I.—From Tuticorin to Madura.
" II.—From Madura, *viâ* Trichinopoly, to Tanjore to join the line executed in 1885-86.
" III.—From Trichinopoly to Erode, to join the line executed in 1884-85.
" IV.—From Shoranúr to Cochin Tidal Station.
" V.—From Kárwár Tidal Station to Mormugáo Tidal Station.
" VI.—From Agoada Fort Jetty, where mean sea-level had to be determined independently, to Agoada Station.

In the sanctioned programme for the season's operations a connection was directed to be made with as many stations of the triangulation as fell within convenient reach of the operations, and subsequent instructions regarding the stations of the Great Arc Series directed that only such few of them as were most easily accessible and within very convenient reach of the line of levelling should be connected; three or four stations at some distance apart being amply sufficient for the adjustment of the trigonometrical heights. Permanent bench-marks, known as test bench-marks, had also to be established in connection with the tidal observatories visited in the course of the operations where that had not already been done.

The levelling operations were carried out by Mr Corkery. He worked with the rectangular level; and his assistant Sub-Surveyor Narsing Das worked with the cylindrical level. They left Poona for the field on the 4th November and returned on the 1st June, the field season thus lasting nearly seven months. Their out-turn is very good considering the nature of the country levelled over, which in some parts was hilly, in others densely wooded, and in others intersected by creeks. The out-turn amounts to 450 miles of double levelling, in doing which the instruments were set up at 4,041 stations, and in the course of which 418 bench-marks, and 6 Great Trigonometrical Survey stations were connected. This out-turn falls short of the preceding season's by 76 miles in actual length and by 18 in the number of Great Trigonometrical Survey stations connected; but in other respects it indicates a greater amount of work done. Thus during last field season the number of bench-marks connected was greater by 24 and the number of stations where the instruments were set up was greater by 332 than during the preceding season; and the rises and falls were greater by 6,741 feet. The work apportioned to Mr. Corkery in accordance with the sanctioned programme was all completed most satisfactorily by him and in a shorter time than in the preceding field season, which commenced on the 3rd November 1885 and ended on the 26th June 1886.

The following extracts are taken from the report submitted to me by Mr. Corkery on his last season's work :—

"I started work on the 11th November at Tuticorin. According to the programme of instructions, section I emanated from the new bench-mark embedded in the verandah of the Port Office, and continuing along the railway line, closed on a bench-mark which I had embedded at Madura. In this section 8 embedded bench-marks, and 93 minor bench-marks, inscribed on prominent features, were connected by spirit-levelling. The distance levelled over was 105½ miles, including 7 miles of branch lines to trigonometrical stations. The two trigonometrical stations connected were Koilpati H. S. of the Ramnad Longitudinal Series, and Kutipárai S. of the Great Arc Series."

"Section II was started from the embedded bench-mark at Madura on the 11th December and proceeding along the railway line *viá* Trichinopoly where a bench-mark was embedded, closed on the 29th January on the embedded bench-mark at Tanjore, which had been laid down in the previous season: a circuit was thus completed from Tanjore to Tuticorin *viá* Ramnad, returning *viá* Madura and Trichinopoly to Tanjore. The height of $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ at Tanjore as determined in 1885-86 was 193·799 feet above mean sea-level: the present determination is 193·985 above the same datum, or a plus error of 0·186 foot. The length of the circuit is rather more than 400 miles, which would give an error of +·00047 foot per mile.

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"I might mention here that a connection has been made between Ramnad $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ and Madura $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ by the Engineer-in-Chief of the Madras Railway Surveys, and that General Walker's rigorous system of double levelling was to have been carried out. A reference to the abovementioned officer in Bangalore for the results might be of use."

"Section III emanated from $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ at Trichinopoly, and closed on $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ at Erode, on the 3rd March: the total distance in this section was 90⅓ miles including 3½ miles of a branch line to Ettimalai S. This section occupied the party for one month exactly. There were 9 embedded bench-marks, and 79 minor bench-marks connected. The value of Erode $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ as determined this year was 539·811 feet: the value given in the most recently published Pamphlet of Heights, No. 1 Madras Presidency, seasons 1869-85, is 539·530 feet. The error is + 0·281 foot. The total distance along the line of levels from Madras to Erode *viá* Tuticorin is about 700 miles, the error per mile is therefore ·0004 foot."

"Section IV, which started from an embedded bench-mark at Shoranúr, previously laid down by Mr. Belcham, was not commenced till the 9th March. The line of levels on this section ran along the main road through Cochin State territory *viá* Trichúr and Kodungallúr; at first we had a little difficulty with the village authorities, but a *parwána* from the Dewan of Cochin soon set matters right. The distance levelled in this section, including 1¼ miles of branch lines, was 67 miles, and it occupied the party from the 9th March to the 10th April. Four creeks were crossed, each detaining the party, but the one which presented the greatest difficulty was Kodungallúr, three quarters of a mile of levelling having occupied us for three days. Nine embedded bench-marks including two test bench-marks for Cochin tidal station and 55 minor bench-marks were connected. Elamkunnu h. s. of the Ponáni Connection Series was also connected. This section closed on $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ A the bench-mark of reference for Cochin tidal station. Starting with the value of Shoranúr $\underset{\text{B. M}}{\overset{\text{G. T. S.}}{\square}}$ as given in Pamphlet No. 1 Madras Presidency, seasons 1869—85, the closing value of Cochin was 6·444 feet, and its value deduced from Cochin tidal observatory direct is 6·514 feet. The error in levelling is —0·07 foot, or 0·00106 foot per mile. Progress in this section was very slow owing to the densely wooded country which the line of levels traversed, and also to the difficulties the creeks presented."

"Cranganoor, as it is known to Europeans and as it is found spelt in maps, is a mystery to the inhabitants of Cochin: it is undoubtedly the same as Kodungallúr. As the first landing place in India of St. Thomas the Apostle, it is worthy of mention. I know of no part of India which will repay the traveller so well as the little State of Cochin; it stands out distinctly from the rest of India in its peoples, its history, and in numerous other ways, to enter into all of which would be out of place in a brief report like this. The constant and numerous changes occurring in the physical aspect of the low-lying grounds in this State, as in the neighbouring one of Travancore, intersected as both are by numerous tidal rivers, are worthy of note; it is considered within the probabilities that Cochin town, and all that strip of land in Travancore and in Cochin lying to the west of the system of rivers which form the numerous creeks, will one day revert to their old ocean homes. Vipeen island is said to have been submerged till the fourteenth century. At present a distinct change is taking place in the configuration of the country about Kodungallúr creek, the river forcing a new way for itself to the sea. A system of bench-marks spread over this country might lead to conclusions which would enable those concerned to take steps to save an exceedingly rich and fertile strip of country from a watery grave."

"A wait of five days at Cochin, for a steamer, was more than I had reckoned on: we sailed for Kárwár on the 15th April reaching it on the 18th. The same day we started work on Section V, by verifying the numerous bench-marks laid down at Kárwár many years previously. Bench-mark No. 99 of Section Hubli to Kárwár of Spirit-levelled Heights No. 1 Madras Presidency, 1869—85, is the only one that showed an appreciable sinking, the difference between its present and its former value being 0·046 foot. The length of this section was 59¾ miles, including 3 miles of branch lines, and starting from $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ at Kárwár on the 19th April, the section closed on $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ at Mormugáo, on the 20th May. The branch line to Pil H.S. occupied us for three days: a path had to be cut through the dense undergrowth for two-thirds of the distance up the hill. Eight embedded bench-marks, including two test bench-marks for Kárwár tidal station and two for Mormugáo tidal station together with 33 minor bench-marks, were connected by level.

ling. Accepting the value for Kárwár $\underset{\text{B. M.}}{\overset{\text{G. T. S.}}{\square}}$ (11·772 feet) taken from Kárwár Tide Tables for 1887, the closing value for Mormugáo $\underset{\text{B. M}}{\overset{\text{G. T. S.}}{\square}}$ was 12·525 feet; its value determined from direct tidal observations for the three years ending March 1887, is 12·424 feet; the error is +0·101 foot, or +0·0018 foot per mile."

"In this section also progress was very slow, 59¾ miles of levelling occupying us for one month and two days. The total of rises and falls was over 4,000 feet; this entailed the setting up of the instrument at more than twice as many stations as would be necessary on a railway line."

"The season's levelling may be said to have closed at Mormugáo on the 20th May; the connection of Agoada S. with mean sea-level involving work of a different nature."

"The total out-turn of work for the past season amounts to 450¼ miles, as compared with 526 miles for the season 1885-86. The difference in the nature of the country traversed is evidenced by the fact that the instruments were set up at 4,041 stations compared with 3,709 stations in 1885-86, and also from the fact that the total of rises and falls in 1885-86 was only half of what it was in 1886-87."

The method pursued in determining the height of Agoada S. of the South Konkan Meridional Series above Mormugáo mean sea-level was as follows:—

Before going to Agoada Mr. Corkery and Narsing Das set their watches by the tide gauge clock at the Mormugáo tidal observatory in order that their observations at Agoada and the observatory clerk's at Mormugáo might be made simultaneously. Agoada S. was then connected by double levelling with a bench-mark laid down at the Agoada Fort Jetty in a convenient position for observing the difference between its height and that of the tide as shown upon a levelling staff set up in the water. One complete observation consisted in reading the back and forward staff and the height of the water on the latter, and noting the time. Observations were taken at intervals of 5 minutes, beginning about one hour before high-water and continuing for an equal time after high-water, and the duration of actual high-water was sufficient to enable a couple of observations to be taken then, so that a whole set comprised about 26 observations. A similar set of observations was taken before, during and after low water. Observations were not taken at night. Thus two sets, one about high-water and the other about low-water, were taken daily. While these observations were being taken at Agoada the observatory clerk was taking simultaneous observations at the Mormugáo tidal observatory. One complete observation at the observatory consisted in marking the position of the pencil on the tidal diagram, reading the graduated staff, and noting the time. I had not required Mr. Corkery to take more than two days' observations; but as the water was rather rough he took the precaution of extending the observations over an extra day. They were taken on the 22nd, 23rd and 24th May. I wished to obtain the exact times of high and low-water at Agoada to compare with the corresponding times at Mormugáo; but the sea was not smooth enough to enable this to be done in the available time. At this part of the coast the tide ebbs and flows in a direction nearly perpendicular to the coast line; and reference to the Tide Tables for the current year shows that at Kárwár, which lies 50 miles to the south, high-water was expected about 12 minutes sooner and low-water about 14 minutes sooner than at Mormugáo, and that at Bombay, which lies 250 miles to the north, high-water was expected about 29 minutes later and low-water about 39 minutes later than at Mormugáo, during the time of the observations. Agoada is 5 miles north of Mormugáo; so high and low-water occurred probably about 1 minute later at the former than at the latter place during the time of the observations. On this hypothesis, and knowing that the tidal diagram revolves at the rate of one inch per hour, the positions of the pencil marked by the observatory clerk were misplaced in the direction of revolution by the minute space of $\frac{1}{60}$th of an inch. The range of the tide during the observations did not amount to 4 feet, and the change of level of the water during one minute even at ebb or flow could only have amounted to about a tenth of an inch, whilst owing to the observations having been taken during the times of slack water the mean height of the water at Agoada obtained from two sets of observations, one taken about high-water and the other about low-water, became practically the same as the mean obtained from the two corresponding sets at Mormugáo. Thus no corrections for minute differences of time or for difference of range were required. One set of observations at Agoada combined with the synchronous set at Mormugáo gave one value of the height of the Agoada bench-mark above the zero of the tide gauge at Mormugáo. Six such values were obtained—three at high-water and three at low-water, the mean of which gave the final height of the bench-mark above the zero of the gauge. The difference of level between the zero of the gauge and mean sea-level, as determined at Mormugáo by tidal observations during the three years ending 22nd March 1887, was a known quantity by means of which the heights above mean sea-level of the bench-mark and Agoada S. were finally deduced. A comparison of the values obtained from the diagram and graduated staff at the observatory appears to show that the height of Agoada S. now obtained is probably accurate to 0·03 of a foot. The foregoing procedure is similar in principle though different in details to the method referred to in paragraph 235 of the Survey of India General Report for 1881-82, page 56.

Reduction of the Tidal Observations.

During the year under report the amount of work done in connection with the tidal calculations was large, but the labour of the reductions was not increased, as was the case during the preceding year, by troublesome computations consequent on serious breaks in the tidal registrations. The observations at fifteen stations have been reduced, two years' calculations having been made in the case of three of them ; so that the total calculations are equivalent to the reduction of eighteen years' observations at one station. The tabulated values of the tidal constants so obtained and discussions of the results will be found at pages xlvi to lxxvi. Two other tables, marked No. 1 and No. 2, giving the results of the tidal registrations at all the closed stations, are also appended.

The present state of the ordinary tidal computations is shown in the following table together with their state at the end of September 1886. The letters A. P. in the table indicate that the actual times and heights of high and low water for 1886 were measured in duplicate from the tidal diagrams and compared with the predicted values contained in the Tide Tables for that year. The actual amount of work done during the year under report can thus be seen. The extra tidal work is not entered in the table. This consisted in preparing a statement about the tides at Bhávnagar for the officer in charge of the Marine Survey of India, and furnishing reports on the Bombay and Burma tidal observations, as before, to the Local Governments.

State of the ordinary reductions of the yearly tidal registrations at the beginning and end of the Survey year 1886-87.

Tidal Observatory.	State at end of September 1886.	State at end of September 1887.
Aden . . .	1884-85. Calculations completed. 1885-86. Diagrams not read off.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
Kurrachee . .	1884-85. Calculations completed. 1885-86. Diagrams completed and all read off, and the hourly readings being copied from the S. series into the other series.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
Bhavnagar . .	Newly started observatory. No diagrams read off yet.	1886. Calculations completed.
Bombay . . .	1885. Diagrams completed, and all read off, and computations completed.	1886. Diagrams not read off. A. P.
Mormugão . .	1885-86. Diagrams completed, and all read off, and computations completed.	1886-87. Diagrams read off and the hourly readings copied from the S. series into the other series. A. P.
Cochin . . .	Newly started observatory. No diagrams read off yet.	1886-87. Calculations completed.
Colombo . . .	1885-86. Diagrams completed, and all read off, and summations of series ready.	1885-86. Calculations completed. 1886-87. Diagrams read off, the hourly readings copied from the S. series into the other series, and the additions of hourly heights of each series ready. A. P.
Galle . . .	1885-86. Diagrams completed, and all read off, and summations of series ready.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
Negapatam . .	1885-86. Diagrams not yet read off.	1885-86. Calculations completed. 1886-87. Calculations completed. A. P.
Madras . . .	1884-85. Calculations completed. 1885-86. Diagrams not yet read off.	1885-86. Diagrams read off, the hourly readings copied from S. series into the other series, and the additions of hourly heights of each series, and the summations of series ready, 1886-87. Diagrams not read off. A. P.
Cocanada . . .	Newly started observatory. No diagrams read off yet.	1886-87. Calculations completed.
Dublat (closed September 1886).	1884-85. Calculations completed. 1885-86. Diagrams not yet read off.	1885-86. Calculations completed. A. P.

TABLE No. 1.

Table showing the mean amplitudes (H) in feet and mean epochs (K) in degrees for each particular tide which have been calculated from the

Station.	Year.	A_0 or Height in feet of Mean level of Sea above Zero.	S_1 H	S_1 K	S_2 H	S_2 K	S_4 H	S_4 K	S_6 H	S_6 K	S_8 H	S_8 K	M_1 H	M_1 K	M_2 H	M_2 K
Okha	1874-75	9·650	0·074	149°·89	1·222	14°·37	0·013	116°·57	0·003	20°·92	0·001	219°·81	0·051	43°·00	3·820	347°·11
Hanstal	1874-75	16·332	0·129	164·01	1·928	84·51	0·021	61·74	0·007	166·57	0·003	158·63	0·055	77·75	6·854	45·55
Kathiwadar*	1881-82	13·872	0·134	200·98	1·207	80·89	0·029	272·78	0·013	41·89	0·002	263·66	0·057	35·46	2·970	55·28
Kárwár	1878-79	5·650	0·067	158·71	0·631	335·49	0·007	114·66	0·002	31·61	0·002	343·61	0·019	70·05	1·724	303·21
	1879-80	5·541	0·075	148·57	0·629	336·44	0·007	87·36	0·007	57·53	0·002	295·46	0·017	45·49	1·733	303·34
	1880-81	5·564	0·055	156·16	0·621	333·98	0·016	94·37	0·004	82·24	0·000	296·57	0·049	28·59	1·757	300·55
	1881-82	5·515	0·052	164·75	0·616	333·29	0·011	109·55	0·006	51·34	0·002	282·53	0·045	10·24	1·754	300·87
	1882-83	5·492	0·035	167·47	0·625	334·73	0·011	91·64	0·006	39·14	0·004	302·91	0·036	48·45	1·741	300·72
	Means	5·552	0·057	159·13	0·624	334·79	0·010	99·52	0·005	52·37	0·002	304·22	0·033	40·56	1·742	301·74
Beypore	1878-79	5·385	0·021	119·85	0·331	19·96	0·004	139·69	0·004	252·47	0·001	20·56	0·017	145·76	0·907	330·23
	1879-80	5·392	0·083	206·72	0·310	19·36	0·003	118·30	0·004	244·06	0·000	251·57	0·032	68·68	0·904	329·74
	1880-81	5·412	0·093	187·29	0·308	21·78	0·004	132·80	0·003	265·76	0·001	45·00	0·038	22·56	0·895	332·96
	1881-82	5·412	0·073	185·05	0·341	16·61	0·006	144·69	0·006	226·93	0·001	319·40	0·024	39·56	0·950	328·89
	1882-83	5·395	0·035	172·85	0·359	11·58	0·007	147·53	0·010	247.65	0·001	339·44	0·032	90·35	1·001	323·67
	1883-84	5·301	0·048	171·77	0·350	11·32	0·007	128·40	0·009	244·94	0·003	95·91	0·055	60·51	0·999	323·52
	Means	5·383	0·059	173·92	0·333	16·77	0·005	135·24	0·006	246·97	0·001	358·65	0·033	71·24	0·943	328·17
Pámban	1878-79	2·666	0·036	146·13	0·377	90·11	0·005	286·82	0·002	245·56	0·004	248·50	0·013	16·74	0·589	46·55
	1879-80	2·707	0·049	130·89	0·375	92·31	0·001	191·31	0·001	167·91	0·005	254·75	0·009	38·20	0·585	46·75
	1880-81	2·759	0·035	153·29	0·377	91·35	0·004	261·87	0·005	195·46	0·002	257·20	0·013	64·33	0·598	45·99
	1881-82	2·705	0·022	163·15	0·360	94·19	0·003	304·16	0·006	179·05	0·001	135·00	0·008	18·94	0·569	48·51
	Means	2·709	0·036	148·37	0·372	91·99	0·003	261·04	0·004	197·00	0·003	223·86	0·011	34·55	0·585	46·95
Vizagapatam	1879-80	4·991	0·028	100·62	0·674	280·15	0·001	359·93	0·001	123·69	0·001	72·90	0·023	355,35	1·532	248·57
	1880-81	4·917	0·047	76·97	0·659	285·86	0·007	76·61	0·001	127·88	0·001	103·00	0·021	23·44	1·460	253·43
	1831-82	4·809	0·035	92·47	0·651	286·00	0·006	50·19	0·001	213·69	0·003	60·52	0·001	198·68	1·459	254·44
	1882-83	4·812	0·096	1·49	0·641	289·50	0·006	59·81	0·002	214·70	0·001	77·91	0·004	241·70	1·439	255·02
	1883-84	4·813	0·037	92·65	0·640	287·46	0·004	66·62	0·001	146·31	0·001	75·96	0·007	351·40	1·464	254·75
	1884-85	4·630	0·044	93·63	0·625	288·28	0·003	45·00	0·001	113·96	0·000	288·44	0·016	288·96	1·462	255·78
	Means	4·829	0·048	76·31	0·648	286·21	0·005	49·69	0·001	156·71	0·001	53·12	0·012	303·26	1·469	253·67
False Point	1881-82	7·552	0·006	325·24	1·005	301·55	0·007	331·19	0·003	153·44	0·003	218·93	0·009	66·41	2·247	268·81
	1882-83	7·597	0·024	47·52	1·030	304·26	0·008	326·94	0·003	185·04	0·003	261·12	0·008	354·55	2·253	271·10
	1883-84	7·593	0·006	47·55	0·993	302·09	0·009	315·96	0·003	163·30	0·004	280·54	0·014	286·59	2·267	269·40
	1884-85	7·492	0·008	86·42	1·000	298·22	0·006	306·67	0·005	158·20	0·005	181·10	0·009	226·80	2·237	267·05
	Means	7·559	0·011	36·68	1·007	301·53	0·008	320·19	0·004	165·00	0·004	235·42	0·010	323·59	2·251	269·09
Dublat	1881-82	14·394	0·044	99·12	2·053	326·81	0·025	202·44	0·002	120·47	0·004	115·94	0·008	344·54	4·623	290·10
	1882-83	14·499	0·050	120·94	2·163	326·29	0·011	219·54	0·005	78·23	0·007	110·35	0·007	96·83	4·596	289·67
	1883-84	14·417	0·040	142·28	2·147	328·84	0·017	201·23	0·005	40·24	0·003	88·26	0·017	62·44	4·594	290·49
	1884-85	14·379	0·047	124·40	2·071	329·36	0·015	255·12	0·001	59·04	0·002	58·39	0·024	264·52	4·626	290·38
	1885-86	14·263	0·047	131·20	2·099	330·45	0·011	237·49	0·002	259·38	0·009	129·89	0·027	291·07	4·603	293·80
	Means	14·390	0·046	123·59	2·107	327·75	0·016	223·16	0·003	111·47	0·005	100·57	0·017	355·88	4·608	290·89
Diamond Harbour*	1881-82	8·976	0·082	156·14	2·215	26·06	0·117	328·35	0·013	266·42	0·002	304·70	0·020	87·65	5·175	344·81
	1882-83	9·011	0·088	147·38	2·288	25·14	0·122	323·01	0·013	234·83	0·004	41·50	0·020	103·07	5·179	343·56
	1883-84	8·999	0·093	149·53	2·252	26·15	0·132	330·30	0·015	267·73	0·004	240·64	0·022	145·06	5·177	344·30
	1884-85	8·897	0·092	161·09	2·202	26·49	0·123	328·73	0·013	269·56	0·007	285·95	0·052	202·53	5·135	344·71
	1885-86	8·804	0·101	162·94	2·199	25·98	0·123	326·18	0·006	233·13	0·002	175·03	0·032	277·22	5·154	344·82
	Means	8·937	0·091	155·42	2·231	25·96	0·123	327·31	0·012	254·33	0·004	281·56	0·029	163·11	5·164	344·44
Amherst*	1880-81	13·591	0·426	178·00	2·851	108·69	0·095	146·81	0·022	221·61	0·009	209·25	0·041	191·71	6·230	69·94
	1881-82	13·974	0·143	148·53	2·705	101·22	0·118	102·23	0·004	221·06	0·006	348·16	0·021	273·03	6·081	67·60
	1882-83	13·701	0·096	97·13	2·750	104·70	0·104	116·81	0·009	118·99	0·009	269·33	0·035	300·37	6·389	68·46
	1883-84	13·757	0·124	120·19	2·680	100·39	0·080	108·12	0·008	327·53	0·003	301·83	0·014	88·34	6·376	66·06
	1884-85	13·588	0·137	132·64	2·700	05·11	0·099	101·27	0·002	164·48	0·002	266·99	0·038	92·93	6·427	65·09
	1885-86	13·311	0·131	121·86	2·563	102·09	0·075	107·50	0·002	341·57	0·003	244·36	0·045	28·99	6·415	67·26
	Means	13·654	0·176	133·06	2·708	102·03	0·095	113·81	0·008	232·54	0·005	273·32	0·032	342·56	6·320	67·40
Moulmein*	1880-81	8·453	0·095	145·51	1·400	148·32	0·068	230·06	0·006	177·99	0·002	164·48	0·034	128·32	3·884	111·89
	1881-82	8·659	0·099	154·60	1·344	145·31	0·069	225·18	0·006	187·13	0·001	251·57	0·019	101·26	3·698	112·36
	1882-83	8·658	0·095	147·70	1·343	150·01	0·065	231·29	0·004	185·32	0·002	218·29	0·002	183·42	3·756	114·99
	1883-84	8·737	0·099	150·78	1·349	149·26	0·062	227·80	0·005	261·42	0·002	319·76	0·029	144·52	3·720	113·24
	1884-85	8·146	0·114	143·69	1·364	150·10	0·071	222·67	0·007	246·37	0·002	120·96	0·019	121·57	3·887	113·66
	1885-86	8·388	0·074	154·09	1·364	151·41	0·073	228·02	0·007	222·05	0·000	198·44	0·026	71·05	3·803	115·25
	Means	8·507	0·096	149·40	1·361	149·07	0·068	227·50	0·006	213·38	0·002	212·25	0·022	125·02	3·791	113·57

Station.	Year.	M_3 H	M_3 K	M_4 H	M_4 K	M_6 H	M_6 K	M_8 H	M_8 K	O_1 H	O_1 K	K_1 H	K_1 K	K_2 H	K_2 K	P_1 H	P_1 K	J_1 H	J_1 K	Q_1 H	Q_1 K	L_2 H	L_2 K
Okha	1874-75	0·030	20°·64	0·136	106°·94	0·007	269°·65	0·011	96°·17	0·693	56°·61	1·414	53°·11	0·328	17°·44	0·384	49°·94	0·107	81°·41	0·137	58°·62	0·221	23°·22
Hanstal	1874-75	0·056	92·09	0·727	329·61	0·305	246·02	0·083	150·47	0·754	74·70	1·495	81·11	0·527	81·25	0·384	83·65	0·095	127.70	0·139	77·17	0·570	36·77
Kathiwadar*	1881-82	0·020	151·87	0·220	178·11	0·139	137·46	0·002	198·64	0·720	66·42	1·611	65·90	0·324	79·21	0·436	70·67	0·175	106·68	0·152	67·95	0·079	260·51
Kárwár	1878-79	0·012	279·86	0·045	28·20	0·013	288·51	0·001	210·08	0·496	49·72	1·001	46·55	0·175	329·58	0·269	41·49	0·046	51·36	0·111	57·10	0·093	326·01
	1879-80	0·014	285·59	0·059	22·11	0·010	282·53	0·003	50·95	0·498	50·23	0·996	46·56	0·174	328·70	0·274	42·73	0·078	54·61	0·133	61·56	0·041	325·14
	1880-81	0·018	275·29	0·054	11·48	0·013	277·11	0·004	8·76	0·505	48·75	1·010	44·66	0·164	327·07	0·282	42·59	0·087	70·68	0·130	54·03	0·059	318·48
	1881-82	0·012	263·69	0·059	16·37	0·011	283·85	0·002	58·37	0·494	48·39	1·008	44·33	0·175	333·49	0·287	40·86	0·064	67·07	0·101	58·23	0·038	291·59
	1882-83	0·012	260·70	0·060	7·26	0·009	287·36	0·002	215·12	0·493	48·88	1·006	44·85	0·180	329·56	0·274	40·05	0·065	42·28	0·097	62·86	0·050	323·70
	Means	0·014	273·03	0·055	17·08	0·011	283·87	0·002	108·66	0·497	49·19	1·004	45·39	0·174	329·68	0·277	41·54	0·068	57·20	0·114	58·76	0·056	316·98
Beypore	1878-79	0·011	213·51	0·021	45·30	0·010	120·50	0·008	136·69	0·337	58·02	0·704	52·37	0·065	11·24	0·184	48·93	0·035	66·65	0·078	67·77	0·018	349·01
	1879-80	0·010	183·64	0·015	35·80	0·004	114·14	0·010	130·03	0·338	56·82	0·691	53·35	0·079	2·79	0·188	56·07	0·047	44·07	0·089	75·93	0·037	340·99
	1880-81	0·011	199·61	0·018	53·33	0·003	184·37	0·007	139·68	0·334	58·87	0·683	54·16	0·089	13·04	0·197	57·29	0·064	84·25	0·082	59·17	0·020	341·51
	1881-82	0·010	195·90	0·020	40·78	0·006	137·66	0·008	161·96	0·337	57·03	0·715	50·71	0·069	11·35	0·177	53·82	0·040	81·78	0·078	62·31	0·033	347·41
	1882-83	0·009	193·50	0·026	31·39	0·012	132·67	0·009	161·87	0·356	55·13	0·727	47·07	0·098	17·06	0·211	48·46	00·34	39·75	0·078	67·28	0·025	1·09
	1883-84	0·008	198·96	0·027	22·52	0·013	106·13	0·009	158·34	0·362	55·64	0·730	48·17	0·105	359·99	0·230	51·48	0·073	33·80	0·091	62·43	0·028	1·88
	Means	0·010	197·52	0·021	38·19	0·008	132·58	0·009	148·10	0·344	56·92	0·708	50·97	0·084	9·25	0·198	52·68	0·049	58·38	0·083	65·82	0·027	350·32
Pámban	1878-79	0·016	170·37	0·020	198·68	0·011	41·90	0·005	294·01	0·114	46·52	0·297	43·66	0·103	83·59	0·105	43·73	0·008	68·24	0·025	84·20	0·023	56·01
	1879-80	0·016	168·41	0·016	190·48	0·011	50·29	0·004	347·63	0·113	44·83	0·293	45·02	0·110	92·07	0·110	46·84	0·013	44·49	0·021	98·42	0·026	48·86
	1880-81	0·015	164·79	0·015	199·10	0·011	40·24	0·004	303·29	0·116	42·81	0·295	45·17	0·116	88·59	0·108	45·78	0·014	37·95	0·023	91·24	0·016	78·71
	1881-82	0·017	177·45	0·014	187·35	0·009	34·25	0·007	312·85	0·115	46·77	0·291	48·73	0·121	94·19	0·115	49·57	0·021	42·10	0·016	81·48	0·026	50·20
	Means	0·016	170·26	0·016	193·90	0·011	41·67	0·005	314·45	0·115	45·23	0·294	45·65	0·113	89·61	0·110	46·48	0·014	48·20	0·021	88·84	0·023	58·45
Vizagapatam	1879-80	0·007	332·20	0·014	310·31	0·003	143·75	0·004	173·70	0·139	329·82	0·371	338·24	0·179	269·95	0·112	335·86	0·035	328·23	0·010	20·37	0·049	256·97
	1880-81	0·001	208·03	0·014	330·58	0·004	77·90	0·002	214·14	0·140	332·21	0·364	342·06	0·157	274·07	0·104	346·07	0·027	355·63	0·007	277·12	0·044	245·07
	1831-82	0·006	41·42	0·015	338·94	0·005	29·76	0·002	243·13	0·144	332·92	0·366	341·64	0·168	284·80	0·117	346·12	0·014	313·86	0·004	305·98	0·027	296·64
	1882-83	0·008	13·89	0·018	342·39	0·008	35·02	0·005	205·65	0·142	329·45	0·335	345·88	0·306	278·35	0·049	329·35	0·024	351·11	0·014	335·85	0·088	216·85
	1883-84	0·007	10·16	0·013	10·58	0·004	60·69	0·005	214·77	0·138	331·80	0·355	342·32	0·181	278·86	0·116	340·31	0·026	342·87	0·020	348·49	0·046	280·56
	1884-85	0·009	21·56	0·004	226·74	0·007	66·47	0·004	241·00	0·129	333·33	0·358	342·51	0·163	279·20	0·109	345·49	0·024	18·02	0·014	337·74	0·078	256·26
	Means	0·006	344·54	0·013	319·92	0·005	68·93	0·004	215·40	0·139	331·59	0·358	342·11	0·192	277·54	0·101	340·53	0·025	344·95	0·012	330·93	0·055	258·73
False Point	1881-82	0·012	33·67	0·035	224·18	0·006	80·09	0·003	229·19	0·175	335·42	0·408	343·65	0·268	296·45	0·133	349·22	0·021	306·02	0·004	306·91	0·068	280·88
	1882-83	0·016	26·87	0·041	235·89	0·014	46·67	0·002	262·39	0·179	335·24	0·407	346·25	0·241	296·82	0·157	339·51	0·030	318·76	0·017	340·10	0·050	226·85
	1883-84	0·012	35·98	0·035	223·90	0·014	43·84	0·006	191·97	0·176	334·24	0·413	343·77	0·289	307·24	0·127	345·62	0·031	329·20	0·012	311·94	0·068	265·77
	1884-85	0·016	27·09	0·029	233·04	0·004	142·18	0·004	220·08	0·172	333·70	0·406	341·23	0·292	295·23	0·132	344·08	0·020	359·46	0·005	187·36	0·095	286·15
	Means	0·014	30·90	0·035	229·25	0·010	78·20	0·004	225·91	0·176	334·65	0·409	343·73	0·273	298·94	0·137	344·61	0·026	328·36	0·010	286·58	0·070	264·91
Dublat	1881-82	0·049	131·12	0·101	142·52	0·014	274·98	0·014	315·90	0·181	332·09	0·498	353·36	0·573	310·19	0·158	335·50	0·031	351·62	0·010	305·51	0·175	290·56
	1882-83	0·043	134·96	0·089	144·83	0·013	235·85	0·009	273·02	0·197	335·44	0·488	350·31	0·618	325·25	0·151	350·64	0·016	296·42	0·008	0·81	0·158	291·81
	1883-84	0·051	138·02	0·081	148·83	0·008	249·69	0·012	279·22	0·186	342·23	0·503	351·62	0·599	328·38	0·141	347·41	0·022	307·33	0·013	10·96	0·210	295·09
	1884-85	0·049	132·61	0·086	148·94	0·013	165·08	0·006	302·24	0·183	343·00	0·490	350·29	0·634	332·77	0·156	350·11	0·053	2·05	0·012	312·40	0·170	299·65
	1885-86	0·049	136·53	0·081	159·65	0·007	180·69	0·009	298·43	0·196	335·68	0·493	353·56	0·691	327·33	0·148	349·66	0·033	17·33	0·010	57·70	0·245	301·84
	Means	0·048	134·65	0·088	148·95	0·011	221·26	0·010	293·76	0·189	337·69	0·494	351·83	0·623	324·78	0·151	340·66	0·031	338·95	0·011	353·48	0·192	295·79
Diamond Harbour*	1881-82	0·042	219·54	0·756	246·42	0·156	106·44	0·065	347·24	0·237	344·11	0·499	14·99	0·667	19·58	0·176	6·13	0·029	299·22	0·024	8·89	0·174	356·98
	1882-83	0·028	225·47	0·734	245·36	0·148	104·98	0·058	343·26	0·230	345·98	0·492	13·83	0·644	26·50	0·174	11·57	0·033	339·95	0·036	9·66	0·347	344·19
	1883-84	0·061	244·68	0·752	246·27	0·163	105·93	0·060	343·91	0·211	342·12	0·508	15·50	0·730	24·65	0·173	8·61	0·006	67·95	0·036	304·32	0·201	335·29
	1884-85	0·062	237·14	0·753	249·01	0·141	112·37	0·053	348·72	0·217	350·44	0·498	14·32	0·718	22·76	0·184	11·94	0·035	28·37	0·019	301·12	0·280	344·23
	1885-86	0·058	224·72	0·765	249·81	0·144	110·03	0·053	354·04	0·233	348·26	0·515	13·49	0·622	30·05	0·171	11·16	0·045	24·04	0·016	43·56	0·276	8·11
	Means	0·050	230·31	0·752	247·37	0·150	107·95	0·058	347·43	0·226	346·18	0·502	14·43	0·676	24·71	0·176	9·88	0·030	7·91	0·026	349.51	0·256	349·76
Amherst*	1880-81	0·034	287·00	0·273	60·32	0·070	256·69	0·006	282·25	0·310	327·71	0·668	3·47	1·771	91·39	0·132	307·74	0·109	13·16	0·064	324·60	0·226	112·34
	1881-82	0·003	224·23	0·423	51·34	0·146	248·25	0·014	243·79	0·319	338·50	0·686	6·29	0·858	81·38	0·193	348·07	0·083	6·52	0·060	320·88	0·303	119·89
	1882-83	0·019	273·03	0·355	41·49	0·139	250·72	0·021	220·09	0·323	351·90	0·744	6·27	0·682	96·78	0·207	353·68	0·031	82·46	0·039	321·97	0·348	103·28
	1883-84	0·021	274·63	0·303	37·02	0·138	254·39	0·016	218·83	0·339	344·72	0·714	2·90	0·883	100·63	0·207	2·59	0·022	10·63	0·018	10·61	0·362	81·05
	1884-85	0·033	237·32	0·315	35·73	0·142	250·34	0·021	222·19	0·335	347·32	0·702	1·12	0·973	96·40	0·195	5·61	0·028	58·60	0·020	7·37	0·373	89·84
	1885-86	0·031	259·81	0·273	32·03	0·151	248·96	0·023	239·89	0·310	349·30	0·738	3·88	0·752	111·49	0·212	12·27	0·045	72·50	0·035	347·19	0·314	78·07
	Means	0·024	259·34	0·324	42·99	0·131	251·56	0·017	237·84	0·323	343·24	0·709	3·99	0·987	96·35	0·191	351·66	0·053	40·65	0·039	342·10	0·321	97·41
Moulmein*	1880-81	0·023	273·89	0·926	168·90	0·105	200·19	0·034	125·48	0·256	44·11	0·452	39·41	0·409	150·55	0·113	62·00	0·038	51·90	0·043	52·63	0·204	133·82
	1881-82	0·031	214·84	0·880	169·67	0·107	198·05	0·036	140·90	0·252	49·17	0·447	40·42	0·282	152·49	0·144	61·19	0·018	47·53	0·054	54·80	0·390	155·27
	1882-83	0·020	138·86	0·897	174·13	0·095	200·97	0·044	134·00	0·252	49·96	0·414	41·51	0·316	161·82	0·144	56·84	0·009	221·74	0·039	52·88	0·242	129·10
	1883-84	0·020	164·54	0·869	171·08	0·093	197·15	0·040	135·54	0·275	51·38	0·425	41·17	0·371	163·73	0·119	54·02	0·022	22·11	0·042	57·16	0·320	135·71
	1884-85	0·019	117·12	0·906	172·78	0·077	208·07	0·043	119·40	0·273	55·47	0·456	43·96	0·275	158·46	0·145	52·59	0·016	62·95	0·056	79·36	0·330	123·33
	1885-86	0·028	42·02	0·897	176·01	0·084	218·47	0·036	123·01	0·245	53·58	0·429	42·60	0·309	158·63	0·116	54·42	0·015	71·92	0·046	57·33	0·297	144·17
	Means	0·024	158·55	0·896	172·10	0·094	203·82	0·039	129·72	0·259	50·61	0·437	41·51	0·327	157·61	0·130	56·84	0·020	79·69	0·047	59·03	0·297	136·90

* These are Riverain Stations at which A_0 is the height of mean level of the water above zero.

Statement showing the interruptions which occurred in the obse

Name of Station.	Year of Observation.	Period of interruption. From	Period of interruption. To	Total No. of days' interruption. In each period.	Total No. of days' interruption. In the year.	Name of Station.
Vizagapatam	1882-83	7th November 1882	12th January 1883	67	67	Amherst
False Point	1882-83	2nd October 1882	22nd October 1882	21	21	
Dudlat	1881-82	8th October 1881	26th October 1881	19	19	
Diamond Harbour	1885-86	10th August 1885	24th August 1885	15	15	
Moulmein	1881-82	30th May 1881	31st May 1881	2	9	
		21st January 1882	27th January 1882	7		
	1884-85	6th September 1884	15th October 1884	40	40	

...es for each particular tide which have been calculated from the values obtained by Tidal observations each year at the stations where the operations are completed.

K₂	K₂ K	P₁ H	P₁ K	J₁ H	J₁ K	Q₁ H	Q₁ K	L₂ H	L₂ K	N₂ H	N₂ K	λ₂ H	λ₂ K
8	17°·44	0·384	49°·94	0·107	81°·41	0·137	58°·62	0·221	23°·22	0·781	321°·97	0·073	23°·43
7	81·25	0·384	83·65	0·095	127.70	0·139	77·17	0·570	36·77	1·193	25·79	0·235	38·60
4	79·21	0·436	70·67	0·175	106·68	0·152	67·95	0·079	260·51	0·755	33·70	0·043	107·14
5	329·58	0·269	41·49	0·046	51·36	0·111	57·10	0·093	326·01	0·416	281·60	0·022	243·58
4	328·70	0·274	42·73	0·078	54·61	0·133	61·56	0·041	325·14	0·426	283·57	0·004	122·14
4	327·07	0·282	42·59	0·087	70·68	0·130	54·03	0·059	318·48	0·413	282·47	0·032	28·65
5	333·49	0·287	40·86	0·064	67·07	0·101	58·23	0·038	291·59	0·400	281·16	0·021	340·85
0	329·56	0·274	40·05	0·065	42·28	0·097	62·86	0·050	323·70	0·397	279·48	0·021	268·47
4	329·68	0·277	41·54	0·068	57·20	0·114	58·76	0·056	316·98	0·410	281·66	0·020	272·74
5	11·24	0·184	48·93	0·035	66·65	0·078	67·77	0·018	349·01	0·191	305·94	0·004	186·90
9	2·79	0·188	56·07	0·047	44·07	0·089	75·93	0·037	340·99	0·189	309·11	0·012	1·13
9	13·04	0·197	57·29	0·064	84·25	0·082	59·17	0·020	341·51	0·190	302·47	0·013	288·64
9	11·35	0·177	53·82	0·040	81·78	0·078	62·31	0·033	347·41	0·199	306·94	0·017	13·56
8	17·06	0·211	48·46	00·34	39·75	0·078	67·28	0·025	1·09	0·215	298·94	0·011	354·41
5	359·99	0·230	51·48	0·073	33·80	0·091	62·43	0·028	1·88	0·221	296·36	0·002	252·58
4	9·25	0·198	52·68	0·049	58·38	0·083	65·82	0·027	350·32	0·201	303·29	0·010	302·87
3	83·59	0·105	43·73	0·008	68·24	0·025	84·20	0·023	56·01	0·076	29·10	0·017	63·03
0	92·07	0·110	46·84	0·013	44·49	0·021	98·42	0·026	48·86	0·087	30·26	0·023	24·06
6	88·59	0·108	45·78	0·014	37·95	0·023	91·24	0·016	78·71	0·084	32·20	0·008	353·92
1	94·19	0·115	49·57	0·021	42·10	0·016	81·48	0·026	50·20	0·082	31·83	0·014	173·02
3	89·61	0·110	46·48	0·014	48·20	0·021	88·84	0·023	58·45	0·082	30·85	0·016	63·51
9	269·95	0·112	335·86	0·035	328·23	0·010	20·37	0·049	256·97	0·355	243·13	0·021	200·61
7	274·07	0·104	346·07	0·027	355·63	0·007	277·12	0·044	245·07	0·300	249·79	0·019	331·77
8	284·80	0·117	346·12	0·014	313 86	0·004	305·98	0·027	296·64	0·291	251·26	0·022	244·04
6	278·35	0·049	329·35	0·024	351·11	0·014	335·85	0·088	216·85	0·309	241·50	0·024	278·17
1	278·86	0·116	340·31	0·026	342·87	0·020	348·49	0·046	280·56	0·296	248·12	0·012	213·86
3	279·20	0·109	345·49	0·024	18·02	0·014	337·74	0·078	256·26	0·298	251·80	0·039	299·35
2	277·54	0·101	340·53	0·025	344·95	0·012	330·93	0·055	258·73	0·308	247·60	0·023	261·30
8	296·45	0·133	349·22	0·021	306·02	0·004	306·91	0·068	280·88	0·471	265·34	0·045	276·88
1	296·82	0·157	339·51	0·030	318·76	0·017	340·10	0·050	226·85	0·481	268·12	0·081	82·96
9	307·24	0·127	345·62	0·031	329·20	0·012	311·94	0·068	265·77	0·425	263·65	0·019	330·52
2	295·23	0·132	344·08	0·020	359·46	0·005	187·36	0·095	286·15	0·439	258·37	0·066	272·09
3	298·94	0·137	344·61	0·026	328·36	0·010	286·58	0·070	264·91	0·454	263·87	0·053	330·61
3	310·19	0·158	335·50	0·031	351·62	0·010	305·51	0·175	290·56	1·041	284·86	0·298	339·00
8	325·25	0·151	350·64	0·016	296·42	0·008	0·81	0·158	291·81	0·852	286·37	0·139	292·51
9	328·38	0·141	347·41	0·022	307·33	0·013	10·96	0·210	295·09	0·820	285·06	0·085	261·20
4	332·77	0·156	350·11	0·053	2·05	0·012	312·40	0·170	299·65	0·875	282·67	0·063	276·85
1	327·33	0·148	349·66	0·033	17·33	0·010	57·70	0·245	301·84	0·882	286·51	0·163	325·19
3	324·78	0·151	346·66	0·031	338·95	0·011	353·48	0·192	295·79	0·894	285·09	0·150	298·95
7	19·58	0·176	6·13	0·029	299·22	0·024	8·89	0·174	356·98	0·988	339·18	0·171	18·73
4	26·50	0·174	11·57	0·033	339·95	0·036	9·66	0·347	344·19	0·914	339·74	0·058	296·13
0	24·65	0·173	8·61	0·006	67·95	0·036	304·32	0·201	335·29	0·898	335·80	0·046	22·48
8	22·76	0·184	11·94	0·035	28·37	0·019	301·12	0·280	344·23	0·945	335·79	0·192	356·71
2	30·05	0·171	11·16	0·045	24·04	0·016	43·56	0·276	8·11	1·030	347·01	0·267	358·05
6	24·71	0·176	9·88	0·030	7·91	0·026	349.51	0·256	349·76	0·955	339·50	0·147	354·42
1	91·39	0·132	307·74	0·109	13·16	0·064	324·60	0·226	112·34	1·374	59·61	0·393	112·83
8	81·38	0·193	348·07	0·083	6·52	0·060	320·88	0·303	119·89	1·248	51·10	0·280	65·29
2	96·78	0·207	353·68	0·031	82·46	0·039	321·97	0·348	103·28	1·343	51·00	0·226	177·83
3	100·63	0·207	2·59	0·022	10·63	0·018	10·61	0·362	81·05	1·230	52·12	0·185	91·65
3	96·40	0·195	5·61	0·028	58·60	0·020	7·37	0·373	89·84	1·194	50·50	0·178	132·83
2	111·49	0·212	12·27	0·045	72·50	0·035	347·19	0·314	78·07	1·312	47·65	0·216	183·97
7	96·35	0·191	351·66	0·053	40·65	0·039	342·10	0·321	97·41	1·284	52·00	0·246	127·40
9	150·55	0·113	62·00	0·038	51·90	0·043	52·63	0·204	133·82	0·735	97·22	0·161	152·00
2	152·49	0·144	61·19	0·018	47·53	0·054	54·80	0·390	155·27	0·672	106·41	0·249	182·20
6	161·82	0·144	56·84	0·009	221·74	0·039	52·88	0·242	129·10	0·630	102·12	0·118	162·23
1	163·73	0·119	54·02	0·022	22·11	0·042	57·16	0·320	135·71	6·654	95·13	0·104	106·79
5	158·46	0·145	52·59	0·016	62·95	0·056	79·36	0·330	123·33	0·620	92·37	0·183	153·28
9	158·63	0·116	54·42	0·015	71·92	0·046	57·33	0·297	144·17	0·713	99·45	0·165	170·32
27	157·61	0·130	56·84	0·020	79·69	0·047	59·03	0·297	136·90	0·671	98·78	0·163	154·47

K₂	ν₂ H	ν₂ K	μ₂ H	μ₂ K	R₂ H	R₂ K	T₂ H	T₂ K	(MS)₄ H	(MS)₄ K	(2SM)₂ H	(2SM)₂ K	2N₂ H	2N₂ K
8	0·164	7°·53	0·203	182°·32	...	°	...	°	0·064	111°·40	0·044	292°·21	...	°
7	0·296	47·27	0·595	177·80	...	...	...	...	0·351	12·04	0·135	298·71	...	...
4	0·131	15·36	0·286	343·27	...	...	...	...	0·159	215·39	0·029	153·77	...	...
5	0·077	339·76	0·033	283·28	...	...	...	...	0·022	80·36	0·012	30·76	0·054	238·25
4	0·136	296·95	0·057	244·88	0·006	61·03	0·046	9·46	0·028	75·49	0·004	353·33	0·050	249·05
4	0·122	260·60	0·046	260·00	...	...	...	...	0·021	60·64	0·004	14·58	0·084	239·63
5	0·057	232·42	0·051	244·24	0·009	229·83	0·075	300·28	0·029	59·79	0·007	106·45	0·043	252·12
0	0·047	338·36	0·033	284·47	...	...	...	...	0·028	59·77	0·009	351·28	0·052	241·42
4	0·088	293·62	0·044	263·37	0·008	145·43	0·061	154·87	0·026	67·21	0·007	315·28	0·057	244·09
5	0·035	248·75	0·024	201·54	...	...	...	...	0·010	76·22	0·006	65·06	0·027	236·65
9	0·041	20·19	0·020	349·25	0·017	163·16	0·043	37·30	0·004	80·10	0·004	218·50	0·023	261·18
9	0·050	354·07	0·008	203·27	...	...	...	...	0·005	100·39	0·004	241·47	0·046	257·79
9	0·095	296·15	0·014	298·75	0·028	100·70	0·036	0·13	0 008	57·14	0·004	243·10	0·011	265·66
8	0·053	276·57	0·030	238·84	...	...	...	...	0·016	69·18	0·007	350·07	0·021	241·61
5	0·003	15·13	0·009	269·00	0·013	126·16	0·061	16·94	0·015	60·44	0·004	0·54	0·019	242·94
4	0·046	321·81	0·018	260·11	0·019	130·01	0·047	18·12	0·010	73·91	0·005	306·46	0·025	250·97
3	0·016	81·70	0·004	77·62	...	...	...	...	0·021	291·60	0·010	5·58	0·003	356·91
0	0·034	49·26	0·010	98·04	0·012	132·75	0·038	104·14	0·017	293·92	0·008	338·44	0·015	13·86
6	0·030	14·96	0·012	94·88	...	...	...	...	0·018	285·94	0·012	339·81	0·008	75·61
1	0·027	334·12	0·011	148·26	0·019	94·37	0·012	79·27	0·017	294·52	0·008	288·4)	0·008	331·14
3	0·027	30·01	·009	104·70	0·016	113·56	0·025	91·71	0·018	291·50	0·010	333·08	0·009	14·38
9	0·114	243·58	0·030	234·03	...	...	...	...	0·007	345.10	0·008	209·68	0·066	234·44
7	0·055	198·62	0·026	258·86	0·015	129·92	0·021	336·23	0·010	20·01	0·110	292·41	0·059	219·03
8	0·002	72·20	0·016	217·61	...	...	...	...	0·014	19·81	0·015	250·23	0·044	258·65
6	0·127	282·51	0·034	326·23	0·039	245·98	0·080	189·27	0·015	356·76	0·016	147·75	0·046	224·66
1	0·116	257·14	0·028	257·70	...	...	...	...	0·012	28·23	0·004	312·24	0·039	244·06
3	0·095	222·81	0·036	264·38	0·025	68·68	0·036	282·19	0·007	283·37	0·012	219·67	0·056	218·29
2	0·085	212·81	0·028	259·80	0·026	148·19	0·046	269·23	0·011	355·55	0·011	238·66	0·052	233·19
8	0·163	246·84	0·070	266·20	...	...	...	...	0·039	272·34	0·019	195·98	0·080	248·65
1	0·120	240·63	0·080	279·61	0·034	217·22	0·017	149·15	0·042	274·77	0·014	177·10	0·075	267·67
9	0·036	304·50	0·069	265·21	...	...	...	...	0·041	266·28	0·020	189·22	0·066	238·31
2	0·136	300·58	0·042	252·43	0·014	283·66	0·099	280·00	0·039	260·66	0·028	212·73	0·050	240·22
3	0·114	273·14	0·065	265·86	0·024	250·44	0·058	214·58	0·040	268·51	0·020	193·76	0·068	248·71
3	0·271	260·94	0·218	10·10	...	...	...	...	0·094	171·25	0·097	194·72	0·207	271·70
8	0·192	240·22	0·111	19·01	0·219	288·94	0·137	299·43	0 059	138·91	0·046	226·91	0·124	297·04
9	0·142	294·91	0·172	14·11	...	...	...	...	0·067	173·83	0·053	193·00	0·096	221·44
4	0·276	302·68	0·107	355·12	0·095	306·69	0·175	60·70	0·074	177·20	0·058	198·08	0·200	252·65
1	0·328	276·15	0·141	9·96	...	...	...	...	0·077	191·00	0·044	196·20	0·147	263·53
3	0·242	274·98	0·150	9·66	0·157	297·82	0·156	0·07	0·074	170·44	0·060	201·78	0·155	261·27
7	0·420	293·85	0·272	79·18	...	...	...	...	0·687	285·58	0·095	251·34	0·138	343·33
4	0·186	284·10	0·333	89·95	0·216	9·60	0·078	55·45	0·702	283·67	0·053	289·79	0·076	42·64
0	0·204	346·13	0·298	90·05	...	...	...	...	0·702	287·52	0·058	273·77	0·212	287·50
8	0·387	330·53	0·338	82·05	0·175	16·53	0·317	86·44	0·728	288·57	0·069	271·17	0·167	313·80
2	0·202	299·30	0·268	85·34	...	...	...	...	0·709	288·26	0·074	289·76	0·147	321·11
6	0·280	310·78	0·302	85·31	0·196	13·07	0·198	70·95	0·706	286·72	0·070	275·17	0·148	333·68
1	0·426	185·52	0·443	278·05	...	...	...	...	0·285	89·98	0·188	345·09	0·325	14·86
8	0·283	267·18	0·247	298·94	0·451	252·46	0·841	143·90	0·406	79·93	0·150	28·36	0·239	40·12
2	0·566	78·79	0·220	325·59	...	...	...	...	0·350	75·70	0·115	15·96	0·258	355·07
3	0·428	48·67	0·274	309·99	0·033	346·62	0·074	284·28	0·391	72·76	0·176	5·22	0·271	23·10
3	0·232	25·41	0·202	281·13	...	...	...	...	0·300	65·55	0·181	13·44	0·204	72·32
2	0·099	55·06	0·326	292·90	0·174	316·23	0·352	78·55	0·275	64·14	0·176	327·91	0·173	61·11
7	0·339	50·11	0·285	297·77	0·219	305·10	0·422	168·91	0·318	74·68	0·164	2·66	0·245	34·43
9	0·314	101·46	0·308	272·43	...	...	...	...	0·741	209·92	0·127	37·64	0·117	110·84
2	0·215	91·35	0·314	258·84	0·097	69·59	0·200	110·28	0·701	208·62	0·137	40·25	0·050	75·87
6	0·169	58·12	0.316	279·64	...	...	...	...	0·693	214·47	0·109	37·43	0·067	30·18
1	0·173	125·65	0·347	274·02	0·133	78·67	0·151	173·75	0·685	213·33	0·123	38·79	0·120	79·06
5	0·435	127·76	0·320	260·17	...	...	...	...	0·714	215·44	0·155	49·97	0·082	144·78
9	0·331	84·25	0·339	279·08	0·204	71·57	0·264	100·22	0·715	217·96	0·118	40·30	0·120	73·56
27	0·273	98·10	0·324	270·70	0·145	73·28	0·205	128·08	0·708	213·29	0·128	40·73	0·093	85·72

K₂	(M₂N)₄ H	(M₂N)₄ K	(M₂K₁)₃ H	(M₂K₁)₃ K	(2M₂K₁)₃ H	(2M₂K₁)₃ K	Lunar Monthly. H	Lunar Monthly. K	Lunar Fort-nightly. H	Lunar Fort-nightly. K	Luni-solar F[ort]nightly. H	Luni-solar F[ort]nightly. K
8	...	°	...	°	...	°	0·066	311°·38	0·050	43°·87	0·141	250°·
7	...	...	...	...	...	...	0·121	14·17	0·101	36·88	0·169	12·
4	...	...	...	...	...	...	0·052	7·56	0·027	103·41	0·040	152·
5	0·067	209·78	0·017	270·35	0·002	83·44	0·046	350·58	0·051	345·14	0·029	213·
4	0·063	184·05	0·023	15·49	0·008	120·14	0·061	14·28	0·058	0·82	0·023	267·
4	0·028	183·19	0·034	89·46	0·010	87·98	0·048	99·91	0·034	345·59	0·021	221·
5	0·068	156·13	0·020	151·59	0·011	67·01	0·043	0·47	0·038	14·42	0·009	89·
0	0·042	208·87	0·010	338·28	0·008	44·24	0·126	31·69	0·027	37·39	0·030	26·
4	0·054	188·40	0·021	317·03	0·008	80·56	0·065	27·39	0·042	4·67	0·022	163·8
5	0·058	315·67	0·008	89·79	0·011	66·24	0·073	5·95	0·086	14·59	0·066	288·0
9	0·020	32·02	0·016	350·89	0·019	40·08	0·072	85·42	0·086	18·49	0·037	166·8
9	0·043	326·03	0·022	34·80	0·014	39·44	0·105	349·81	0·022	50·01	0·017	274·5
9	0·014	318·61	0·023	87·62	0·009	42·44	0·144	33·01	0·118	48·04	0·041	197·1
8	0·047	350·51	0·010	130·57	0·004	104·87	0·059	43·74	0·044	345·81	0·028	213·9
5	0·016	37·88	0·003	334·69	0·004	133·24	0·031	144·22	0·054	158·34	0·037	201·7
4	0·033	350·12	0·014	51·39	0·010	71·05	0·081	50·36	0·068	45·88	0·038	213·7
3	0·022	157·69	0·005	155·64	0·003	346·54	0·063	348·98	0·045	1·56	0·016	173·5
0	0·023	229·65	0·005	243·16	0·007	319·17	0·053	57·52	0·040	355·31	0·013	208·9
6	0·013	170·99	0·007	309·65	0·007	297·41	0·033	22·84	0·053	359·13	0·027	156·88
1	0·015	265·83	0·001	48·17	0·008	277·23	0·043	39·72	0·033	343·58	0·007	26·51
3	0·018	206·04	0·005	279·16	0·006	310·09	0·048	27·27	0·043	354·90	0·016	141·47
9	0·019	84·25	0·024	329·67	0·006	355·03	0·022	22·48	0·030	22·72	0·076	22·27
7	0·031	32·93	0·029	19·85	0·010	319·83	0·078	52·54	0·051	340·43	0·021	12·97
8	0·063	344·66	0·006	66·94	0·014	316·40	0·049	104·02	0·061	1·76	0·038	314·43
6	0·037	28·55	0·007	294·42	0·014	334·15	0·072	35·07	0·027	2·26	0·048	101·95
1	0·042	30·12	0·022	334·47	0·010	322·76	0·029	264·82	0·082	46·98	0·025	358·32
3	0·030	58·55	0·022	25·11	0·015	326·50	0·010	7·00	0·073	31·98	0·019	39·49
2	0·037	36·51	0·018	358.41	0·012	329·11	0·043	20·99	0·054	14·36	0·038	21·57
8	0·076	17·46	0·029	317·08	0·006	322·40	0·053	53·15	0·061	37·43	0·041	278·80
1	0·062	41·39	0·033	25·78	0·013	331·93	0·072	57·50	0·073	33·15	0·059	73·33
9	0·017	359·87	0·027	100·95	0·010	345·91	0·045	114·53	0·067	12 63	0·039	157·77
2	0·047	26·84	0·015	226·83	0·010	0·61	0·014	42·90	0·099	32·42	0·014	242·10
3	0·051	21·39	0·026	257·66	0·010	340·21	0·046	67·02	0·075	28·91	0·038	278·00
3	0·088	310·22	0·090	193·14	0·033	151·14	0·045	29·34	0·056	60·95	0·049	277·68
8	0·094	238·61	0·070	246·22	0·032	146·72	0·035	125·40	0·039	70·93	0·077	74·99
9	0·172	55·23	0·023	353·34	0·028	125·09	0·060	75·39	0·092	45·93	0·050	128·16
4	0·050	70·14	0·053	141·58	0·050	124·28	0·027	43·17	0·086	34·48	0·027	233·84
1	0·198	19·88	0·072	191·61	0·031	97·06	0·020	171·00	0·032	85·92	0·042	25·57
3	0·120	354·82	0·062	225·18	0·035	128·86	0·037	88·86	0·061	59·64	0·049	292·05
7	0·200	31·77	0·130	294·89	0·067	226·71	0·147	11·65	0·157	36·00	0·401	25·74
4	0·088	62·68	0·065	283·72	0·050	224·58	0·057	351·22	0·142	41·48	0·501	40·25
0	0·100	71·01	0·124	249·04	0·066	214·03	0·156	25·72	0·216	57·21	0·453	40·61
8	0·085	25·04	0·159	278·74	0·059	220·25	0·145	16·59	0·155	40·40	0·424	36·15
2	0·116	67·71	0·107	300·80	0·065	200·75	0·078	2·94	0·096	33·23	0·483	29·36
6	0·118	51·64	0·117	281·44	0·061	217·26	0·117	9·62	0·153	41·66	0·452	34·42
1	0·293	217·41	0·105	331·42	0·066	293·53			Long Period Tides not cor[rected]			
8	0·320	305·68	0·135	2·14	0·054	325·25	0·152	43·45	0·062	315·34	0·080	76·43
2	0·164	115·16	0·071	25·48	0·063	329·61	0·038	51·63	0·132	23·66	0·029	65·67
3	0·271	215·64	0·011	280·38	0·039	309·06	0·109	341·86	0·083	327·64	0·052	134·29
3	0·198	243·84	0·102	301·65	0·044	319·85	0·049	3·52	0·107	33·68	0·067	69·31
2	0·035	159·45	0·122	347·95	0·037	313·14	0·006	290·22	0·017	212·82	0·068	306·24
7	0·214	209·53	0·091	334·84	0·051	315·07	0·071	2·14	0·080	326·63	0·059	58·39
9	0·134	33·22	0·158	95·03	0·118	56·27	0·409	3·00	0·282	42·25	1·088	43·24
2	0·100	327·26	0·154	77·83	0·122	62·13	0·441	17·43	0·379	40·10	1·097	47·84
6	0·158	41·67	0·181	79·19	0·108	64·43	0·229	21·38	0·342	40·47	1·146	45·68
1	0·126	30·32	0·197	92·78	0·111	69·66	0·407	18·72	0·377	49·27	1·091	45·23
5	0·203	35·75	0·162	103·41	0·099	57·40	0·344	5·08	0·217	31·98	1·050	42·49
9	0·086	4·24	0·133	87·40	0·111	60·91	0·369	9·33	0·371	32·04	1·063	45·30
27	0·135	18·74	0·164	89·27	0·112	61·80	0·367	12·49	0·328	39·35	1·089	44·96

Statement showing the interruptions which occurred in the observations entered in S Series.

...rruption. To	Total No. of days' interruption. In each period.	In the year.
...th January 1883	67	67
...nd October 1882	21	21
...th October 1881	19	19
...th August 1885	15	15
1st May 1881	2	9
7th January 1882	7	
5th October 1884	40	40

Name of Station.	Year of Observation.	Period of interruption. From	Period of interruption. To	Total No. of days' interruption. In each period.	In the year.
Amherst	1880-81	7th August 1880	8th August 1880	2	144
		28th November 1880	4th December 1880	7	
		9th January 1881	15th January 1881	7	
		30th March 1881	4th August 1881	128	
	1881-82	13th November 1881	17th November 1881	5	51
		6th April 1882	23rd April 1882	18	
		18th May 1882	1st June 1882	15	
		23rd July 1882	4th August 1882	13	
	1882-83	1st October 1882	24th October 1882	24	24
	1884-85	16th May 1885	19th May 1885	4	13
		27th July 1885	4th August 1885	9	
	1885-86	8th August 1885	11th August 1885	4	13
		22nd August 1885	30th August 1885	9	

ed from the values obtained by Tidal observations each year at the stations where the operations are completed.

L_2		N_2		λ_2		ν_2		μ_2		R_2		T_2		$(MS)_4$		$(2SM)_2$		$2N_2$		$(M_2N)_4$		$(M_2K_1)_3$		$(2M_2K_1)_3$		Lunar Monthly.		Lunar Fortnightly.		Luni-solar Fortnightly.		Solar-annual.		Solar Semi Annual.		Station.
	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	
21	23°·22	0·781	321°·97	0·073	23°·43	0·164	7°·53	0·203	182°·32	...	°	...	°	0·064	111°·40	0·044	292°·21	...	°	...	°	...	°	...	°	0·066	311°·38	0·050	43°·87	0·141	250°·16	0·162	3°·11	0·121	144°·75	Okha.
70	36·77	1·193	25·79	0·235	38·60	0·296	47·27	0·595	177·80	...	...	...	...	0·351	12·04	0·135	298·71	...	...	...	...	...	...	...	...	0·121	14·17	0·101	36·88	0·169	12·73	0·024	195·32	0·090	156·38	Hanstal.
79	260·51	0·755	33·70	0·043	107·14	0·131	15·36	0·286	343·27	...	...	...	...	0·159	215·39	0·029	153·77	...	...	...	...	...	...	...	...	0·052	7·56	0·027	103·41	0·040	152·79	0·236	133·36	0·109	155·95	Kathiwadar.
03	326·01	0·416	281·60	0·022	243·58	0·077	339·76	0·033	283·28	...	...	...	...	0·022	80·36	0·012	30·76	0·054	238·25	0·067	209·78	0·017	270·35	0·002	83·44	0·046	350·58	0·051	345·14	0·029	213·90	0·170	321·95	0·045	296·82	
41	325·14	0·426	283·57	0·004	122·14	0·136	296·95	0·057	244·88	0·006	61·03	0·046	9·46	0·028	75·49	0·004	353·33	0·050	249·05	0·063	184·05	0·023	15·49	0·008	120·14	0·061	14·28	0·058	0·82	0·023	267·52	0·344	307·25	0·083	201·81	
59	318·48	0·413	282·47	0·032	28·65	0·122	260·60	0·046	260·00	...	...	...	...	0·021	60·64	0·004	14·58	0·084	239·63	0·028	183·19	0·034	89·46	0·010	87·98	0·048	99·91	0·034	345·59	0·021	221·88	0·491	302·72	0·128	191·21	Kárwár.
38	291·59	0·400	281·16	0·021	340·85	0·057	232·42	0·051	244·24	0·009	229·83	0·075	300·28	0·029	59·79	0·007	106·45	0·043	252·12	0·068	156·13	0·020	151·59	0·011	67·01	0·043	0·47	0·038	14·42	0·009	89·22	0·383	302·56	0·053	224·01	
50	323·70	0·397	279·48	0·021	268·47	0·047	338·36	0·033	284·47	...	...	...	...	0·028	59·77	0·009	351·28	0·052	241·42	0·042	208·87	0·010	338·28	0·008	44·24	0·126	31·69	0·027	37·39	0·030	26·66	0·373	317·09	0·033	225·45	
56	316·98	0·410	281·66	0·020	272·74	0·088	293·62	0·044	263·37	0·008	145·43	0·061	154·87	0·026	67·21	0·007	315·28	0·057	244·09	0·054	188·40	0·021	317·03	0·008	80·56	0·065	27·39	0·042	4·67	0·022	163·84	0·352	310·31	0·068	227·86	
18	349·01	0·191	305·94	0·004	186·90	0·035	248·75	0·024	201·54	...	...	...	...	0·010	76·22	0·006	65·06	0·027	236·65	0·058	315·67	0·008	89·79	0·011	66·24	0·073	5·95	0·086	14·59	0·066	288·09	0·307	311·24	0·139	225·98	
37	340·99	0·189	309·11	0·012	1·13	0·041	20·19	0·020	349·25	0·017	163·16	0·043	37·30	0·004	80·10	0·004	218·50	0·023	261·18	0·020	32·02	0·016	350·89	0·019	40·08	0·072	85·42	0·086	18·49	0·037	166·84	0·344	315·68	0·252	181·30	
20	341·51	0·190	302·47	0·013	288·64	0·050	354·07	0·008	203·27	...	...	...	...	0·005	100·39	0·004	241·47	0·046	257·79	0·043	326·03	0·022	34·80	0·014	39·44	0·105	349·81	0·022	50·01	0·017	274·53	0·328	310·74	0·180	208·39	Beypore.
33	347·41	0·199	306·94	0·017	13·56	0·095	296·15	0·014	298·75	0·028	100·70	0·036	0·13	0·008	57·14	0·004	243·10	0·011	265·66	0·014	318·61	0·023	87·62	0·009	42·44	0·144	33·01	0·118	48·04	0·041	197·13	0·321	328·87	0·189	193·16	
25	1·09	0·215	298·94	0·011	354·41	0·053	276·57	0·030	238·84	...	...	...	...	0·016	69·18	0·007	350·07	0·021	241·61	0·047	350·51	0·010	130·57	0·004	104·87	0·059	43·74	0·044	345·81	0·028	213·94	0·243	298·01	0·123	214·49	
28	1·88	0·221	296·36	0·002	252·58	0·003	15·13	0·009	269·00	0·013	126·16	0·061	16·94	0·015	60·44	0·004	0·54	0·019	242·94	0·016	37·88	0·003	334·69	0·004	133·24	0·031	144·22	0·054	158·34	0·037	201·77	0·308	300·79	0·113	208·26	
27	350·32	0·201	303·29	0·010	302·87	0·046	321·81	0·018	260·11	0·019	130·01	0·047	18·12	0·010	73·91	0·005	306·46	0·025	250·97	0·033	350·12	0·014	51·39	0·010	71·05	0·081	50·36	0·068	45·88	0·038	213·72	0·309	310·89	0·166	205·26	
23	56·01	0·076	29·10	0·017	63·03	0·016	81·70	0·004	77·62	...	...	...	...	0·021	291·60	0·010	5·58	0·003	356·91	0·022	157·69	0·005	155·64	0·003	346·54	0·063	348·98	0·045	1·56	0·016	173·59	0·122	298·92	0·138	95·54	
26	48·86	0·087	30·26	0·023	24·06	0·034	49·26	0·010	98·04	0·012	132·75	0·038	104·14	0·017	293·92	0·008	338·44	0·015	13·86	0·023	229·65	0·005	243·16	0·007	319·17	0·053	57·52	0·040	355·31	0·013	208·90	0·138	318·05	0·178	109·88	Pámban.
16	78·71	0·084	32·20	0·008	353·92	0·030	14·96	0·012	94·88	...	...	...	...	0·018	285·94	0·012	339·81	0·008	75·61	0·013	170·99	0·007	309·65	0·007	297·41	0·033	22·84	0·053	359·13	0·027	156·88	0·164	286·80	0·184	116·70	
26	50·20	0·082	31·83	0·014	173·02	0·027	334·12	0·011	148·26	0·019	94·37	0·012	79·27	0·017	294·52	0·008	288·49	0·008	331·14	0·015	265·83	0·001	48·17	0·008	277·23	0·043	39·72	0·033	343·58	0·007	26·51	0·171	304·03	0·129	111·04	
23	58·45	0·082	30·85	0·016	63·51	0·027	30·01	·009	104·70	0·016	113·56	0·025	91·71	0·018	291·50	0·010	333·08	0·009	14·38	0·018	206·04	0·005	279·16	0·006	310·09	0·048	27·27	0·043	354·90	0·016	141·47	0·149	301·95	0·157	108·29	
49	256·97	0·355	243·13	0·021	200·61	0·114	243·58	0·030	234·03	...	...	...	...	0·007	345.10	0·008	209·68	0·066	234·44	0·019	84·25	0·024	329·67	0·006	355·03	0·022	22·48	0·030	22·72	0·076	22·27	0·740	190·06	0·301	88·60	
44	245·07	0·300	249·79	0·019	331·77	0·055	198·62	0·026	258·86	0·015	129·92	0·021	336·23	0·010	20·01	0·110	292·41	0·059	219·03	0·031	32·93	0·029	19·85	0·010	319·83	0·078	52·54	0·051	340·43	0·021	12·97	0·833	173·28	0·328	126·02	
27	296·64	0·291	251·26	0·022	244·04	0·002	72·20	0·016	217·61	...	...	...	...	0·014	19·81	0·015	250·23	0·044	258·65	0·063	344·66	0·006	66·94	0·014	316·40	0·049	104·02	0·061	1·76	0·038	314·43	0·577	188·65	0·458	140·37	Vizagapatam.
38	216·85	0·309	241·50	0·024	278·17	0·127	282·51	0·034	326·23	0·039	245·98	0·080	189·27	0·015	356·76	0·016	147·75	0·046	224·66	0·037	28·55	0·007	294·42	0·014	334·15	0·072	35·07	0·027	2·26	0·048	101·95	0·707	174·73	0·241	100·78	
46	280·56	0·296	248·12	0·012	213·86	0·116	257·14	0·028	257·70	...	...	...	...	0·012	28·23	0·004	312·24	0·039	244·06	0·042	30·12	0·022	334·47	0·010	322·76	0·029	264·82	0·082	46·98	0·025	358·32	0·612	194·53	0·364	127·12	
78	256·26	0·298	251·80	0·039	299·35	0·095	222·81	0·036	264·38	0·025	68·68	0·036	282·19	0·007	283·37	0·012	219·67	0·056	218·29	0·030	58·55	0·022	25·11	0·015	326·50	0·010	7·00	0·073	31·98	0·019	39·49	0·694	182·48	0·350	128·64	
55	258·73	0·308	247·60	0·023	261·30	0·085	212·81	0·028	259·80	0·026	148·19	0·046	269·23	0·011	355·55	0·011	238·66	0·052	233·19	0·037	36·51	0·018	358.41	0·012	329·11	0·043	20·99	0·054	14·36	0·038	21·57	0·694	183·96	0·340	118·59	
58	280·88	0·471	265·34	0·045	276·88	0·163	246·84	0·070	266·20	...	...	...	...	0·039	272·34	0·019	195·98	0·080	248·65	0·076	17·46	0·029	317·08	0·006	322·40	0·053	53·15	0·061	37·43	0·041	278·80	0·746	166·12	0·364	142·23	
50	226·85	0·481	268·12	0·081	82·96	0·120	240·63	0·080	279·61	0·034	217·22	0·017	149·15	0·042	274·77	0·014	177·10	0·075	267·67	0·062	41·39	0·033	25·78	0·013	331·93	0·072	57·50	0·073	33·15	0·059	73·33	0·840	165·73	0·210	149·02	False Point.
58	265·77	0·425	263·65	0·019	330·52	0·036	304·50	0·069	265·21	...	...	...	...	0·041	266·28	0·020	189·22	0·066	238·31	0·017	359·87	0·027	100·95	0·010	345·91	0·045	114·53	0·067	12 63	0·039	157·77	0·841	172·28	0·282	153·59	
95	286·15	0·439	258·37	0·066	272·09	0·136	300·58	0·042	252·43	0·014	283·66	0·099	280·00	0·039	260·66	0·028	212·73	0·050	240·22	0·047	26·84	0·015	226·83	0·010	0·61	0·014	42·90	0·099	32·42	0·014	242·10	0·888	161·65	0·260	157·89	
70	264·91	0·454	263·87	0·053	330·61	0·114	273·14	0·065	265·86	0·024	250·44	0·058	214·58	0·040	268·51	0·020	193·76	0·068	248·71	0·051	21·39	0·026	257·66	0·010	340·21	0·046	67·02	0·075	28·91	0·038	278·00	0·829	166·45	0·279	150·68	
75	290·56	1·041	284·86	0·298	339·00	0·271	260·94	0·218	10·10	...	...	...	...	0·094	171·25	0·097	194·72	0·207	271·70	0·088	310·22	0·090	193·14	0·033	151·14	0·045	29·34	0·056	60·95	0·049	277·68	0·796	146·93	0·234	162·17	
58	291·81	0·852	286·37	0·139	292·51	0·192	240·22	0·111	19·01	0·219	288·94	0·137	299·43	0·059	138·91	0·046	226·91	0·124	297·04	0·094	238·61	0·070	246·22	0·032	146·72	0·035	125·40	0·039	70·93	0·077	74·99	1·003	154·05	0·182	109·69	
10	295·09	0·820	285·06	0·085	261·20	0·142	294·91	0·172	14·11	...	...	...	...	0·067	173·83	0·053	193·00	0·096	221·44	0·172	55·23	0·023	353·34	0·028	125·09	0·060	75·39	0·092	45·93	0·050	128·16	0·864	152·91	0·202	133·60	Dublat.
70	299·65	0·875	282·67	0·063	276·85	0·276	302·68	0·107	355·12	0·095	306·69	0·175	60·70	0·074	177·20	0·058	198·08	0·200	252·65	0·050	70·14	0·053	141·58	0·050	124·28	0·027	43·17	0·086	34·48	0·027	233·84	0·930	145·51	0·211	161·91	
45	301·84	0·882	286·51	0·163	325·19	0·328	276·15	0·141	9·96	...	...	...	...	0·077	191·00	0·044	196·20	0·147	263·53	0·198	19·88	0·072	191·61	0·031	97·06	0·020	171·00	0·032	85·92	0·042	25·57	0·787	153·64	0·146	136·80	
92	295·79	0·894	285·09	0·150	298·95	0·242	274·98	0·150	9·66	0·157	297·82	0·156	0·07	0·074	170·44	0·060	201·78	0·155	261·27	0·120	354·82	0·062	225·18	0·035	128·86	0·037	88·86	0·061	59·64	0·049	292·05	0·876	150·61	0·195	140·83	
74	356·98	0·988	339·18	0·171	18·73	0·420	293·85	0·272	79·18	...	...	...	...	0·687	285·58	0·095	251·34	0·138	343·33	0·200	31·77	0·130	294·89	0·067	226·71	0·147	11·65	0·157	36·00	0·401	25·74	1·011	139·77	0·023	64·21	
47	344·19	0·914	339·74	0·058	296·13	0·186	284·10	0·333	89·95	0·216	9·60	0·078	55·45	0·702	283·67	0·053	289·79	0·076	42·64	0·088	62·68	0·065	283·72	0·050	224·58	0·057	351·22	0·142	41·48	0·501	40·25	1·189	146·81	0·109	76·79	
01	335·29	0·898	335·80	0·046	22·48	0·204	346·13	0·298	90·05	...	...	...	...	0·702	287·52	0·058	273·77	0·212	287·50	0·100	71·01	0·124	249·04	0·066	214·03	0·156	25·72	0·216	57·21	0·453	40·61	0·980	140·81	0·103	91·82	Diamond Harbour.
80	344·23	0·945	335·79	0·192	356·71	0·387	330·53	0·338	82·05	0·175	16·53	0·317	86·44	0·728	288·57	0·069	271·17	0·167	313·80	0·085	25·04	0·159	278·74	0·059	220·25	0·145	16·59	0·155	40·40	0·424	36·15	0·991	142·83	0·069	150·10	
76	8·11	1·030	347·01	0·267	358·05	0·202	299·30	0·268	85·34	...	...	...	...	0·709	288·26	0·074	289·76	0·147	321·11	0·116	67·71	0·107	300·80	0·065	200·75	0·078	2·94	0·096	33·23	0·483	29·36	1·119	140·31	0·182	262·35	
56	349·76	0·955	339·50	0·147	354·42	0·280	310·78	0·302	85·31	0·196	13·07	0·198	70·95	0·706	286·72	0·070	275·17	0·148	333·68	0·118	51·64	0·117	281·44	0·061	217·26	0·117	9·62	0·153	41·66	0·452	34·42	1·058	142·11	0·097	129·05	
26	112·34	1·374	59·61	0·393	112·83	0·426	185·52	0·443	278·05	...	...	...	...	0·285	89·98	0·188	345·09	0·325	14·86	0·293	217·41	0·105	331·42	0·066	293·53	Long Period Tides not computed.										
03	119·89	1·248	51·10	0·280	65·29	0·283	267·18	0·247	298·94	0·451	252·46	0·841	143·90	0·406	79·93	0·150	28·36	0·239	40·12	0·320	305·68	0·135	2·14	0·054	325·25	0·152	43·45	0·062	315·34	0·080	76·43	0·638	149·83	0·188	138·72	
48	103·28	1·343	51·00	0·226	177·83	0·566	78·79	0·220	325·59	...	...	...	...	0·350	75·70	0·115	15·96	0·258	355·07	0·164	115·16	0·071	25·48	0·063	329·61	0·038	51·63	0·132	23·66	0·029	65·67	0·814	129·63	0·124	331·92	Amherst.
62	81·05	1·230	52·12	0·185	91·65	0·428	48·67	0·274	309·99	0·033	346·62	0·074	284·28	0·391	72·76	0·176	5·22	0·271	23·10	0·271	215·64	0·011	280·38	0·039	309·06	0·109	341·86	0·083	327·64	0·052	134·29	0·739	149·27	0·161	107·36	
73	89·84	1·194	50·50	0·178	132·83	0·232	25·41	0·202	281·13	...	...	...	...	0·300	65·55	0·181	13·44	0·204	72·32	0·198	243·84	0·102	301·65	0·044	319·85	0·049	3·52	0·107	33·68	0·067	69·31	0·713	146·54	0·119	180·74	
14	78·07	1·312	47·65	0·216	183·97	0·099	55·06	0·326	292·90	0·174	316·23	0·352	78·55	0·275	64·14	0·176	327·91	0·173	61·11	0·035	159·45	0·122	347·95	0·037	313·14	0·006	290·22	0·017	212·82	0·068	306·24	0·886	106·54	0·154	153·91	
21	97·41	1·284	52·00	0·246	127·40	0·339	50·11	0·285	297·77	0·219	305·10	0·422	168·91	0·318	74·68	0·164	2·66	0·245	34·43	0·214	209·53	0·091	334·84	0·051	315·07	0·071	2·14	0·080	326·63	0·059	58·39	0·758	136·36	0·149	110·53	
04	133·82	0·735	97·22	0·161	152·00	0·314	101·46	0·308	272·43	...	...	...	...	0·741	209·92	0·127	37·64	0·117	110·84	0·134	33·22	0·158	95·03	0·118	56·27	0·409	3·00	0·282	42·25	1·088	43·24	2·460	144·56	0·563	282·51	
90	155·27	0·672	106·41	0·249	182·20	0·215	91·35	0·314	258·84	0·097	69·59	0·200	110·28	0·701	208·62	0·137	40·25	0·050	75·87	0·100	327·26	0·154	77·83	0·122	62·13	0·441	17·43	0·379	40·10	1·097	47·84	2·389	152·84	0·653	283·89	
42	129·10	0·630	102·12	0·118	162·23	0·169	58·12	0.316	279·64	...	...	...	...	0·693	214·47	0·109	37·43	0·067	30·18	0·158	41·67	0·181	79·19	0·108	64·43	0·229	21·38	0·342	40·47	1·146	45·68	2·453	148·89	0·593	295·13	Moulmein.
20	135·71	6·654	95·13	0·104	106·79	0·173	125·65	0·347	274·02	0·133	78·67	0·151	173·75	0·685	213·33	0·123	38·79	0·120	79·06	0·126	30·32	0·197	92·78	0·111	69·66	0·407	18·72	0·377	49·27	1·091	45·23	2·519	151·86	0·653	298·36	
30	123·33	0·620	92·37	0·183	153·28	0·435	127·76	0·320	260·17	...	...	...	...	0·714	215·44	0·155	49·97	0·082	144·78	0·203	35·75	0·162	103·41	0·099	57·40	0·344	5·08	0·217	31·98	1·050	42·49	2·032	143·52	0·501	267·69	
97	144·17	0·713	99·45	0·165	170·32	0·331	84·25	0·339	279·08	0·204	71·57	0·264	100·22	0·715	217·96	0·118	40·30	0·120	73·56	0·086	4·24	0·133	87·40	0·111	60·91	0·369	9·33	0·371	32·04	1·063	45·30	2·128	150·71	0·730	287·80	
97	136·90	0·671	98·78	0·163	154·47	0·273	98·10	0·324	270·70	0·145	73·28	0·205	128·08	0·708	213·29	0·128	40·73	0·093	85·72	0·135	18·74	0·164	89·27	0·112	61·80	0·367	12·49	0·328	39·35	1·089	44·96	2·330	148·73	0·616	285 90	

ed in the observations entered in S Series.

ame of Station.	Year of Observation.	Period of interruption.		Total No. of days' interruption.	
		From	To	In each period.	In the year.
herst . . .	1880-81 . .	7th August 1880 . .	8th August 1880 . . .	2	144
		28th November 1880 . .	4th December 1880 . .	7	
		9th January 1881 . .	15th January 1881 . . .	7	
		30th March 1881 . . .	4th August 1881 . . .	128	
	1881-82 . .	13th November 1881 . .	17th November 1881 . .	5	51
		6th April 1882 . . .	23rd April 1882 . . .	18	
		18th May 1882 . . .	1st June 1882 . . .	15	
		23rd July 1882 . . .	4th August 1882 . . .	13	
	1882-83 . .	1st October 1882 . .	24th October 1882 . . .	24	24
	1884-85 . .	16th May 1885 . . .	19th May 1885 . . .	4	13
		27th July 1885 . . .	4th August 1885 . . .	9	
	1885-86 . .	8th August 1885 . . .	11th August 1885 . . .	4	13
		22nd August 1885 . . .	30th August 1885 . . .	9	

TABLE No. 2.

Table showing the comparison between the Analysed and Equilibrium theoretical values of the co-efficients of the various Tides in terms of the Main Lunar Tide M_2 for the Stations at which observations have been completed.

Station.	Year.	Semi-diurnal Tides.										Diurnal Tides.							Over Tides.							Compound Tides.					Long Period Tides.				
		Main Solar.	Luni-solar.	Lunar Elliptic.		Evectional.		Lunar Elliptic 2nd order.	Solar Elliptic.		Variational.	Luni-solar.	Declinational.		Elliptic.		Lunar.	Solar.	Lunar.				Solar.			Ter diurnal.	Quarter diurnal.	Ter diurnal.	Quarter diurnal.	Semi diurnal.	Lunar Monthly.	Lunar Fortnightly.	Luni-solar Fortnightly.	Solar-annual.	Solar Semi Annual.
													Lunar.	Solar.	Solar.	Lunar.																			
		S_2	K_2	N_2	L_2	ν_2	λ_2	$2N_2$	T_2	R_2	μ_2	K_1	O_1	P_1	Q_1	J_1	M_1	S_1	M_3	M_4	M_6	M_8	S_4	S_6	S_8	$(M_2K_1)_3$	$(MS)_4$	$(2M_2K_1)_3$	$(M_2N)_4$	$(2SM)_2$	M_m.	M_f.	MS_f.	S_a.	S_{sa}.
Equilibrium Theoretical values		·465	·127	·194	·028	·038	·007	·026	·027	...	·024	·584	·415	·193	·080	·033	·036	...	·013	...	...	...	...	...	...	·121	·096	·086	·040	...	·046	·086	·007	...	·040
Okha	1874-75	·320	·086	·204	·058	·043	·019	...	...	...	·053	·370	·181	·101	·036	·028	·013	·019	·008	·036	·002	·003	·003	·001	·000	...	·017	...	...	·012	·017	·013	·037	·042	·032
Hanstal	1874-75	·281	·077	·174	·083	·043	·034	...	...	...	·087	·218	·110	·056	·020	·014	·008	·019	·008	·106	·045	·012	·003	·001	·000	...	·051	...	...	·020	·018	·015	·025	·004	·013
Kathiwadar	1881-82	·406	·109	·254	·027	·044	·014	·049	...	...	·096	·542	·242	·147	·051	·059	·019	·045	·007	·074	·047	·010	·001	·004	·001	·014	·054	·014	·025	·010	·018	·009	·013	·079	·037
Kárwár	1878-79	·366	·102	·241	·054	·045	·013	·031	...	...	·019	·581	·288	·156	·064	·027	·011	·039	·007	·026	·008	·001	·004	·001	·001	·010	·013	·001	·039	·007	·027	·030	·017	·099	·026
	1879-80	·363	·100	·246	·024	·078	·002	·029	·027	·003	·033	·575	·287	·158	·077	·045	·010	·043	·008	·034	·006	·002	·004	·004	·001	·013	·016	·005	·036	·002	·035	·033	·013	·198	·048
	1880-81	·353	·093	·235	·034	·069	·018	·048	...	...	·026	·575	·287	·161	·074	·050	·028	·031	·010	·031	·007	·002	·009	·002	·000	·019	·012	·006	·016	·002	·027	·019	·012	·279	·073
	1881-82	·351	·100	·228	·022	·032	·012	·025	·043	·005	·029	·575	·282	·164	·058	·036	·026	·030	·007	·034	·006	·001	·006	·003	·001	·011	·017	·006	·039	·004	·025	·022	·005	·218	·030
	1882-83	·359	·103	·228	·029	·027	·012	·030	...	...	·019	·578	·283	·157	·056	·037	·021	·020	·007	·034	·005	·001	·006	·003	·002	·006	·016	·005	·024	·005	·072	·016	·017	·214	·019
	Means	·358	·100	·236	·033	·050	·011	·033	·035	·004	·025	·577	·285	·159	·066	·039	·019	·033	·008	·032	·006	·001	006	·003	·001	·012	·015	·005	·031	·004	·037	·024	·013	·202	·039
Beypore	1878-79	·365	·072	.211	·020	·039	·004	·030	...	...	·026	·776	·372	·203	·086	·039	·019	·023	·012	·023	·011	·009	·004	·004	·001	·009	·011	·012	·064	·007	·080	·095	·073	·338	·153
	1879-80	·343	·087	·209	·041	·045	·013	·025	·048	·019	·022	·764	·374	·208	·098	·052	·035	·092	·011	·017	·004	·011	·003	·004	·000	·018	·004	·021	·022	·004	·080	·095	·041	·381	·279
	1880-81	·344	·099	·212	·022	·056	·015	·051	...	...	·009	·763	·373	·220	·092	·072	·042	·104	·012	·020	·003	·008	·004	·003	·001	·025	·006	·016	·048	·004	·117	·025	·019	·366	·201
	1881-82	·359	·073	·209	·035	·100	·018	·012	·038	·029	·015	·753	·375	·186	·082	·042	·025	·077	·011	·021	·006	·008	·006	·006	·001	·024	·008	·009	·015	·004	·152	·124	·043	·338	·199
	1882-83	·359	·098	·215	·025	·053	·011	·021	...	...	·030	·726	·356	·211	·078	·034	·032	·035	·009	·026	·012	·009	·007	·010	·001	·010	·016	·004	·047	·007	·059	·044	·028	·243	·123
	1883-84	·350	·105	·221	·028	·003	·002	·019	·061	·013	·009	·731	·362	·230	·091	·073	·055	·048	·008	·027	·013	·009	·007	·009	·003	·003	·015	·004	·016	·004	·031	·054	·037	·308	·113
	Means	·353	·089	·213	·029	·049	·011	·026	·049	·020	·019	·752	·369	·210	·088	·052	·035	·063	·011	·022	·008	·009	·005	·006	·001	·015	·010	·011	·035	·005	·087	·073	·040	·329	·178
Pámban	1878-79	·640	·175	·129	·039	·027	·029	·005	...	..	·007	·504	·193	·178	·042	·014	·022	·061	·027	·034	·019	·008	·008	·003	·007	·008	·036	·005	·037	·017	·107	·076	·027	·207	·234
	1879-80	·641	·188	·149	·044	·058	·039	·026	·065	·021	·017	·501	·193	·188	·036	·022	·015	·084	·027	·027	019	·007	·002	·002	·009	·009	·029	·012	·039	·014	·091	·068	·022	·236	·304
	1880-81	·630	·194	·140	·027	·050	·013	·013	...	...	·020	·493	·194	·181	·038	·023	·022	·059	·025	·025	·018	·007	·007	·008	·003	·012	·030	·012	·022	·020	·055	·089	·045	·274	·308
	1881-82	·633	·213	·144	·046	·047	·025	·014	·021	·033	·019	·511	·202	·202	·028	·037	·014	·039	·030	·025	·016	·012	·005	·011	·002	·002	·030	·014	·026	·014	·076	·058	·012	·301	·227
	Means	·636	·193	·141	·039	·046	·027	·015	·043	·027	·016	·502	·196	·187	·036	·024	·018	·061	·027	·028	·018	·009	·006	·006	·005	·008	·031	·011	·031	·016	·082	·073	·027	·255	·268
Vizagapatam	1879-80	·440	·117	·232	·032	·074	·014	·043	...	...	·020	·242	·091	·073	·007	·023	·015	·018	·005	·009	·002	·003	·001	·001	·001	·016	·005	·004	·012	·005	·014	·020	·050	·483	·196
	1880 81	·451	·108	·205	·030	·038	·013	·040	·014	·010	·018	·249	·096	·071	·005	·018	·014	·032	·001	·010	·003	·001	·005	·001	·001	·020	·007	·007	·021	·007	·053	·035	·014	·571	·225
	1881-82	·446	·115	·199	·0 9	·001	·015	·030	...	...	·011	·251	·099	·080	·003	·010	·001	·024	·004	·010	·003	·001	·004	·001	·002	·004	·010	·010	·043	·010	·034	·042	·026	·395	·314
	1882-83	·445	·213	·215	·061	·088	·017	·032	·056	·027	·024	·233	·099	·034	·010	·017	·003	·067	·006	·013	·006	·003	·004	·001	·001	·005	·010	·010	·026	·011	·050	·019	·033	·491	·167
	1883-84	·437	·124	·202	·031	·079	·008	·027	...	...	·019	·242	·094	·079	·014	·018	·005	·025	·005	·009	·003	·003	·003	·001	·001	·015	·0 08	·007	·029	·003	·020	·056	·017	·418	·249
	1884-85	·427	·111	·.04	·053	·065	·027	·038	·025	·017	·025	·245	·088	·075	·010	·016	·011	·030	·006	·003	·005	·003	·002	·001	·000	·015	·005	·010	·021	·008	·007	·050	·013	·475	·239
	Means	·441	·131	·210	·038	·058	·016	·035	·032	·018	·020	·244	·095	·069	·008	·017	·008	·033	·005	·009	·004	·002	·003	·001	·001	·013	·008	·008	·025	·007	·030	·037	·026	·472	·232
False Point	1881-82	·447	·119	·210	·030	·073	·020	·036	...	...	·031	·182	·078	·059	.002	·009	·004	·003	·005	·016	·003	·001	·003	·001	·001	·013	·017	·003	·034	·008	·024	·027	·018	·332	·162
	1882-83	.457	·107	·213	·022	·053	·036	·033	·008	·015	·036	·181	·079	·070	·008	·013	·004	·011	·007	·018	·006	·001	·004	·001	·001	·015	·019	·006	·028	·006	·032	·032	·026	·373	·093
	1883-84	·438	·127	·187	·030	·016	·008	·029	...	...	·030	·182	·078	·056	·005	·014	·006	·003	·005	·015	·006	·003	·004	·001	·002	·012	·018	·004	·007	·009	·020	·030	·017	·371	·124
	1884-85	·447	·131	·196	·042	·061	·030	·022	·044	·006	·019	·181	·077	·059	·002	·009	·004	·004	·007	·013	·002	·002	·003	·002	·002	·007	·017	·004	·021	·013	·006	·044	·006	·397	·116
	Means	·447	·121	·202	·031	·051	·024	·030	·026	·011	·029	·182	·078	·061	·004	·011	·005	·005	·006	·016	·004	·002	·004	·001	·002	·012	·018	·004	·023	·009	·021	·033	·017	·368	·124
Dublat	1881-82	·444	124	·225	·038	·059	·064	·045	...	...	·047	·108	·039	·034	·002	·007	·002	·010	·001	·022	·003	·003	·005	·000	·001	·019	·020	·007	·019	·021	·010	·012	·011	·172	·051
	1882-83	·471	·134	·185	·034	·042	·030	·027	·030	·048	·024	·106	·043	·033	·002	·003	·002	·011	·009	·019	003	·002	·002	·001	·002	·015	·013	·007	·020	·010	·008	·008	·017	·218	·040
	1883-84	·467	·130	·178	·046	·031	·019	·021	...	...	·037	·109	·040	·031	·003	·005	·004	·009	·011	·018	·002	·003	·004	·001	·001	·005	·015	·006	·037	·012	·013	·020	·011	·188	·044
	1884-85	·448	·137	·189	·037	·060	·014	·043	·038	·021	·023	·106	·040	·034	·003	·011	·005	·010	·010	·019	·003	·001	·003	·000	·000	·011	·016	·011	·011	·013	·006	·019	·006	-201	·046
	1885-86	·456	·150	·192	·053	·071	·035	·032	...	.	·031	·107	·043	·032	·002	·007	·006	·010	·011	·018	·002	·002	·002	·000	·002	·016	·017	·007	·043	·010	·004	·007	·009	·171	·032
	Means	·457	·135	·194	·042	·053	·032	·034	·034	·035	·032	·107	·041	·033	·002	·007	·004	·010	·008	·019	·003	·002	003	·000	·001	·013	·016	·008	·026	·013	·008	·013	·011	·190	·043
Diamond Harbour	1881-82	·428	·129	·191	·034	·081	·033	·027	...	...	·053	·096	·046	·034	·005	·006	·004	·016	·008	·146	·030	·013	·023	·003	·000	·025	·133	·013	·039	·018	·028	·030	·077	·195	·004
	1882-83	·442	·124	·176	·067	·036	·011	·015	·015	·042	·064	·095	·044	·034	·007	·006	·004	·017	·005	·142	·029	·011	·024	·003	·001	·013	·136	·010	·017	·010	·011	·027	·097	·230	·021
	1883-84	·435	·141	·173	·039	·039	·009	·041	...	...	·058	·098	·041	·033	·007	·001	·004	·018	·012	·145	·031	·012	·025	·003	·001	·024	·136	·013	·019	·011	·030	·042	·088	·189	·020
	1884-85	·429	·140	·184	·055	·075	·037	·033	·062	·034	·066	·097	·042	·036	·004	·007	·010	·018	·012	·147	·027	·010	·024	·003	·001	·031	·142	·011	·017	·013	·028	·030	·083	·193	·013
	1885-86	·427	·121	·200	·054	·039	·052	·029	...	...	·052	·100	·045	·033	·003	·009	·006	·020	·011	·148	·028	·010	·024	·001	·000	·021	·138	·013	·023	·014	·015	·019	·094	·217	·035
	Means	·432	·131	·185	·050	·054	·028	·029	·039	·038	·059	·097	·044	·034	·005	·006	·006	·018	·010	·146	·029	·011	·024	·003	·001	·023	·137	·012	·023	·013	·022	·030	·088	·205	·019
Amherst	1880-81	·458	·284	·221	·036	·068	·063	·052	...	...	·071	·107	·050	·021	·010	·017	·007	·068	·005	·044	·011	·001	·015	·004	·001	·017	·046	·011	·047	·030	Long Period Tides not computed.				
	1881-82	·445	·141	·205	·050	·047	·046	·039	·138	·074	·041	·113	·052	·032	·010	·014	·003	·024	·000	·070	·024	·002	·019	·001	·001	·022	·067	·009	·053	·025	·025	·010	·013	·105	·031
	1882-83	·430	·107	·210	·054	·089	·035	·040	...	...	·034	·116	·051	·032	·006	·005	·005	·015	·003	·056	·022	·003	·016	·001	·001	·011	·055	·010	·026	·018	·006	·021	·005	·127	·019
	1883-84	·420	·138	·193	·057	·067	·029	·043	·012	·005	·043	·112	·053	·032	·003	·003	·002	·019	·003	·048	·022	·003	·013	·001	·000	·002	·046	·006	·043	·028	·017	·013	·008	·116	·025
	1884-85	·420	·151	·186	·058	·036	·028	·032	...	...	·031	·109	·052	·030	·003	·004	·006	·021	·005	·049	·022	·003	·015	·000	·000	·016	·047	·007	·031	·028	·008	·017	·010	·111	·019
	1885-86	·400	·117	·205	·049	·015	·034	·027	·055	·027	·051	·115	·048	·033	·005	·007	·007	·020	·005	·043	·024	·004	·012	·000	·000	·019	·043	·006	·005	·027	·001	·003	·011	·138	·024
	Means	·429	·156	·203	·051	·054	·039	·030	·068	·035	·045	·112	·051	·030	·006	·008	·005	·028	·004	·051	·021	·003	·015	·001	·001	·015	·051	·008	·034	·026	·011	·013	·009	·119	·024
Moulmein	1880-81	·360	·105	·189	·053	·081	·041	·030	...	...	·079	·116	·068	·029	·011	·010	·009	·024	·006	·238	·027	·009	·018	·002	·001	·041	·191	·030	·035	·033	·105	·073	·280	·633	·145
	1881-82	·363	·076	·182	·105	·058	·067	·014	·054	·026	·085	·121	·066	·039	·015	·005	·005	·027	·008	·238	·029	·010	·019	·002	·000	·042	·190	·033	·027	·037	·119	·102	·297	·646	·177
	1882-83	·358	·084	·168	·064	·045	·031	·018	...	...	·084	·110	·067	·038	·010	·002	·001	·025	·005	·239	·025	·012	·017	·001	·001	·048	·185	·029	·042	029	·061	·091	·305	·653	·158
	1883-84	·363	·100	·176	·086	·047	·028	·032	·041	·036	·093	·114	·074	·032	·011	·006	·008	·027	·005	·234	·025	·011	·017	·001	·001	·053	·184	·030	·034	·033	·109	·101	·293	·677	·176
	1884-85	·351	·071	·160	·085	·112	·047	·021	...	...	·082	·117	·070	·037	·014	·004	·005	·029	·005	·233	·020	·011	·018	·002	·001	·042	·184	·025	·052	·040	·089	·056	·270	·523	·129
	1885-86	·359	·081	·187	·078	·087	·043	·032	·060	·054	·089	·113	·064	·031	·012	·004	·007	·019	·007	·236	·022	·009	·019	·002	·000	·035	·188	·029	·023	·031	·097	·098	·280	·560	·192
	Means	·359	·086	·177	·079	·072	·043	·025	·055	·039	·085	·115	·068	·034	·012	·005	·006	·025	·006	·236	·025	·010	·018	·002	·001	·044	·187	·029	·036	·034	·097	·087	·288	·615	·163

State of the ordinary reductions of the yearly tidal registrations, &c.—contd.

Tidal Observatory.	State at end of September 1886.	State at end of September 1887.
DIAMOND HARBOUR (closed April 1886).	1884-85. Additions of hourly heights of each series ready. 1885-86. Diagrams not yet read off.	1884-85. Calculations completed. 1885-86. Calculations completed. A. P.
KIDDERPORE . .	1884-85. Calculations completed. 1885-86. Diagrams completed, and all read off, and the hourly readings copied from the S. series into the other series.	1885-86. Calculations completed. 1886-87. Diagrams not read off. A. P.
CHITTAGONG . .	Newly started observatory. No diagrams read off yet.	1886-87. Calculations completed.
AKYAB . . .	......	Newly started observatory. No diagrams read off yet.
ELEPHANT POINT .	1884. Calculations completed. 1885. Diagrams completed, and all read off, and the hourly readings from the diagrams in hand.	1885. Calculations completed. 1886. Diagrams not read off. A. P.
RANGOON . . .	1884-85. Calculations completed. 1885-86. Diagrams completed, and all read off, and calculations as far as the end of additions of the hourly heights of each series ready.	1885-86. Calculations incomplete. 1886-87. Diagrams not read off. A. P.
AMHERST (closed October 1886).	1884-85. Readings of diagrams completed, and the additions of the hourly heights of each series ready. 1885-86. Diagrams not yet read off.	1884-85. Calculations completed. 1885-86. Calculations completed. A. P.
MOULMEIN (closed April 1886).	1884-85. Readings of diagrams and computations completed. 1885-86. Diagrams not yet read off.	1885-86. Calculations completed. A. P.
PORT BLAIR . .	1884-85. Readings of diagrams and computations completed. 1885-86. Diagrams not yet read off.	1885-86. Diagrams not yet read off. 1886-87. Diagrams not read off. A. P.

The Tide Tables.

In addition to the calculations already mentioned, the usual work was done in connection with the issue of the Tide Tables which will contain the predicted heights and times of every high and low water at twenty-seven tidal stations during the year 1888, and January 1889. The values of the constants have been sent to Mr. Roberts in London ready for use. The mode of calculating them was described in the Annual Report for 1884-85, and the method employed for the riverain tides will be found described in the Tide Tables, in the prefaces to the several riverain stations; the new method of treating the Hooghly observations being also referred to at page xxxv. I should mention that the prefaces, with the exception of that for Chittagong, were prepared by Major Baird.

In my last annual report I gave a table in which was entered the final datum for each of twenty-three tidal observatories, together with the distance of each datum below mean sea-level as then determined. The following new stations may now be added, the distance of the datum below mean sea-level having been determined in each case from the tidal observations of one year only:—

Name of Tidal Observatory.	Datum to which the Heights in the Tide Tables for 1888 are referred.	Datum below mean Sea-level.
		Feet.
Bhávnagar	Indian spring low-water mark	17·178
Cochin	Do. do. do. do.	1·870
Cocanada	Do. do. do. do.	2·610
Chittagong	Do. do. do. do.	6·873

The usual tabular statements showing the percentage and amount of the errors in the predicted times and heights of high and low water for the year 1886, as determined by comparison of the values entered in the Tide Tables for that year with the actual values obtained by measurement from the tidal diagrams, are given in Tables 3 to 7.

No. 3.

Statement showing the Percentage and the amount of the Errors in the Predicted Times of High Water at the various Tidal Stations for the year 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	704	35	43	12	7	3
Kurrachee	698	24	43	17	12	4
Bombay	705	47	42	6	3	2
Mormugáo	702	29	39	14	11	7
Colombo	704	25	39	13	13	10
Galle	662	31	39	10	11	9
Negapatam	681	24	34	13	17	12
Madras	600	19	33	13	16	19
Dublat	494	26	37	17	13	5
Diamond Harbour	194	17	29	19	26	9
Kidderpore	701	22	36	11	17	14
Elephant Point	701	42	40	10	7	1
Rangoon	648	27	48	13	8	4
Amherst	522	44	41	8	6	1
Moulmein	219	19	47	16	14	4
Port Blair	694	27	33	12	22	6

No. 4.

Errors in the Predicted Times of Low Water, 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	704	30	43	13	10	4
Kurrachee	699	30	42	13	12	3
Bombay	706	36	44	9	9	2
Mormugáo	704	27	42	13	12	6
Colombo	706	25	38	13	13	11
Galle	672	35	43	8	8	6
Negapatam	682	19	29	13	17	22
Madras	601	26	34	10	17	13
Dublat	493	24	44	15	13	4
Diamond Harbour	194	11	33	14	24	18
Kidderpore	702	23	37	14	16	10
Elephant Point	703	29	44	14	12	1
Rangoon	649	24	43	15	15	3
Amherst	524	34	43	11	9	3
Moulmein	218	28	42	13	12	5
Port Blair	691	24	31	9	15	21

No. 5.

Statement showing the Percentage and the amount of the Errors in the Predicted Height of High Water at the various Tidal Stations for the year 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	704	90	10	...	...
Kurrachee	698	80	18	2	...
Bombay	705	72	23	4	1
Mormugáo	702	84	15	1	...
Colombo	704	89	10	1	...
Galle	662	93	7	...	...
Negapatam	681	85	13	1	1
Madras	600	81	15	3	1
Dublat	494	30	24	21	25
Diamond Harbour	194	10	11	17	62
Kidderpore	701	23	22	14	41
Elephant Point	701	20	20	26	34
Rangoon	648	36	26	15	23
Amherst	522	34	25	20	21
Moulmein	219	20	32	25	23
Port Blair	694	45	53	2	...

No. 6.

Errors in the Predicted Heights of Low Water, 1886.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
Aden	704	94	6	...	...
Kurrachee	699	72	25	3	...
Bombay	706	68	24	6	2
Mormugáo	704	84	16	...	...
Colombo	706	96	4	...	...
Galle	672	96	4	...	...
Negapatam	682	79	18	2	1
Madras	601	74	23	3	...
Dublat	493	41	31	19	9
Diamond Harbour	194	23	27	23	27
Kidderpore	702	26	17	14	43
Elephant Point	703	30	25	20	25
Rangoon	649	18	17	18	47
Amherst	524	36	20	20	24
Moulmein	218	4	14	31	51
Port Blair	691	70	29	1	...

No. 7.

Table of Average Errors in the Predicted Times and Heights of High and Low Water at the several Tidal Stations for the year 1886.

Station.	Mean range at springs, in feet.	Average Errors					
		Of Time, in minutes.		Of Height, in terms of the Range.		Of Height, in inches.	
		H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Aden	6·7	11	12	·025	·025	2	2
Kurrachee	9·7	13	12	·026	·026	3	3
Bombay	14·5	8	10	·017	·023	3	4
Mormugáo	7·0	13	13	·036	·036	3	3
Colombo	2·4	15	15	·069	·069	2	2
Galle	2·2	13	12	·076	·076	2	2
Negapatam	2·6	22	19	·096	·096	3	3
Madras	3·5	18	16	·071	·071	3	3
Dublat	14·2	13	13	·047	·035	8	6
Diamond Harbour	15·8	17	19	·074	·048	14	9
Kidderpore	11·7	16	15	·114	·135	16	19
Elephant Point	10·2	9	11	·050	·035	11	8
Rangoon	16·4	11	13	·041	·061	8	12
Amherst	20·5	8	10	·033	·033	8	8
Moulmein	12·7	13	12	·059	·085	9	13
Port Blair	6·6	14	18	·063	·038	5	3

From this last table it will be seen that Bombay came first in the order of excellence as regards both its time and height predictions; Aden, Kurrachee and Mormugáo being also very good. The predictions for Madras, Negapatam and the Ceylon stations were not as good as those for the open coast stations elsewhere, nor do the predictions for Port Blair compare so favourably with the others as might have been expected from the position of the station. With regard to the riverain stations, it is interesting to observe the difference between the results obtained at the stations situated at the mouths of rivers and at those situated up-stream, the former, as might be expected, being superior to the latter. Thus the predictions for Amherst were very good, and superior to those for Moulmein; the Elephant Point predictions were good, and superior to those for Rangoon; and the Dublat predictions were good, and superior to those for Diamond Harbour and Kidderpore. The predictions on the whole may be considered to be very satisfactory, the least so being those for Negapatam and Kidderpore.

The predictions for Kidderpore are likely to improve gradually year by year for the reason given at page xxxv, and where there are peculiarities in the tides, as at Bhávnagar and Moulmein, a continued comparison of the actual and predicted times and heights of the tides will doubtless enable improvements to be made by degrees in the predictions. Until the Tide Tables for 1888 are published, there will be no predictions for Bhávnagar to compare with actuals. All that is known at present is that the tidal registrations there have been carried on very satisfactorily since their commencement. At Moulmein, although the time predictions are good, the predictions for height are not equally satisfactory. The observatory has been removed, but actual values continue to be obtained for comparison with the predictions, as already stated. I do not think that attention has been drawn in preceding reports to a remarkable peculiarity of the Moulmein tides which, strange to say, does not appear to have been noticed until brought to light by our tidal registrations. It is this that at the jetty, where our tidal measurements were taken, the water, although rising higher at spring tides than at neaps, falls lower at neaps than at springs.

I append to this report a copy of a memorandum by Major Baird on certain tidal disturbances at the head of the Bay of Bengal on the 11th March and 9th April 1885. In February last, whilst he was attached to this office, he came across some very peculiar tidal curves of those dates; and as General Strachey, R.E., had asked him about the time of the Krakatoa tidal disturbances to look out for any irregularities on future tidal diagrams indicating disturbances of a like kind and keep him informed, he sent him the memorandum in question and tracings from the tidal curves.

Values of the Tidal Constants, Aden, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or seventh year's observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

A_0 = 5·883 feet.

S_1	H= R=	0·077	M_6	R=	0·003	Q_1	R=	0·110	T_2	R=	...
	κ = ζ =	162° 20		ζ =	159°·23		ζ =	67°·67		ζ =	...
S_2	H= R=	0·692		H=	0·003		H=	0·136		H=	...
	κ = ζ =	245°·33		κ =	14°·06		κ =	34°·55		κ =	...
S_4	H= R=	0·005	M_8	R=	0·003	L_2	R=	0·039	$(MS)_4$	R=	0·006
	κ = ζ =	323°·62		ζ =	214°·38		ζ =	325°·57		ζ =	221°·47
S_6	H= R=	0·005		H=	0·002		H=	0·034		H=	0·006
	κ = ζ =	220°·86		κ =	20°·82		κ =	196°·90		κ =	173°·08
S_8	H= R=	0·002	O_1	R=	0·539	N_2	R=	0·461	$(2SM)_2$	R=	0·020
	κ = ζ =	334°·98		ζ =	335°·58		ζ =	2°·43		ζ =	60°·69
				H=	0·669		H=	0·444		H=	0·019
				κ =	36°·93		κ =	219°·56		κ =	109°·08
M_1	R=	0·014	K_1	R=	1·153	λ_2	R=	0·035	$2N_2$	R=	0·094
	ζ =	225°·58		ζ =	143°·92		ζ =	115°·22		ζ =	76°·29
	H=	0·015		H=	1·307		H=	0·033		H=	0·091
	κ =	58°·21		κ =	35°·00		κ =	200°·60		κ =	198°·94
M_2	R=	1·633	K_2	R=	0·146	ν_2	R=	0·094	$(M_2N)_4$	R=	0·070
	ζ =	274°·15		ζ =	283°·63		ζ =	181°·92		ζ =	228°·42
	H=	1·573		H=	0·195		H=	0·090		H=	0·065
	κ =	225°·76		κ =	245°·84		κ =	179°·76		κ =	37°·16
M_3	R=	0·022	P_1	R=	0·409	μ_2	R=	0·086	$(M_2K_1)_3$	R=	0·010
	ζ =	118° 21		ζ =	282°·95		ζ =	276°·78		ζ =	293°·04
	H=	0·021		H=	0·409		H=	0·080		H=	0·011
	κ =	225°·63		κ =	31°·64		κ =	180°·00		κ =	135°·73
M_4	R=	0·009	J_1	R=	0·055	R_2	R=	...	$(2M_2K_1)_3$	R=	0·002
	ζ =	75° 62		ζ =	59° 79		ζ =	...		ζ =	309°·81
	H=	0·008		H=	0·067		H=	...		H=	0·003
	κ =	338°·84		κ =	44°·53		κ =	...		κ =	321°·94

Long Period Tides.

	R	ζ	H	κ
Lunar monthly Tide	0·018	266°·80	0·016	1°·28
„ fortnightly „	0·024	5·50	0·038	14·40
Luni-solar „ „	0·014	140·97	0·013	189·36
Solar-annual „	0·448	22·11	0·448	3·41
„ semi-annual „	0·183	181·57	0·183	144·18

The value of the mean level of the sea (A_0) is 5·883 feet above the zero of the gauge, it is the largest value obtained, but is only 0·129 foot greater than the least value, that of 1882-83, since the observations were commenced in 1879.

The main lunar tide (M_2) has a mean amplitude (H) of 1·573 feet and is identical with the mean of the preceding six years' values. The epoch of this tide is 225°·63 and agrees very well with those of preceding years.

The main solar tide (S_2) has an amplitude of 0·692 foot and is very accordant with all the values of the amplitude of this tide at Aden; its epoch too agrees well with previous values.

The amplitude 1·307 feet of the main diurnal tide (K_1) is very accordant with all the values obtained in previous years; its epoch also agrees well with former values, the greatest difference being a little under 4° or 16 minutes in time.

The main solar tide (S_2) is 44 per cent. of the main tide, and this proportion is the same as in former years; theoretically it should be 47 per cent.

The proportion of the luni-solar tide (K_2) to the main tide is 0·124 which is very nearly the same as the theoretical proportion 0·127, and this has always been found to be the case at Aden.

The proportion of the smaller elliptic tide (L_2) is 0·022, and that of the larger elliptic tide (N_2) is 0·282, the theoretical values of these two tides are 0·028 and 0·194 respectively of the main tide; the proportions now obtained are very close to those of previous years.

The larger evectional tide (ν_2) is 0·057 of the main tide, theoretically it should be 0·038, but the values of this tide at Aden have varied considerably and range from 0·03 to 0·10 of the main tide.

The smaller evectional tide (λ_2) is 0·021 of the main tide and is almost identical with last year's value, theoretically it should be 0·007.

The lunar elliptic tide of the second order ($2N_2$) is slightly more than double the theoretical value 0·026, and this proportion has always been obtained.

The variational tide (μ_2) is 0·051 of the main tide, a proportion which is about double the theoretical and agrees well with those hitherto obtained.

The proportions of the diurnal tides to the main tide are as follow :—

		Aden, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·831	0·584
Lunar	(M_1)	·010	·036
Solar declinational	(P_1)	·260	·193
Lunar „	(O_1)	·425	·415
„ elliptic	(J_1)	·043	·033
Solar „	(Q_1)	·086	·080

With the exception of the value of (M_1), which is the smallest yet obtained, the proportions all agree well with former values.

The overtides as usual at this port are insignificant, and the same remark applies to the compound tides; except the quarter diurnal tide $(M_2N)_4$ which is 0·041 of the main tide.

Of the long period tides the lunar monthly tide is 0·010 of the main tide, which agrees with the 1883-84 value; the theoretical proportion is 0·046, and this was only attained in 1880-81, when it was 0·049.

The lunar fortnightly tide is 0·024 of the main tide or three times as great as last year, but fairly accordant with the other five years' values; the theoretical proportion for this tide is 0·086.

The luni-solar fortnightly tide is 0·008 of the main tide, or very nearly the theoretical proportion 0·007, and agrees very well with former values.

The solar-annual tide is 29 per cent. of the main tide, which is about 5 per cent. greater than the mean of the other six years' determinations; its time of maximum is this year the 24th March, or seven days later than last year.

The solar semi-annual tide has the largest proportion to the main tide that has yet been determined, *viz.*, 0·116, the theoretical proportion being 0·040.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=7·206 feet.

Tide		Value	Tide		Value	Tide		Value	Tide		Value
S_1	H = R =	0·072	M_6	R =	0·059	Q_1	R =	0·101	T_2	R =	...
	κ = ζ =	173°·62		ζ =	335°·18		ζ =	190°·10		ζ =	...
S_2	H = R =	0·950		H =	0·053		H =	0·125		H =	...
	κ = ζ =	322°·33		κ =	198°·57		κ =	52°·58		κ =	...
S_4	H = R =	0·010	M_8	R =	0·006	L_2	R =	0·085	$(MS)_4$	R =	0·036
	κ = ζ =	43°·43		ζ =	88°·85		ζ =	355°·68		ζ =	30°·22
S_6	H = R =	0·006		H =	0·005		H =	0·075		H =	0·035
	κ = ζ =	315°·69		κ =	266°·70		κ =	281°·14		κ =	344°·68
S_8	H = R =	0·001	O_1	R =	0·535	N_2	R =	0·646	$(2SM)_2$	R =	0·021
	κ = ζ =	194°·04		ζ =	40°·12		ζ =	105°·64		ζ =	79°·52
				H =	0·663		H =	0·623		H =	0·020
				κ =	47°·12		κ =	275°·58		κ =	125°·06
M_1	R =	0·038	K_1	R =	1·152	λ_2	R =	0·068	$2N_2$	R =	0·113
	ζ =	291°·72		ζ =	97°·69		ζ =	205°·27		ζ =	212°·11
	H =	0·037		H =	1·305		H =	0·066		H =	0·109
	κ =	133°·57		κ =	46°·30		κ =	240°·50		κ =	237°·53
M_2	R =	2·648	K_2	R =	0·201	ν_2	R =	0·216	$(M_2N)_4$	R =	0·107
	ζ =	338°·04		ζ =	238°·28		ζ =	234°·77		ζ =	266°·69
	H =	2·552		H =	0·269		H =	0·208		H =	0·099
	κ =	292°·50		κ =	315°·67		κ =	288°·47		κ =	31°·09
M_3	R =	0·039	P_1	R =	0·407	μ_2	R =	0·090	$(M_2K_1)_3$	R =	0·022
	ζ =	225°·54		ζ =	354°·13		ζ =	3°·42		ζ =	95°·36
	H =	0·036		H =	0·407		H =	0·084		H =	0·024
	κ =	337°·23		κ =	44°·74		κ =	272°·34		κ =	358°·44
M_4	R =	0·032	J_1	R =	0·033	R_2	R =	...	$(2M_2K_1)_3$	R =	0·018
	ζ =	106°·52		ζ =	314°·13		ζ =	...		ζ =	31°·52
	H =	0·029		H =	0·040		H =	...		H =	0·019
	κ =	15°·44		κ =	46°·12		κ =	...		κ =	351°·83

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·072	216°·40	0·064	0°·93
,, fortnightly ,, ...	0·048	1 ·79	0·076	122 ·25
Luni-solar ,, ,, ...	0·066	290 ·43	0·064	335 ·97
Solar-annual ,, ...	0·224	66 ·54	0·224	105 ·93
,, semi-annual ,, ...	0·109	71 ·68	0·109	150 ·47

The mean level of the sea (A_0) is 7·206 feet above the zero of the gauge; it is very accordant with the two preceding years' values and almost identical with the 1877-78 value.

The mean amplitude (H) of the main lunar tide (M_2) is only 0·006 greater than last year and its epoch is 1½° or 3 minutes in time less.

The values of the amplitude and epoch of the main solar tide (S_2) agree well with all the previous values.

The amplitude 1·305 feet of the main diurnal tide (K_1) is very accordant with the four previous years' values, and its epoch 46°·30 agrees very closely with all the values hitherto obtained.

The proportion of the main solar tide (S_2) to the main lunar tide (M_2) is 0·372, a proportion which agrees well with former values.

The luni-solar tide (K_2) is 0·105 of the main tide, which is somewhat less than the theoretical proportion 0·127.

The larger elliptic tide (N_2) is 24 per cent. of the main tide and similar proportions have always been obtained. Its theoretical proportion is 19 per cent.

The smaller elliptic tide (L_2) is again 3 per cent. of the main tide and agrees with the theoretical proportion.

Of the two evectional tides, the larger (ν_2) has a proportion of 0·082 of the main tide which is more than double the theoretical value; the smaller tide (λ_2) has the same proportion to the main tide as determined last year, *viz.*, 0·026, and is nearly four times as great as the theoretical proportion 0·007.

The lunar elliptic tide of the second order ($2N_2$) is 4 per cent. of the main tide; the values of this tide are found to be in alternate years 4 and 3 per cent., the latter being the theoretical proportion.

The proportion of the variational tide (μ_2) to the main tide is 0·033 which is just double of that determined last year, and is now as much over as it was then under the theoretical value 0·024.

The proportions of the various diurnal tides, with the exception of (J_1) are all very accordant with the last four years' values: the proportion of (J_1) is 0·016 of the main tide, its theoretical proportion being 0·033, last year it was 0·028 of the main tide.

The overtides, both lunar and solar, and the compound tides agree in their proportions to the main tide with all the former values.

Of the long period tides, the lunar monthly tide is 0·025 of the main tide, which is the largest value obtained since 1879-80, but as usual it is less than the theoretical proportion.

The lunar fortnightly tide is this year slightly greater in its proportion to the main tide than in the two previous years, and the values of these three years exceed those obtained for many years previously and are about one-third the theoretical proportion.

The luni-solar fortnightly tide is 0·025 of the main tide, theoretically it should be 0·007; the previous six years' values range from 0·007 to 0·017.

The solar-annual tide is 0·088 of the main tide, the previous six years' values ranged from 0·016 to 0·055 of the main tide.

The solar-semi-annual tide is 0·043 of the main tide, and agrees almost exactly with the theoretical value.

The epoch of the solar annual tide is 106° or 62° later than last year: the epoch of the solar semi-annual tide is 150° or 10° earlier than last year, and the epochs of the other three long-period tides are all as usual very divergent.

VALUES OF THE TIDAL CONSTANTS, BHAVNAGAR, 1886.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886 or first year's observations at Bhávnagar; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886 observations:—

Short Period Tides.

A_0 = 22·799 feet.

S_1	H = R =	0·154	M_6	R =	0·254	Q_1	R =	0·146	T_2	R =	...
	κ = ζ =	179°·93		ζ =	176°·64		ζ =	263°·10		=	...
S_2	H = R =	3·376		H =	0·228		H =	0·178		H =	...
	κ = ζ =	175°·52		κ =	119°·29		κ =	73°·30		κ =	..
S_4	H = R =	0·102	M_8	R =	0·018	L_2	R =	0·591	$(MS)_4$	R =	0·661
	κ = ζ =	237°·39		ζ =	135°·83		ζ =	130°·11		=	94°·34
S_6	H = R =	0·027		H =	0·015		H =	0·589		H =	0·638
	κ = ζ =	307°·75		κ =	179°·37		κ =	165°·60		κ =	195°·23
S_8	H = R =	0·009	O_1	R =	0·830	N_2	R =	2·361	$({}_2SM)_2$	R =	0·045
	κ = ζ =	25°·20		ζ =	167°·33		ζ =	115°·14		ζ =	112°·59
				H =	1·011		H =	2·280		H =	0·044
				κ =	82°·78		κ =	110°·77		κ =	11°·71
M_1	R =	0·090	K_1	R =	2·010	λ_2	R =	0·288	$2N_2$	R =	0·280
	ζ =	83°·19		ζ =	264°·31		ζ =	68°·11		ζ =	213°·58
	H =	0·066		H =	2·257		H =	0·278		H =	0·271
	κ =	201°·08		κ =	91°·69		κ =	142°·14		κ =	103°·95
M_2	R =	10·909	K_2	R =	0·544	ν_2	R =	0·662	$(M_2N)_4$	R =	0·225
	ζ =	33°·98		ζ =	333°·34		ζ =	187°·02		ζ =	356°·08
	H =	10·534		H =	0·715		H =	0·640		H =	0·210
	κ =	134°·87		κ =	168°·73		κ =	134°·76		κ =	92°·59
M_3	R =	0·082	P_1	R =	0·655	μ_2	R =	0·379	$(M_2K_1)_3$	R =	0·175
	ζ =	166°·14		ζ =	284°·31		ζ =	72°·37		ζ =	152°·22
	H =	0·078		H =	0·655		H =	0·353		H =	0·189
	κ =	317°·46		κ =	93°·45		κ =	274°·14		κ =	80°·48
M_4	R =	0·961	J_1	R =	0·100	R_2	R =	...	$(2M_2K_1)_3$	R =	0·117
	ζ =	314°·05		ζ =	248°·70		ζ =	...		ζ =	335°·41
	H =	0·896		H =	0·119		H =	...		H =	0·123
	κ =	155°·81		κ =	179°·39		κ =	...		κ =	349°·80

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·120	260°·84	0·107	6°·09
„ fortnightly „	0·049	309 ·19	0·075	39 ·17
Luni-solar „ „	0·119	129 ·33	0·115	28 ·45
Solar-annual „	0·266	199 ·79	0·266	120 ·66
„ semi-annual „	0·083	323 ·25	0·083	164 ·98

The mean level of the sea (A_0) is 22·799 feet above the zero of the gauge.
The proportions of the several tides to the main lunar tide (M_2) are as follow :—

			Bhávnagar, 1886.	Theoretical.
SEMI DIURNAL TIDES.	Main solar	S_2	0·320	0·465
	Luni-solar	K_2	·068	·127
	Lunar elliptic	N_2	·216	·194
	„ „	L_2	·056	·028
	Evectional	ν_2	·061	·038
	„	λ_2	·026	·007
	Lunar elliptic of the second order	$2N_2$	·026	·026
	Variational	μ_2	·034	·024
DIURNAL TIDES.	Luni-solar	K_1	·214	·584
	Lunar declinational	O_1	·096	·415
	Solar „	P_1	·062	·193
	„ elliptic	Q_1	·017	·080
	Lunar „	J_1	·011	·033
	„	M_1	·006	·036
	Solar	S_1	·015	...
OVER TIDES.	Lunar	M_3	·007	·013
	„	M_4	·085	...
	„	M_6	·022	...
	„	M_8	·001	...
	Solar	S_4	·010	...
	„	S_6	·003	...
	„	S_8	·001	...
COMPOUND TIDES.	Ter-diurnal	$(M_2 K_1)_3$	·018	·121
	Quarter-diurnal	$(MS)_4$	·061	·096
	Ter-diurnal	$(2M_2K_1)_3$	·012	·086
	Quarter-diurnal	$(M_2N)_4$	·020	·040
	Semi-diurnal	$(2SM)_2$	·004	...
LONG PERIOD TIDES.	Lunar monthly		·010	·046
	„ fortnightly		·007	·086
	Luni-solar „		·011	·007
	Solar-annual		·025	...
	„ semi-annual		·008	·040

Values of the Tidal Constants, Cochin, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87 or first year's observations at Cochin; and also the mean values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations:—

Short Period Tides.

A_0=2·422 feet.

S_1	H = R =	0·031	M_6	R =	0·010	Q_1	R =	0·056	T_2	R =	...
	κ = ζ =	161°·45		ζ =	107°·43		ζ =	91°·95		ζ =	...
S_2	H = R =	0·256		H =	0·009		H =	0·068		H =	...
	κ = ζ =	25°·81		κ =	95°·32		κ =	60°·49		κ =	...
S_4	H = R =	0·006	M_8	R =	0·003	L_2	R =	0·026	$(MS)_4$	R =	0·021
	κ = ζ =	203°·07		ζ =	63°·44		ζ =	260°·47		ζ =	259°·43
S_6	H = R =	0·007		H =	0·002		H =	0·027		H =	0·020
	κ = ζ =	226°·17		κ =	287°·28		κ =	24°·44		κ =	135°·40
S_8	H = R =	0·002	O_1	R =	0·252	N_2	R =	0·159	$(2SM)_2$	R =	0·005
	κ = ζ =	162°·47		ζ =	31°·00		ζ =	123°·38		ζ =	200°·10
				H =	0·306		H =	0·153		H =	0·004
				κ =	58°·21		κ =	300°·67		κ =	324°·13
M_1	R =	0·014	K_1	R =	0·523	λ_2	R =	0·013	$2N_2$	R =	0·014
	ζ =	178°·39		ζ =	200°·18		ζ =	200°·25		ζ =	155°·45
	H =	0·010		H =	0·586		H =	0·013		H =	0·014
	κ =	5°·49		κ =	50°·99		κ =	320°·82		κ =	274°·08
M_2	R =	0·757	K_2	R =	0·068	ν_2	R =	0·035	$(M_2N)_4$	R =	0·025
	ζ =	95°·56		ζ =	143°·76		ζ =	184°·04		ζ =	48°·41
	H =	0·731		H =	0·089		H =	0·033		H =	0·023
	κ =	331°·52		κ =	26°·05		κ =	355°·39		κ =	101°·66
M_3	R =	0·005	P_1	R =	0·163	μ_2	R =	0·010	$(M_2K_1)_3$	R =	0·034
	ζ =	164°·85		ζ =	266°·99		ζ =	56°·47		ζ =	44°·52
	H =	0·005		H =	0·163		H =	0·009		H =	0·037
	κ =	158°·79		κ =	52°·49		κ =	168°·39		κ =	131°·29
M_4	R =	0·030	J_1	R =	0·022	R_2	R =	...	$(2M_2K_1)_3$	R =	0·016
	ζ =	324°·44		ζ =	169°·93		ζ =	...		ζ =	206°·08
	H =	0·028		H =	0·026		H =	...		H =	0·017
	κ =	76°·36		κ =	77°·35		κ =	...		κ =	107°·19

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·016	351°·33	0·014	50°·00
„ fortnightly „	0·046	353·80	0·070	355·35
Luni-solar „ „	0·038	168·49	0·037	292·52
Solar-annual „	0·309	8·47	0·309	312·98
„ semi-annual „	0·134	264·94	0·134	153·95

The mean level of the sea (A_0) is 2·422 feet above the zero of the gauge.
The proportions of the several tides to the main lunar tide (M_2) are as follow :—

			Cochin, 1887.	Theoretical.
SEMI-DIURNAL TIDES.	Main solar	S_2	0·350	0·465
	Luni-solar	K_2	·122	·127
	Lunar elliptic	N_2	·209	·194
	„ „	L_2	·037	·028
	Evectional	ν_2	·045	·038
	„	λ_2	·018	·007
	Lunar elliptic of the second order	$2N_2$	·019	·026
	Variational	μ_2	·012	·024
DIURNAL TIDES.	Luni-solar	K_1	·802	·584
	Lunar declinational	O_1	·419	·415
	Solar „	P_1	.223	·193
	„ elliptic	Q_1	·093	·080
	Lunar „	J_1	·036	·033
	„	M_1	·014	·036
	Solar	S_1	·042	......

			Cochin, 1887.	Theoretical.
Over Tides	Lunar	M_3	0·007	0·013
	"	M_4	·038	......
	"	M_6	·012	......
	"	M_8	·003	......
	Solar	S_4	·008	......
	"	S_6	·010	......
	"	S_8	·003	......
Compound Tides.	Ter-diurnal	$(M_2\,K_1)_3$	·051	·121
	Quarter-diurnal	$(M\,S)_4$	·027	·096
	Ter-diurnal	$(2M_2\,K_1)_3$	·023	·086
	Quarter-diurnal	$(M_2N)_4$	·031	·040
	Semi-diurnal	$(2SM)_2$	·005	......
Long Period Tides.	Lunar-monthly		·019	·046
	" fortnightly		·096	·086
	Luni-solar "		·051	·007
	Solar-annual		·423	......
	" semi-annual		·183	·040

Values of the Tidal Constants, Galle, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or second year's observations at Galle ; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

$A_0 = 2{\cdot}700$ feet.

S_1	H=R=	0·012	M_6	R=	0·003	Q_1	R=	0·019	T_2	R=	0·041
	κ=ζ=	74°·88		ζ=	75°·07		ζ=	159°·20		ζ=	147°·61
S_2	H=R=	0·357		H=	0·003		H=	0·024		H=	0·041
	κ=ζ=	93°·95		κ=	335°·69		κ=	95°·68		κ=	58°·79
S_4	H=R=	0·004	M_8	R=	0·002	L_2	R=	0·032	$(MS)_4$	R=	0·006
	κ=ζ=	245°·56		ζ=	344°·06		ζ=	101°·74		ζ=	274°·01
S_6	H=R=	0·000		H=	0·002		H=	0·028		H=	0·006
	κ=ζ=	135°·00		κ=	211°·54		κ—	6°·56		κ=	240°·89
S_8	H=R=	0·001	O_1	R=	0·042	N_2	R=	0·069	$(2SM)_2$	R=	0·012
	κ=ζ=	258°·69		ζ=	30°·68		ζ=	187°·19		ζ=	307°·06
				H=	0·052		H=	0·066		H=	0·012
				κ=	79°·25		κ=	41°·97		κ=	340°·19
M_1	R=	0·007	K_1	R=	0·145	λ_2	R=	0·013	$2N_2$	R=	0·021
	ζ=	41°·19		ζ=	98°·26		ζ=	310°·16		ζ=	323°·51
	H=	0·008		H=	0·165		H=	0·012		H=	0·020
	κ=	245°·42		κ=	17°·59		κ=	17°·88		κ=	66°·21
M_2	R=	0·545	K_2	R=	0·067	ν_2	R=	0·040	$(M_2N)_4$	R=	0·014
	ζ=	90°·45		ζ=	85°·65		ζ=	330°·36		ζ=	47°·12
	H=	0·525		H=	0·089		H=	0·038		H=	0·013
	κ=	57°·32		κ=	104°·40		κ=	16°·39		κ=	228°·78
M_3	R=	0·013	P_1	R=	0·049	μ_2	R=	0·027	$(M_2K_1)_3$	R=	0·007
	ζ=	30°·72		ζ=	294°·46		ζ=	172°·45		ζ=	142°·28
	H=	0·012		H=	0·049		H=	0·025		H=	0·008
	κ=	161°·03		κ=	14°·67		κ=	106°·19		κ=	28°·48
M_4	R=	0·012	J_1	R=	0·005	R_2	R=	0·018	$(2M_2K_1)_3$	R=	0·001
	ζ=	230°·57		ζ=	22°·89		ζ=	89°·01		ζ=	81°·25
	H=	0·011		H=	0·006		H=	0·018		H=	0·001
	κ=	164°·32		κ=	53°·28		κ=	357°·83		κ=	95°·67

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·019	218°·66	0·017	337°·01
" fortnightly "	0·017	336 ·37	0·027	38 ·74
Luni-solar " "	0·014	88 ·36	0·013	133 ·17
Solar-annual "	0·287	320 ·09	0·287	330 ·35
" semi-annual "	0·089	81 ·60	0·089	102 ·12

The mean level of the sea (A_0) this year at Galle is 2·700 feet above the zero of the gauge. The value obtained from the previous year's observations is 2·656 feet, or about half an inch lower.

The main lunar tide (M_2) has a mean amplitude of 0·525 of a foot, which is almost identical with the former value 0·526. Its epoch is 57°·32, the value last year being 59°·80, giving a difference of 4 minutes in time.

The main solar tide (S_2) has an amplitude of 0·357 of a foot, which is identical with the value obtained in the preceding year. It is 68 per cent. of the main lunar tide, instead of 47 per cent. according to theory. Galle and Colombo continue to have larger proportions for this tide than any other stations. The epoch of the main solar tide (S_2) is 93°·95, its value during the preceding year being 96°·56, or 5 minutes in time later.

Of the two lunar elliptic tides (L_2 and N_2) the amplitudes as compared with the main tide are 0·053 and 0·126, and compare well with the previous year's values; the theoretical proportions are 0·028 and 0·194; thus again this year the former is greater and the latter is less than the theoretical value.

The lunar elliptic semi-diurnal tide of the second order ($2N_2$) is 0·038 of the main tide instead of 0·026 according to theory and is three times as large as the preceding year's value.

The solar elliptic tides (R_2 and T_2) have been computed this year and are 0·034 and 0·078 of the main tide. According to theory the latter should be only 0·027.

The proportions of the two evectional tides (λ_2 and ν_2) to the main tide are 0·023 and 0·072 instead of 0·007 and 0·038 the theoretical values. In the previous year they were found to be even larger.

The variational tide (μ_2) is 0·048 of the main tide which is identical with last year's value and exactly double the theoretical value.

The luni-solar semi-diurnal tide (K_2) is 17 per cent. of the main tide. The previous year it was 18 per cent. but theory makes it only 13 per cent. of the main tide. Its amplitude agrees very closely with last year's value and its epoch is 104°·40, whilst last year it was 91°·99.

The proportions of the diurnal tides to the main tide are as follow:—

	Galle, 1885-86.	Theoretical.
Luni-solar (K_1)	0·314	0·584
Lunar declinational (O_1)	·099	·415
Solar „ (P_1)	·093	·193
„ elliptic (Q_1)	·046	·080
Lunar „ (J_1)	·011	·033
„ (M_1)	·015	·036

It will be seen that as was the case in the previous year all the diurnal tide proportions at Galle are smaller than their theoretical values.

The proportions of the semi-diurnal tides on the other hand continue to be generally greater than the theoretical values.

Of the overtides, the only two of any significance are the lunar ter-diurnal (M_3) and quarter diurnal (M_4), which are 0·023 and 0·021 of the main tide, values which accord well with those obtained in the previous year.

The compound tides are all small and below the theoretical values, and agree fairly well with last year's determinations.

Of the long period tides, the lunar monthly is 0·032 instead of 0·046 of the main tide; in the previous year it was very much greater, being 0·127.

The lunar fortnightly tide is 0·051 of the main tide, last year's value being 0·038 and the theoretical being 0·086.

The luni-solar fortnightly tide is 0·025 of the main tide, which is identical with the value found last year; but theoretically it ought to be only 0·007.

The solar-annual tide is 55 per cent. of the main tide, last year it was 72 per cent. At Colombo it is also smaller, being only 47 per cent. of the main tide, whilst the proportion for the preceding year was 60 per cent. The epoch of this tide at Galle is 330°, the previous year's value being 314°.

The solar semi-annual tide is more than four times as great as its theoretical value, being 0·170 instead of 0·040 of the main tide, but it is less than the value, 0·184, previously obtained. Its epoch is 102°, whilst last year it was 125°.

Values of the Tidal Constants, Colombo, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or second year's observations at Colombo; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=2·261 feet.

S_1	H = R =	0·030	M_6	R =	0·003	Q_1	R =	0·022	T_2	R =	0·041
	κ = ζ =	59°·87		ζ =	166°·43		ζ =	45°·18		ζ =	23°·75
S_2	H = R =	0·389		H =	0·003		H =	0·027		H =	0·041
	κ = ζ =	101°·28		κ =	62°·83		κ =	88°·34		κ =	353°·08
S_4	H = R =	0·004	M_8	R =	0·001	L_2	R =	0·021	$(MS)_4$	R =	0·008
	κ = ζ =	248°·46		ζ =	6°·34		ζ =	194°·72		ζ =	302°·41
S_6	H = R =	0·002		H =	0·001		H =	0·018		H =	0·008
	κ = ζ =	214°·38		κ =	228°·21		κ =	46°·01		κ =	267°·88
S_8	H = R =	0·001	O_1	R =	0·081	N_2	R =	0·051	$(2SM)_2$	R =	0·005
	κ = ζ =	105°·95		ζ =	322°·93		ζ =	142°·52		ζ =	314°·12
				H =	0·101		H =	0·050		H =	0·005
				κ =	67°·36		κ =	46°·72		κ =	348°·65
M_1	R =	0·012	K_1	R =	0·204	λ_2	R =	0·033	$2N_2$	R =	0·013
	ζ =	357°·16		ζ =	174°·12		ζ =	297°·20		ζ =	279°·90
	H =	0·013		H =	0·231		H =	0·032		H =	0·012
	κ =	192°·29		κ =	35°·67		κ =	55°·85		κ =	122°·83
M_2	R =	0·584	K_2	R =	0·078	ν_2	R =	0·014	$(M_2N)_4$	R =	0·015
	ζ =	88°·57		ζ =	179°·33		ζ =	57°·56		ζ =	26°·57
	H =	0·563		H =	0·104		H =	0·014		H =	0·014
	κ =	54°·04		κ =	82°·45		κ =	49°·84		κ =	256°·23
M_3	R =	0·016	P_1	R =	0·062	μ_2	R =	0·018	$(M_2K_1)_3$	R =	0·002
	ζ =	37°·84		ζ =	233°·50		ζ =	165°·57		ζ =	280°·01
	H =	0·015		H =	0·062		H =	0·017		H =	0·002
	κ =	166°·04		κ =	11°·86		κ =	96°·51		κ =	107·03
M_4	R =	0·015	J_1	R =	0·005	R_2	R =	0·059	$(2M_2K_1)_3$	R =	0·002
	ζ =	243°·25		ζ =	137°·56		ζ =	129·03		ζ =	14°·04
	H =	0·014		H =	0·006		H =	0·059		H =	0·002
	κ =	174°·19		κ =	59°·88		κ =	339°·70		κ =	83°·42

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·040	260°·12	0·035	321°·39
,, fortnightly ,, ...	0·040	77·35	0·064	13·97
Luni-solar ,, ,, ...	0·012	25·72	0·012	60·25
Solar-annual ,, ...	0·267	15·24	0·267	326·88
,, semi-annual ,, ...	0·060	179·99	0·060	83·27

The mean level of the sea (A_0) is 2·261 feet above the zero of the gauge; last year it was found to be 2·208 or more than half an inch lower.

The main lunar tide (M_2) has an amplitude of 0·563 of a foot; in the previous year it was 0·546. The epoch is 54°·04, last year's value being 52°·78. These values do not differ much from the corresponding values at Galle.

The amplitude of the main solar tide (S_2) is 0·389 of a foot, last year's value being 0·362. It is 0·691 of the main tide, which is one and half times as great as the value assigned by theory; but it is very accordant with the value obtained last year. The epoch is 101°·28 which is not far from last year's value, and these values also correspond fairly with those obtained at Galle.

The luni-solar semi-diurnal tide (K_2) is 0·185 of the main tide; last year it was 0·132, or almost the same as the theoretical value 0·127. The epoch is 82° and differs considerably from last year's value which was 109°.

The smaller lunar elliptic tide (L_2) is 0·032 of the main tide, which approaches very nearly the theoretical value 0·028; but the larger component (N_2) is 0·089 of the main tide, or a little less than half its theoretical proportion 0·194.

The lunar elliptic tide of the second order ($2N_2$) is 0·021 of the main tide and accords well with its theoretical value 0·026. In the previous year it was 0·020.

The proportions of the two evectional tides (λ_2 and ν_2) to the main tide are 0·057 and 0·025 respectively; theoretically they should be 0·007 and 0·038.

The proportion of the variational tide (μ_2) is 0·030 instead of 0·024, the theoretical value; in the previous year it was 0·037.

The proportions of the diurnal tides to the main tide are as follow:—

	Colombo, 1885-86.	Theoretical.
Luni-solar (K_1)	0·410	0·584
Lunar declinational (O_1)	·179	·415
Solar „ (P_1)	·110	·193
„ elliptic (Q_1)	·048	·080
Lunar „ (J_1)	·011	·033
„ (M_1)	·023	·036

Thus all the diurnal tides are considerably less than their theoretical values and have a general accordance with the values obtained last year.

Of the over tides, the lunar ter-diurnal (M_3) and quarter-diurnal (M_4) are 0·027 and 0·025 of the main tide and agree closely with last year's values; the others are insignificant.

The compound tides as at Galle are all small and below the theoretical values.

Of the long period tides the lunar monthly is 0·062, the theoretical value being 0·046; in the previous year it was 0·079. Its epoch 321° is not accordant with last year's value 18°.

The lunar fortnightly is 0·114 of the main tide; in the preceding year it was 0·060; theoretically it ought to be 0·086. The mean of the two years is 0·087. Its epoch is 14°, whilst last year it was 321°.

The luni-solar fortnightly tide is 0·021 of the main tide; last year it was 0·026; but the theoretical value is only 0·007. The results are very close to those obtained at Galle which were 0·025 in both the corresponding years. The epoch is 60°; in the previous year it was 36°.

The solar-annual tide is 47 per cent. of the main tide, being less than the proportion obtained last year. Its epoch is 327°, the previous year's value being 309°.

The solar semi-annual tide is 0·107 of the main tide; last year it was 0·225, and the theoretical value is 0·040. The epoch is 83°; last year it was 128°.

Values of the Tidal Constants, Negapatam, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or third year's accepted observations at Negapatam; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

$A_0 = 1·811$ feet.

S_1	$H = R =$	0·040	M_6	$R =$	0·013	Q_1	$R =$	0·006	T_2	$R =$	...
	$\kappa = \zeta =$	95°·91		$\zeta =$	66°·14		$\zeta =$	246°·54		$\zeta =$	...
S_2	$H = R =$	0·284		$H =$	0·011		$H =$	0·007		$H =$	...
	$\kappa = \zeta =$	280°·91		$\kappa =$	124°·49		$\kappa =$	284°·01		$\kappa =$	...
S_4	$H = R =$	0·006	M_8	$R =$	0·004	L_2	$R =$	0·045	$(MS)_4$	$R =$	0·019
	$\kappa = \zeta =$	106°·61		$\zeta =$	294°·31		$\zeta =$	224°·54		$\zeta =$	186°·16
S_6	$H = R =$	0·001		$H =$	0·004		$H =$	0·039		$H =$	0·018
	$\kappa = \zeta =$	146°·31		$\kappa =$	252°·11		$\kappa =$	264°·92		$\kappa =$	85°·61
S_8	$H = R =$	0·001	O_1	$R =$	0·070	N_2	$R =$	0·174	$(2SM)_2$	$R =$	0·006
	$\kappa = \zeta =$	240°·95		$\zeta =$	325°·26		$\zeta =$	292°·87		$\zeta =$	97°·60
				$H =$	0·087		$H =$	0·168		$H =$	0·006
				$\kappa =$	318°·05		$\kappa =$	237°·00		$\kappa =$	198°·15
M_1	$R =$	0·016	K_1	$R =$	0·198	λ_2	$R =$	0·016	$2N_2$	$R =$	0·036
	$\zeta =$	314°·26		$\zeta =$	78°·94		$\zeta =$	82°·43		$\zeta =$	230°·52
	$H =$	0·017		$H =$	0·224		$H =$	0·016		$H =$	0·035
	$\kappa =$	303°·16		$\kappa =$	346°·55		$\kappa =$	306°·94		$\kappa =$	219°·33
M_2	$R =$	0·767	K_2	$R =$	0·058	ν_2	$R =$	0·040	$(M_2N)_4$	$R =$	0·025
	$\zeta =$	349°·86		$\zeta =$	289°·75		$\zeta =$	94°·63		$\zeta =$	277°·13
	$H =$	0·739		$H =$	0·078		$H =$	0·039		$H =$	0·024
	$\kappa =$	249°·31		$\kappa =$	285°·04		$\kappa =$	209°·02		$\kappa =$	120°·70
M_3	$R =$	0·004	P_1	$R =$	0·080	μ_2	$R =$	0·017	$(M_2K_1)_3$	$R =$	0·010
	$\zeta =$	236°·31		$\zeta =$	247°·68		$\zeta =$	328°·80		$\zeta =$	261°·96
	$H =$	0·004		$H =$	0·080		$H =$	0·016		$H =$	0·010
	$\kappa =$	85°·49		$\kappa =$	339°·72		$\kappa =$	127°·70		$\kappa =$	69°·02
M_4	$R =$	0·018	J_1	$R =$	0·016	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	0·006
	$\zeta =$	272°·28		$\zeta =$	134°·74		$\zeta =$	...		$\zeta =$	83°·23
	$H =$	0·017		$H =$	0·019		$H =$	...		$H =$	0·006
	$\kappa =$	71°·18		$\kappa =$	356°·72		$\kappa =$	...		$\kappa =$	334°·53

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·086	2°·93	0·076	318°·25
„ fortnightly „	0·050	260 ·19	0·080	354 ·06
Luni-solar „ „	0·026	341 ·10	0·025	81 ·65
Solar-annual „	0·348	250 ·84	0·348	248 ·80
„ semi-annual „	0·300	132 ·71	0·300	128 ·63

Previously to the year 1885-86, three years' observations were taken, the last of which had to be rejected.

The mean level of the sea (A_0) as obtained this year is 1·811 feet above the zero of the gauge, which is the lowest value yet obtained.

The mean amplitude of the main lunar tide (M_2) is 0·739 of a foot, and although the largest yet obtained, it is very close to the previous values. The epoch is 249°·3, the mean of the two former values being 251°·6.

The main solar tide (S_2) has an amplitude of 0·284 of a foot, which is the largest yet obtained here. The mean of the two previous years' values, which closely agree, is 0·274. The epoch this year is 280°·9. The average of the two former values is 284°·2, or a difference of about 6½ minutes.

The luni-solar semi-diurnal tide (K_2) is a little less than the theoretical value, being 0·106 instead of 0·127. The mean of the two former results is also 0·106. Its epoch is 285°·04 and is almost identical with the mean of the former values.

The smaller lunar elliptic tide (L_2) is 0·053 of the main tide, or nearly double the theoretical value 0·028. The larger component (N_2) is 0·227 of the main tide; theoretically it should be 0·194.

The lunar elliptic tide of the second order ($2N_2$) is 0·047 of the main tide or nearly twice as large as its theoretical value 0·026.

The evectional tides (λ_2 and ν_2) are 0·022 and 0·053 respectively of the main tide. Their theoretical values are 0·007 and 0·038.

The variational tide (μ_2) is 0·022 of the main tide, which agrees closely with the theoretical value 0·024; the two previous values were 0·025 and 0·033.

The proportions of the diurnal tides to the main tide are as follow :—

	Negapatam, 1885-86.	Theoretical.
Luni-solar (K_1)	0·303	0·584
Lunar declinational (O_1)	0·118	0·415
Solar „ (P_1)	0·108	0·193
„ elliptic (Q_1)	0·009	0·080
Lunar „ (J_1)	0·026	0·033
„ (M_1)	0·023	0·036

They have always been very much less than the theoretical proportions.

All the overtides, only three of which are of significance, agree very closely with the values previously obtained.

The proportions of the compound tides to the main tide, which agree very well with the previous determinations, are all less than the theoretical values.

Of the long period tides, the lunar monthly is this year 0·103 of the main tide, being more than double last year's value 0·044, which is very nearly the theoretical proportion 0·046; but it is less than the first year's value, which was as much as 0·114.

The lunar fortnightly tide is 0·108 of the main tide; the first year's value was 0·086, which is the theoretical value, but last year it was only 0·023 of the main tide.

The luni-solar fortnightly tide is 0·034 of the main tide, which is almost five times as large as the theoretical value, 0·007; but in the other two years it was very much larger, being 0·118 and 0·133 of the main tide.

The solar-annual tide is 0·471 of the main tide, which is much less than the other two years' values, 0·763 and 0·718. Its epoch is 249°, or 17° later than the mean of the two previous values, which were very near each other.

The solar semi-annual tide is 0·406 of the main tide, a value which is more than ten times the theoretical proportion 0·040, but in the two previous years the values were still higher, being 0·435 and 0·562 of the main tide. Its epoch is 129° and agrees well with the previous values.

VALUES OF THE TIDAL CONSTANTS, NEGAPATAM, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87 or fourth year's accepted observations at Negapatam; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations :—

Short Period Tides.

A_0=2·048 feet.

S_1	H=R=	0·021	M_6	R=	0·011	Q_1	R=	0·001	T_2	R=	0·037
	κ=ζ=	97°·36		ζ=	136°·61		ζ=	255°·96		ζ=	320°·11
S_2	H=R=	0·261		H=	0·010		H=	0·001		H=	0·037
	κ=ζ=	281°·07		κ=	135°·14		κ=	310°·17		κ=	243°·38
S_4	H=R=	0·006	M_8	R=	0·003	L_2	R=	0·045	$(MS)_4$	R=	0·018
	κ=ζ=	125°·88		ζ=	336°·50		ζ=	346°·47		ζ=	107°·61
S_6	H=R=	0·001		H=	0·003		H=	0·047		H=	0·018
	κ=ζ=	251°·57		κ=	334°·54		κ=	219°·13		κ=	107°·12
S_8	H=R=	0·001	O_1	R=	0·072	N_2	R=	0·156	$(2SM)_2$	R=	0·003
	κ=ζ=	218°·66		ζ=	227°·60		ζ=	276°·15		ζ=	229°·97
				H=	0·087		H=	0·151		H=	0·003
				κ=	325°·84		κ=	231°·62		κ=	230°·46
M_1	R=	0·023	K_1	R=	0·194	λ_2	R=	0·032	$2N_2$	R=	0·016
	ζ=	36°·97		ζ=	85°·01		ζ=	189°·28		ζ=	271°·85
	H=	0·016		H=	0·216		H=	0·031		H=	0·015
	κ=	289°·39		κ=	348°·58		κ=	324°·38		κ=	183°·27
M_2	R=	0·730	K_2	R=	0·074	ν_2	R=	0·016	$(M_2N)_4$	R=	0·051
	ζ=	251°·48		ζ=	298°·24		ζ=	229°·44		ζ=	226°·65
	H=	0·706		H=	0·097		H=	0·015		H=	0·048
	κ=	250°·99		κ=	286°·00		κ=	273°·36		κ=	181°·63
M_3	R=	0·002	P_1	R=	0·075	μ_2	R=	0·016	$(M_2K_1)_3$	R=	0·014
	ζ=	253°·30		ζ=	255°·24		ζ=	104°·30		ζ=	240°·74
	H=	0·002		H=	0·075		H=	0·015		H=	0·015
	κ=	72°·27		κ=	347°·52		κ=	103°·32		κ=	143°·81
M_4	R=	0·052	J_1	R=	0·012	R_2	R=	0·031	$(2M_2K_1)_3$	R=	0·009
	ζ=	76°·56		ζ=	89°·51		ζ=	43°·55		ζ=	240°·09
	H=	0·021		H=	0·014		H=	0·031		H=	0·009
	κ=	75°·58		κ=	34°·82		κ=	300°·28		κ=	335°·54

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·009	302°·83	0·008	346°·87
„ fortnightly „	0·065	22·38	0·098	5·40
Luni-solar „ „	0·027	50·67	0·026	51·16
Solar-annual „	0·444	231·87	0·444	229·60
„ semi-annual „	0·328	133·60	0·328	129·04

The mean of level of the sea (A_0) in the year 1886-87 is 2·048 feet above the zero of the gauge, and is identical with the highest value previously obtained, which was in 1882-83.

The value of the mean amplitude (H) of the main lunar tide (M_2) is 0·706 of a foot, and is the lowest yet obtained. Its epoch is 250°·99 and agrees very well with former values.

The amplitude of the main solar tide (S_2) is 0·261 of a foot; all the former values are slightly larger. It is 37 per cent. of the main tide; theoretically it should be 47 per cent. The epoch of this tide is 281°·07 which accords well with previous values.

The value of the luni-solar semi-diurnal tide (K_2) which has hitherto been slightly less than the theoretical value 0·127, is this year slightly in excess of it, being 0·137.

Of the two lunar elliptic tides (L_2 and N_2) the smaller component (L_2) is 0·067, and the larger component (N_2) is 0·214 of the main tide. Theoretically they should be 0·028 and 0·194.

The lunar elliptic tide of the second order ($2N_2$) is 0·021 of the main tide instead of 0·026, the theoretical value.

Of the two evectional tides (λ_2 and ν_2) the component which should be the smaller (λ_2) is 0·044 of the main tide, or six times as large as its theoretical value 0·007. The component (ν_2) is on the other hand very much smaller than it ought to be theoretically, being only 0·021 instead of 0·038 of the main tide.

The two solar elliptic tides (R_2 and T_2) have been computed from the observations for the two years 1885-86 and 1886-87. Their amplitudes are 0·044 and 0·052 respectively of the main tide, values which agree very well with those computed in 1882-83, although considerably in excess of the theoretical.

The variational tide (μ_2) is very accordant with the theoretical and with the former year's values.

The proportions of the diurnal tides to the main tide are as follow :—

		Negapatam, 1886-87.	Theoretical.
Luni-solar	(K_1)	0·306	0·584
Lunar declinational	(O_1)	0·123	0·415
Solar „	(P_1)	0·106	0·193
„ elliptic	(Q_1)	0·001	0·080
Lunar „	(J_1)	0·020	0·033
„	(M_1)	0·023	0·036

These tides are as usual very much less than their theoretical values.

All the overtides of which the only ones of any significance are the solar quarter-diurnal (S_4), the lunar quarter-diurnal (M_4) and the sexter-diurnal (M_6) agree very closely with the values previously obtained.

The proportions of the compound tides to the main tide are as follow :—

	Negapatam, 1886-87.	Theoretical.
$(M_2K_1)_3$	0·021	0·121
$(MS)_4$	0·025	0·096
$(2M_2K_1)_3$	0·013	0·086
$(M_2N)_4$	0·068	0·040
$(2SM)_2$	0·004	...

Of the long-period tides the lunar monthly is 0·011 of the main tide instead of 0·046, the theoretical value, and this is the lowest value yet obtained.

The lunar fortnightly tide is 0·139 of the main tide. The theoretical value is 0·086; the former values are given in the discussion for the preceding year.

The luni-solar fortnightly tide is 0·037 of the main tide instead of 0·007, the theoretical value, and agrees well with the preceding year's value.

The solar-annual tide is 63 per cent. of the main tide, which is less than last year's value, but greater than the values obtained from the first two years' observations. Its epoch is 230°, or 19° earlier than last year.

The solar semi-annual tide is 0·465 of the main tide, which agrees with the mean of former values. Its epoch is 129°, the value obtained in the preceding year.

Values of the Tidal Constants, Cocanada, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87 or first year's observations at Cocanada; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations:—

Short Period Tides.

A_0 = 5·488 feet.

S_1	H = R =	0·036	M_6	R =	0·016	Q_1	R =	0·014	T_2	R =	...
	κ = ζ =	92°·89		ζ =	183°·23		ζ =	44°·13		ζ =	...
S_2	H = R =	0·644		H =	0·014		H =	0·017		H =	..
	κ = ζ =	284°·85		κ =	97°·59		κ =	35°·95		κ =	...
S_4	H = R =	0·003	M_8	R =	0·002	L_2	R =	0·071	$(MS)_4$	R =	0·015
	κ = ζ =	125°·54		ζ =	60°·64		ζ =	164°·07		ζ =	39°·23
S_6	H = R =	0·003		H =	0·002		H =	0·075		H =	0·014
	κ = ζ =	204°·78		κ =	66°·46		κ =	272°·21		κ =	130°·69
S_8	H = R =	0·003	O_1	R =	0·110	N_2	R =	0·319	$(2SM)_2$	R =	0·015
	κ = ζ =	220°·60		ζ =	153°·44		ζ =	340°·13		ζ =	306°·19
				H =	0·133		H =	0·308		H =	0·015
				κ =	332°·93		κ =	243°·91		κ =	214°·74

Short Period Tides—continued.

$A_0 = 5·488$ feet.

M_1	R =	0·029	K_1	R =	0·311	λ_2	R =	0·008	$2N_2$	R =	0·045
	ζ =	222°·31		ζ =	65°·87		ζ =	91°·45		ζ =	165°·59
	H =	0·019		H =	0·347		H =	0·008		H =	0·043
	κ =	341°·40		κ =	340°·18		κ =	82°·90		κ =	241°·70
M_2	R =	1·537	K_2	R =	0·135	ν_2	R =	0·073	$(M_2N)_4$	R =	0·033
	ζ =	160°·83		ζ =	277°·03		ζ =	179°·37		ζ =	125°·17
	H =	1·486		H =	0·175		H =	0·071		H =	0·031
	κ =	252°·29		κ =	286°·38		κ =	190°·83		κ =	120°·41
M_3	R =	0·007	P_1	R =	0·099	μ_2	R =	0·020	$(M_2K_1)_3$	R =	0·022
	ζ =	208°·97		ζ =	262°·83		ζ =	73°·82		ζ =	290°·15
	H =	0·006		H =	0·099		H =	0·019		H =	0·024
	κ =	346°·15		κ =	344°·27		κ =	256°·73		κ =	295°·91
M_4	R =	0·028	J_1	R =	0·024	R_2	R =	...	$(2M_2K_1)_3$	R =	0·011
	ζ =	285°·83		ζ =	238°·83		ζ =	...		ζ =	57°·82
	H =	0·026		H =	0·028		H =	...		H =	0·011
	κ =	108°·73		κ =	338°·46		κ =	...		κ =	326°·42

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·032	9°·84	0·029	197°·51
„ fortnightly „	0·052	142 ·15	0·078	54 ·62
Luni-solar „ „	0·034	110 ·05	0·033	18 ·60
Solar-annual „	0·853	191 ·08	0·853	199 ·64
„ semi-annual „	0·403	91 ·51	0·403	108 ·63

The mean level of the sea (A_0) is 5·488 feet above the zero of the gauge.
The proportions of the several tides to the main lunar tide (M_2) are as follow :—

			Cocanada, 1886-87.	Theoretical.
SEMI DIURNAL TIDES.	Main solar	S_2	0·433	0·465
	Luni-solar	K_2	·118	·127
	Lunar elliptic	N_2	·207	·194
	„ „	L_2	·050	·028
	Evectional	ν_2	·048	·038
	„	λ_2	·005	·007
	Lunar elliptic of the 2nd order . .	$2N_2$	·029	·026
	Variational	μ_2	·013	·024
DIURNAL TIDES.	Luni-solar	K_1	·234	·584
	Lunar declinational	O_1	·090	·415
	Solar „	P_1	·067	·193
	„ elliptic	Q_1	·011	·080
	Lunar „	J_1	·019	·033
	„	M_1	·013	·036
	Solar	S_1	·024	...
OVER TIDES	Lunar	M_3	·004	·013
	„	M_4	·017	...
	„	M_6	·009	...
	„	M_8	·001	...
	Solar	S_4	·002	...
	„	S_6	·002	...
	„	S_8	·002	...

		Cocanada, 1886-87.	Theoretical.
COMPOUND TIDES.	Ter-diurnal . . . . $(M_2K_1)_3$	0·016	0·121
	Quarter-diurnal . . . . $(MS)_4$	·009	·096
	Ter-diurnal . . . . $(2M_2K_1)_3$	·007	·086
	Quarter-diurnal . . . . $(M_2N)_4$	·021	·040
	Semi-diurnal . . . . $(2SM)_2$	·010	...
LONG PERIOD TIDES.	Lunar monthly	·020	·046
	,, fortnightly	·052	·086
	Luni solar ,, ...	·022	·007
	Solar-annual	·574	...
	,, semi-annual	·271	·040

The foregoing values agree remarkably well with those obtained at the neighbouring tidal station of Vizagapatam, the observatory at which was closed on the termination of the 1884-85 observations.

VALUES OF THE TIDAL CONSTANTS, DUBLAT, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or fifth and final year's observations at Dublat; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

$A_0 = 9{\cdot}434$ feet.

S_1	H= R=	0·047	M_6	R =	0·008	Q_1	R =	0·008	T_2	R =	...
	κ = ζ =	131°·20		ζ =	14°·62		ζ =	207°·18		ζ =	...
S_2	H= R=	2·099		H =	0·007		H =	0·010		H =	...
	κ = ζ =	330°·45		κ =	180°·69		κ =	57°·70		κ =	...
S_4	H= R=	0·011	M_8	R =	0·010	L_2	R =	0·278	$(MS)_4$	R =	0·080
	κ = ζ =	237°·49		ζ =	317°·01		ζ =	274°·03		ζ =	15°·65
S_6	H= R=	0·002		H =	0·009		H =	0·245		H =	0·077
	κ = ζ =	259°·38		κ =	298°·43		κ =	301°·84		κ =	191°·00
S_8	H= R=	0·009	O_1	R =	0·158	N_2	R =	0·915	$(2SM)_2$	R =	0·045
	κ = ζ =	129°·89		ζ =	98°·99		ζ =	137°·33		ζ =	11°·56
				H =	0·196		H =	0·882		H =	0·044
				κ =	335°·68		κ =	286°·51		κ =	196°·20
M_1	R=	0·027	K_1	R =	0·435	λ_2	R =	0·169	$2N_2$	R =	0·153
	ζ =	339°·89		ζ =	53°·77		ζ =	171°·59		ζ =	140°·51
	H=	0·027		H =	0·493		H =	0·163		H =	0·147
	κ =	291°·07		κ =	353°·56		κ =	325°·19		κ =	263°·53
M_2	R=	4·776	K_2	R =	0·518	ν_2	R =	0·340	$(M_2N)_4$	R =	0·213
	ζ =	118°·44		ζ =	267°·62		ζ =	259°·04		ζ =	55°·33
	H=	4·603		H =	0·691		H =	0·328		H =	0·198
	κ =	293°·80		κ =	327°·33		κ =	276°·15		κ =	19°·88
M_3	R=	0·052	P_1	R =	0·148	μ_2	R =	0·152	$(M_2K_1)_3$	R =	0·066
	ζ =	53°·49		ζ =	290°·12		ζ =	19°·24		ζ =	76°·46
	H=	0·049		H =	0·148		H =	0·141		H =	0·072
	κ =	136°·53		κ =	349°·66		κ =	9°·96		κ =	191°·61
M_4	R=	0·087	J_1	R =	0·027	R_2	R =	...	$(2M_2K_1)_3$	R =	0·029
	ζ =	168°·93		ζ =	52°·50		ζ =	...		ζ =	46°·13
	H=	0·081		H =	0·033		H =	...		H =	0·031
	κ =	159°·65		κ =	17°·33		κ =	...		κ =	97°·06

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·023	140°·84	0·020	171°·00
,, fortnightly ,, ...	0·020	203 ·94	0·032	85 ·92
Luni-solar ,, ,, ...	0·044	200 ·93	0·042	25 ·57
Solar-annual ,, ...	0·787	123 ·17	0·787	153 ·64
,, semi-annual ,, ...	0·146	75 ·86	0·146	136 ·80

The mean level of the sea (A_0) at Dublat is 9·434 feet above the new zero of the gauge, which is equivalent to a height of 14·263 feet above the old zero to which all previous values have been referred. The mean of all the values is 14·390 feet, or 1½ inches higher.

The mean amplitude (H) of the main lunar tide (M_2) is 4·603 feet, which is very accordant with the former values, the mean of all the determinations being 4·608. The epoch is 293°·80 which also agrees well with previous values.

The main solar tide (S_2) has an amplitude of 2·099 feet, which is nearly equal to the mean value 2·107. Its proportion to the main tide is 0·456, which is almost identical with the mean of the five years' determinations 0·457. The theoretical value is just 1 per cent. greater. Its epoch is well established, the values obtained during the five years' observations being very accordant. The mean value is 327°·75.

The luni-solar semi-diurnal tide (K_2) is 0·150 of the main tide, being the largest proportion obtained; but the average of the five years' determinations is 0·135, which does not differ much from the theoretical value 0·127. The epoch is 327°·33, or about 5 minutes later than the average value 324°·78.

The smaller component of the lunar elliptic tide (L_2) is 0·053 of the main tide, the mean of the five years being 0·042, whilst the theoretical value is about half this proportion. The larger component (N_2) is 0·192 of the main tide and agrees closely with the mean, 0·194, of the five years' determinations, which is identical with the theoretical value.

The lunar elliptic tide of the second order ($2N_2$) is 0·032 of the main tide, which compares well with the theoretical value 0·026. The average obtained from all the observations is 0·034.

The smaller component of the evectional tide (λ_2) is 0·035 of the main tide, and agrees closely with the mean 0·032, but theoretically it should be as small as 0·007. The larger component (ν_2) is about twice as large as it ought to be by theory. This year's value is the largest, being 0·071, while the mean is 0·053, and the theoretical value is 0·038.

The variational tide (μ_2) has a proportion to the main tide of 0·031, the mean value is 0·032, and the theoretical is 0·024.

The proportions of the diurnal tides to the main tide are as follow:—

	Dublat, 1885-86.	Theoretical.
Luni-solar (K_1)	0·107	0·584
Lunar declinational (O_1)	0·043	0·415
Lunar „ (P_1)	0·032	0·193
„ elliptic (Q_1)	0·002	0·080
Lunar „ (J_1)	0·007	0·033
„ (M_1)	0·006	0·036

The values of these tides obtained during the five years' observations are remarkably accordant, and are all much below the theoretical proportions.

Of the overtides, the lunar quarter-diurnal (M_4) is the largest, having a proportion of 0·018 to the main tide, and agrees very well with former values. Its epoch is also well established, being 148°·95.

The proportions of the compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·016
$(MS)_4$	0·017
$(2M_2K_1)_3$	0·007
$(M_2N)_4$	0·043
$(2SM)_2$	0·010

These are all small and, with the exception of $(MN)_4$, which this year is almost identical with the theoretical value, are very accordant with the former values.

With reference to the long period tides their proportions to the main tide have a general agreement with previous values. With the exception of the luni-solar fortnightly tide the mean proportions obtained during the five years' observations are less than the theoretical proportions. The epochs of these tides are divergent, with the exception of that of the solar annual, which is 153°·6, or only 3° more than the value obtained from the five years' observations.

VALUES OF THE TIDAL CONSTANTS, DIAMOND HARBOUR, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85 or fourth year's observations at Diamond Harbour; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=8·897 feet.

S_1	H= R=	0·092	M_6	R =	0·157	Q_1	R =	0·016	T_2	R =	0·317
	κ = ζ =	161° 09		ζ =	9°·70		ζ =	136°·04		ζ =	178°·44
S_2	H= R=	2·202		H =	0·141		H =	0·019		H =	0·317
	κ = ζ =	26°·49		κ =	112°·37		κ =	301°·12		κ =	86°·44
S_4	H= R=	0·123	M_8	R =	0·061	L_2	R =	0·330	$(MS)_4$	R =	0·754
	κ = ζ =	328°·73		ζ =	91°·82		ζ =	310°·96		ζ =	134°·34
S_6	H= R=	0·013		H =	0·053		H =	0·280		H =	0·728
	κ = ζ =	269°·56		κ =	348°·72		κ =	344°·23		κ =	288°·57
S_8	H= R=	0·007	O_1	R =	0·176	N_2	R =	0·979	$(2SM)_2$	R =	0·072
	κ = ζ =	285°·95		ζ =	123°·09		ζ =	243°·83		ζ =	65°·39
				H =	0·217		H =	0·945		H =	0·069
				κ =	350°·44		κ =	335°·79		κ =	271°·17
M_1	R =	0·045	K_1	R =	0·441	λ_2	R =	0·199	$2N_2$	R =	0·173
	ζ =	328°·3		ζ =	88°·84		ζ =	238°·47		ζ =	284°·12
	H =	0·052		H =	0·498		H =	0·192		H =	0·167
	κ =	202°·53		κ =	14°·32		κ =	356°·71		κ =	313°·80
M_2	R =	5·324	K_2	R =	0·542	ν_2	R =	0·401	$(M_2N)_4$	R =	0·091
	ζ =	190°·49		ζ =	352°·28		ζ =	320°·33		ζ =	138°·86
	H =	5·135		H =	0·718		H =	0·387		H =	0·085
	κ =	344°·71		κ =	22°·76		κ =	330°·53		κ =	25°·04
M_3	R =	0·065	P_1	R =	0·184	μ_2	R =	0·364	$(M_2K_1)_3$	R =	0·146
	ζ =	185°·80		ζ =	294°·90		ζ =	133° 60		ζ =	199° 04
	H =	0·062		H =	0·184		H =	0·338		H =	0·159
	κ =	237°·14		κ =	11°·94		κ =	82°·05		κ =	278°·74
M_4	R =	0·809	J_1	R =	0·029	R_2	R =	0·175	$(2M_2K_1)_3$	R =	0·056
	ζ =	300°·56		ζ =	39° 22		ζ =	104°·52		ζ =	197°·28
	H =	0·753		H =	0·035		H =	0·175		H =	0·059
	κ =	249°·01		κ =	28°·37		κ =	16° 53		κ =	220° 25

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·164	314°·32	0·145	16°·59
„ fortnightly „	0·099	160 ·87	0·155	40 ·40
Luni-solar „	0·439	190 ·38	0·424	36 ·15
Solar-annual „	0·991	129 ·86	0·991	142 ·83
„ semi-annual „	0·069	124 ·18	0·069	150 ·10

The mean level of the water (A_0) for 1884-85 is 8·897 feet above the zero of the gauge, which is the lowest height yet reached. The highest was 1⅓ inches greater and was reached in 1882-83.

The mean amplitude (H) of the main lunar tide (M_2) is 5·135 feet, which is somewhat less than previous values. The epoch is 344°·7, which is very accordant with all the former values.

The main solar tide (S_2) has an amplitude this year of 2·202 feet, which agrees well with former values. It is 0·429 of the main tide, or about 3½ per cent. less than the theoretical value 0·465. Its epoch, 26°·5, also agrees very closely with the values previously obtained.

The luni-solar semi-diurnal tide (K_2) is 0·140 of the main tide, which, although slightly in excess of the theoretical value, 0·127, agrees well with the mean of previous determinations. The epoch, 22°·8, agrees well with previous determinations.

The smaller component (L_2) of the lunar elliptic tide is 0·055 of the main tide, or twice as large as the theoretical value 0·028, whilst the larger component (N_2) has a proportion of 0·184, or 1 per cent. less than the theoretical value 0·194. These proportions accord well with the former results. The epochs of these tides are very regular throughout.

The lunar elliptic tide of the second order ($2N_2$) is 0·033 of the main tide, according to theory it should be 0·026.

The solar elliptic tides (R_2 and T_2) have been computed from the observations for 1883-84 and 1884-85. The amplitudes are 0·034 and 0·062 respectively of the main tide. The latter is more than double the theoretical value 0·027, and four times as large as the value, 0·015, obtained before. The former does not differ much from the determination in 1882-83, which was 0·042.

The evectional tides (λ_2 and ν_2) are 0·037 and 0·075 of the main tide, whilst according to theory they should be only 0·007 and 0·038, values which were approached in former years.

The variational tide (μ_2) is 0·066 of the main tide, which agrees with former values, but is much in excess of the theoretical value, 0·024.

The proportions of the diurnal tides to the main tide are as follow :—

		Diamond Harbour, 1884-85.	Theoretical.
Luni-solar	(K_1)	0·097	0·584
Lunar declinational	(O_1)	0·042	0·415
Solar ,,	(P_1)	0·036	0·193
,, elliptic	(Q_1)	0·004	0·080
Lunar ,,	(J_1)	0·007	0·033
,,	(M_1)	0·010	0·03

These proportions, which are all less than the theoretical values, agree very well with the former results.

The largest overtide is the lunar quarter-diurnal (M_4) which has an amplitude equal to 15 per cent. of the main tide. This proportion has been maintained every year.

The proportions of the compound tides to the main tide are as follow :—

$(M_2K_1)_3$	0·031
$(MS)_4$	0·142
$(2M_2K_1)_3$	0·011
$(M_2N)_4$	0·017
$(2SM)_2$	0·013

These proportions correspond fairly well with former values.

The proportions of the long period tides to the main tide accord well with former values, and are less than the theoretical, with the exception of the luni-solar fortnightly tide, which is 0·083 or 12 times its theoretical value. The epochs of the lunar fortnightly, the luni-solar fortnightly and the solar annual agree very well with their former values, but the accordance of the epochs of the lunar monthly is not so good, and the values obtained for the solar semi-annual are very divergent.

VALUES OF THE TIDAL CONSTANTS, DIAMOND HARBOUR, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or fifth and final year's observations at Diamond Harbour ; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=8·804 feet.

S_1	H= R=	·101
	κ = ζ =	162°·94
S_2	H= R=	2·199
	κ = ζ =	25°·98
S_4	H= R=	·123
	κ = ζ =	326°·18
S_6	H= R=	·006
	κ = ζ =	233°·13
S_8	H= R=	·002
	κ = ζ =	175°·03
M_1	R=	·032
	ζ =	108°·90
	H=	·032
	κ =	277°·22
M_2	R=	5·348
	ζ =	90°·56
	H=	5·154
	κ =	344°·82
M_3	R=	·062
	ζ =	203°·32
	H=	·058
	κ =	224°·72
M_4	R=	8·24
	ζ =	101°·28
	H=	·765
	κ =	249°·81

M_6	R=	·161
	ζ =	67°·24
	H=	·144
	κ =	110°·03
M_8	R=	·062
	=	57°·00
	H=	·053
	κ =	354°·04
O_1	R=	·188
	ζ =	15°·19
	H=	·233
	κ =	348°·26
K_1	R=	·454
	ζ =	91°·25
	H=	·515
	κ =	13°·49
K_2	R=	·466
	ζ =	5°·49
	H=	·622
	κ =	30°·05
P_1	R=	·171
	ζ =	293°·88
	H=	·171
	κ =	11°·16
J_1	R=	·037
	ζ =	311°·85
	H=	·045
	κ =	24°·04

Q_1	R=	·013
	ζ =	221°·48
	H=	·016
	κ =	43°·56
L_2	R=	·315
	ζ =	136°·93
	H=	·276
	κ =	8°·11
N_2	R=	1·069
	ζ =	243°·74
	H=	1·030
	κ =	347°·01
λ_2	R=	·277
	ζ =	329°·24
	H=	·267
	κ =	358°·05
ν_2	R=	·211
	ζ =	359°·59
	H=	·203
	κ =	299°·30
μ_2	R=	·289
	ζ =	296°·82
	H=	·268
	κ =	85°·34
R_2	R=	...
	ζ =	...
	H=	...
	κ =	...

T_2	R=	...
	ζ =	...
	H=	...
	κ =	...
$(MS)_4$	R=	·736
	ζ =	34°·00
	H=	·709
	κ =	288°·26
$(2SM)_2$	R=	·077
	ζ =	184°·02
	H=	·074
	κ =	289°·76
$2N_2$	R=	·153
	ζ =	8°·83
	H=	·147
	κ =	321°·11
$(M_2N)_4$	R=	·124
	ζ =	70°·18
	H=	·116
	κ =	67°·71
$(M_2K_1)_3$	R=	·098
	ζ =	124°·31
	H=	·107
	κ =	300°·80
$(2M_2K_1)_3$	R=	·061
	ζ =	334°·46
	H=	·065
	κ =	200°·75

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	·088	211°·95	·078	2°·94
,, fortnightly ,, ...	·060	265 ·10	·096	33 ·23
Luni-solar ,, ,, ...	·501	283 ·63	·483	29 ·36
Solar-annual ,, ...	1·119	127 ·59	1·119	140 ·31
,, semi-annual ,, ...	·182	236 ·91	·182	262 ·35

The mean level of the water (A_0) in 1885-86 is 8·804 feet above the zero of the gauge, which is the lowest value obtained at Diamond Harbour. The mean result is 8·937 feet or about 1½ inches higher.

The mean amplitude (H) of the main lunar tide (M_2) is 5·154 feet, the average value being 5·164 feet. The epoch of this tide is very accordant, being 344°·8, whilst the average is 344°·4.

The mean amplitude (H) of the main solar tide (S_2) is 2·199 feet which is about ⅓ of an inch less than the mean of the five years' results, 2·231. It is 0·427 of the main tide, which is very close to the mean value, 0·432; theoretically it ought to be 0·465. The epoch is 25°·98, which is almost identical with the mean value 25°·96 obtained from the five years' observations which are all very accordant.

The luni-solar semi-diurnal tide (K_2) is 0·121 of the main tide and agrees very well both with the theoretical value 0·127 and the average value 0·131. The epoch of this tide is 30°·1, the mean of all the results being 24°·7.

The lunar elliptic tides (L_2 and N_2) are respectively 0·054 and 0·200 of the main tide, values which agree very well with the means 0·050 and 0·185 and not far from the theoretical values 0·028 and 0·194. The epochs of these tides are well established.

The lunar elliptic tide of the 2nd order ($2N_2$) is 0·029 of the main tide, a value which is identical with the mean of all the observations and very near the theoretical proportion, 0·026.

The evectional tides (λ_2 and ν_2) are 0·052 and 0·039 of the main tide. According to theory they should be 0·007 and 0·038; the mean values are 0·028 and 0·054.

The amplitude of the variational tide (μ_2) is 0·052 of the main tide, the mean value is 0·059, and the theoretical value is about half this proportion, or 0·024. The epoch is 85°·34 and the mean of all the determinations which are fairly accordant is 85°·31.

The proportions of the diurnal tides to the main tide are as follow:—

	Diamond Harbour, 1885-86.	Theoretical.
Luni-solar (K_1)	0·100	0·584
Lunar declinational (O_1)	·045	·415
Solar ,, (P_1)	·033	·193
,, elliptic (Q_1)	·003	·080
Lunar ,, (J_1)	·009	·033
,, (M_1)	·006	·036

These proportions are very low in comparison with the theoretical values, but this has been found to be the case every year at Diamond Harbour and the values *inter se* are very accordant.

With regard to the overtides, the lunar quarter-diurnal (M_4) is the largest, being 0·148 of the main tide which agrees almost exactly with former values and with the mean 0·146. The epoch of this tide is very accordant throughout the observations; this year's value is 249°·8 and the mean of all the results 247°·4.

The proportions of the compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·021
$(MS)_4$	0·138
$(2M_2K_1)_3$	0·013
$(M_2N)_4$	0·023
$(2SM)_2$	0·014

These values are almost identical with the means obtained from all the determinations.

With regard to the long period tides, the lunar monthly is this year 0·015 of the main tide, its mean value being 0·022 and the theoretical 0·046. Its epoch this year is 2°·9, the mean of all the determinations being 9°·6.

The lunar fortnightly tide is 0·019 of the main tide, the mean value derived from all the observations is 0·030, which is considerably less than the theoretical proportion 0·086. The epoch is 33°·2, the mean of all the results being 41°·7.

The luni-solar fortnightly tide is 0·094 of the main tide which accords well with the mean 0·088, but theory gives only 0·007 as its value. Its epoch is 29°·4 which compares well with the average value 34°·4.

The solar-annual tide is 0·217 of the main tide and agrees well with the mean value 0·205. Its epoch is well determined, and this year's value, 140°·3, approaches closely to the mean value, 142°·1.

The solar semi-annual tide has a proportion of 0·035 of the main tide, which is the largest value obtained and approaches the theoretical value, 0·040. The average of all the results is 0·019. Its epoch is very irregular.

Values of the Tidal Constants, Kidderpore, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86 or fifth year's observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

$A_0 = 10·950$ feet.

S_1	H=R=	0·088	M_6	R=	0·179	Q_1	R=	0·013	T_2	R=	...
	$\kappa=\zeta=$	204°·50		$\zeta=$	57°·04		$\zeta=$	52°·86		$\zeta=$	...
S_2	H=R=	1·459		H=	0·161		H=	0·016		H=	...
	$\kappa=\zeta=$	102°·45		$\kappa=$	330°·81		$\kappa=$	14°·40		$\kappa=$	...
S_4	H=R=	0·074	M_8	R=	0·076	L_2	R=	0·254	$(MS)_4$	R=	0·679
	$\kappa=\zeta=$	116°·88		$\zeta=$	159°·31		$\zeta=$	55°·64		$\zeta=$	233°·74
S_6	H=R=	0·008		H=	0·065		H=	0·221		H=	0·654
	$\kappa=\zeta=$	340°·40		$\kappa=$	284°·33		$\kappa=$	73°·69		$\kappa=$	85°·00
S_8	H=R=	0·005	O_1	R=	0·168	N_2	R=	0·701	$(2SM)_2$	R=	0·099
	$\kappa=\zeta=$	285°·35		$\zeta=$	80°·18		$\zeta=$	176°·96		$\zeta=$	227°·93
				H=	0.209		H=	0·675		H=	0·096
				$\kappa=$	22°·66		$\kappa=$	47°·08		$\kappa=$	16°·67
M_1	R=	0·050	K_1	R=	0·347	υ_2	R=	0·101	$2N_2$	R=	0·103
	$\zeta=$	96°·7		$\zeta=$	147°·36		$\zeta=$	295°·67		$\zeta=$	119°·27
	H=	0·051		H=	0·394		H=	0·098		H=	0·099
	$\kappa=$	334°·75		$\kappa=$	56°·90		$\kappa=$	134°·35		$\kappa=$	8°·24
M_2	R=	3·764	K_2	R=	0·285	ν_2	R=	0·332	$(M_2N)_4$	R=	0·047
	$\zeta=$	209°·10		$\zeta=$	95°·73		$\zeta=$	328°·98		$\zeta=$	49°·47
	H=	3·627		H=	0·381		H=	0·320		H=	0·043
	$\kappa=$	60°·35		$\kappa=$	94°·88		$\kappa=$	12°·81		$\kappa=$	130°·84
M_3	R=	0·064	P_1	R=	0·132	μ_2	R=	0·222	$(M_2K_1)_3$	R=	0·075
	$\zeta=$	195°·87		$\zeta=$	309°·92		$\zeta=$	128°·96		$\zeta=$	265°·52
	H=	0·060		H=	0·132		H=	0·206		H=	0·082
	$\kappa=$	332°·75		$\kappa=$	40°·01		$\kappa=$	191°·47		$\kappa=$	26°·31
M_4	R=	0·792	J_1	R=	0·009	R_2	R=	...	$(2M_2K_1)_3$	R=	0·038
	$\zeta=$	339°·56		$\zeta=$	192°·40		$\zeta=$	...		$\zeta=$	148°·04
	H=	0·736		H=	0·011		H=	...		H=	0·040
	$\kappa=$	42°·07		$\kappa=$	82°·12		$\kappa=$	...		$\kappa=$	301°·02

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·304	36°·97	0·269	18°·11
„ fortnightly „	0·199	248·46	0·317	34·36
Luni-solar „ „	1·018	251·57	0·981	40·31
Solar-annual „	3·006	160·80	3·006	160·71
„ semi-annual „	1·307	328·51	1·307	328·33

The mean level of the river (A_0) is 10·950 feet above the zero of the gauge, which is the highest value yet obtained, and 2½ inches in excess of the mean, 10·735, of the whole five years' observations.

The main lunar tide (M_2) has an amplitude of 3·627 feet, which agrees well with former values. Its epoch is 60°·35, the mean being 58°·85.

The amplitude of the main solar tide (S_2) is 1·459 feet. In former years it varied from 1·427 to 1·513. It is 40 per cent. of the main lunar tide. Its epoch is well determined; this year's value is 102°·45 and is almost identical with the mean 102°·28 derived from the five years' observations.

The luni-solar semi-diurnal tide (K_2) is 0·105 of the main tide; the mean of five years' results is 0·123, which is very close to 0·127, the theoretical proportion. The epoch is 94°·88, or about 6½ minutes earlier than last year's value 98°·13 which approaches the average 97°·43.

The two lunar elliptic tides (L_2 and N_2) have proportions to the main tide of 0·061 and 0·186, the theoretical values being 0·028 and 0·194. They accord fairly well with former values.

The lunar elliptic tide of the second order ($2N_2$) is 0·027 of the main tide; it is very close to the theoretical value 0·026, which is also the mean of the five years' determinations.

The evectional tides (λ_2 and ν_2) are 0·027 and 0·088 of the main tide, which are close to the mean values, 0·024 and 0·071, but very much greater than their theoretical proportions, 0·007 and 0·038.

The variational tide (μ_2) is 0·057 of the main tide, which nearly agrees with the mean value, 0·066, but is more than double the theoretical value, 0·024.

The proportions of the diurnal tides to the main tide are as follow :—

		Kidderpore, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·109	0·584
Lunar declinational	(O_1)	0·058	0·415
Solar „	(P_1)	0·036	0·193
„ elliptic	(Q_1)	0·004	0·080
Lunar „	(J_1)	0·003	0·033
„	(M_1)	0·014	0·036

Low values, such as the above, have always been obtained for the diurnal tides at Kidderpore.

The most significant of the overtides is the lunar quarter-diurnal (M_4), the proportion of which to the main tide, 0·203, agrees very well with former values. The next in importance is (M_6) which is 0·044 of the main tide and accordant with all former values. Their epochs are also very well determined.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·180 of the main tide, which agrees very well with the mean value, 0·177. Its epoch is well established; this year it is 85°·0, which is almost identical with last year's value 84°·9, and differs only by 1°·9 from the mean of the five years' determinations.

The proportions of the other compound tides to the main tide are as follow :—

$(M_2K_1)_3$	0·023
$(2M_2K_1)_3$	0·011
$(M_2N)_4$	0·012
$(2SM)_2$	0·026

These values compare very well with previous determinations.

Of the long period tides the lunar monthly is 0·074 of the main tide, the mean value being 0·073 and theoretical 0·046.

The lunar fortnightly tide is 0·087 of the main tide or almost identical with its theoretical value, 0·086, and with the mean value, 0·082.

The luni-solar fortnightly tide is 0·27 of the main tide; by theory it should be 0·007, but the proportion has always been high at this station.

The solar-annual tide is 83 per cent. of the main tide, being the highest value yet obtained and about 11 per cent. above the average.

The solar semi-annual tide is 0·360 of the main tide, or nine times as large as its theoretical value, 0·040. The average of five years is 0·239.

The epochs of the lunar monthly tide are irregular; those of the lunar fortnightly tide show a difference of 19°; those of the luni-solar fortnightly and the solar annual show each a difference of 12° and those of the solar semi-annual continue to be very discordant.

VALUES OF THE TIDAL CONSTANTS, CHITTAGONG, 1886-87.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1886-87, or first year's observations at Chittagong; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1886-87 observations :—

Short Period Tides.

A_0=8·251 feet.

S_1	H= R=	0·060	M_6	R=	0·158	Q_1	R=	0·014	T_2	R=	...
	κ = ζ =	120°·09		ζ =	140°·18		ζ =	29°·18		ζ =	...
S_2	H= R=	1·568		H=	0·143		H=	0·016		H=	...
	κ = ζ =	68°·45		κ =	195°·45		κ =	327°·77		κ =	...
S_4	H= R=	0·049	M_8	R=	0·040	L_2	R=	0·387	$(MS)_4$	R=	0·367
	κ = ζ =	54°·55		ζ =	173°·43		ζ =	351°·10		ζ =	119°·24
S_6	H= R=	0·010		H=	0·035		H=	0·425		H=	0·355
	κ = ζ =	131°·08		κ =	127°·12		κ =	60°·30		κ =	17°·66
S_8	H= R=	0·002	O_1	R=	0·246	N_2	R=	0.898	$(2SM)_2$	R=	0·133
	κ = ζ =	217°·41		ζ =	90°·28		ζ =	107°·76		ζ =	197°·83
				H=	0·295		H=	0·869		H=	0·129
				κ =	11°·55		κ =	23°·51		κ =	299°·41

Short Period Tides—contd.

A_0=8·251 feet.

M_1	R=	0·038	K_1	R=	0·523	λ_2	R=	0·214	$2N_2$	R=	0·032
	ζ =	356°·26		ζ =	42°·42		ζ =	224°·31		ζ =	85°·80
	H=	0·025		H=	0·582		H=	0·207		H=	0·031
	κ =	22°·82		κ =	22°·19		κ =	60°·63		κ =	18°·86
M_2	R=	4·575	K_2	R=	0·340	ν_2	R=	0·416	$(M_2N)_4$	R=	0·153
	ζ =	136°·46		ζ =	290°·56		ζ =	243°·71		ζ =	72°·19
	H=	4·428		H=	0·438		H=	0·402		H=	0·143
	κ =	34°·89		κ =	70°·88		κ =	24°·23		κ =	246°·35
M_3	R=	0·041	P_1	R=	0·192	μ_2	R=	0·286	$(M_2K_1)_3$	R=	0·122
	ζ =	10°·51		ζ =	10°·57		ζ =	43°·30		ζ =	72°·13
	H=	0·039		H=	0·192		H=	0·268		H=	0·131
	κ =	218°·15		κ =	26°·00		κ =	200°·14		κ =	310°·32
M_4	R=	0·450	J_1	R=	0·046	R_2	R=	...	$(2M_2K_1)_3$	R=	0·047
	ζ =	185°·12		ζ =	91°·64		ζ =	...		ζ =	85°·89
	H=	0·421		H=	0·053		H=	...		H=	0·049
	κ =	341°·96		κ =	51°·47		κ =	...		κ =	262°·97

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·084	356°·02	0·075	338°·70
„ fortnightly „	0·122	163 ·75	0·181	39 ·64
Luni-solar „ „	0·446	297 ·56	0·432	39 ·14
Solar-annual „	1·666	62 ·02	1·666	136 ·59
„ semi-annual „	0·178	68 ·13	0·178	217 ·27

The mean level of the water (A_0) is 8·251 feet above the zero of the gauge.
The proportions of the several tides to the main lunar tide (M_2) are as follow:—

			Chittagong, 1886-87.	Theoretical.
SEMI-DIURNAL TIDES.	Main solar	S_2	0·354	0·465
	Luni-solar	K_2	·099	·127
	Lunar elliptic	N_2	·196	·194
	„ „	L_2	·096	·028
	Evectional	ν_2	.091	·038
	„	λ_2	·047	·007
	Lunar elliptic of the 2nd order . .	$2N_2$	·007	·026
	Variational	μ_2	·061	·024
DIURNAL TIDES.	Luni-solar	K_1	·131	·584
	Lunar declinational	O_1	·067	·415
	Solar „	P_1	·043	·193
	„ elliptic	Q_1	·004	·080
	Lunar „	J_1	·012	·033
	„	M_1	·006	·036
	Solar	S_1	·014	...
OVER TIDES	Lunar	M_3	·009	·013
	„	M_4	·095	...
	„	M_6	·032	...
	„	M_8	·008	...
	Solar	S_4	·011	...
	„	S_6	·002	...
	„	S_8	·000	...
COMPOUND TIDES.	Ter-diurnal	$(M_2K_1)_3$	·030	·121
	Quarter-diurnal	$(MS)_4$	·080	·096
	Ter-diurnal	$(2M_2K_1)_3$	·011	·086
	Quarter-diurnal	$(M_2N)_4$	·032	·040
	Semi-diurnal	$(2SM)_2$	·029	...
LONG PERIOD TIDES.	Lunar monthly		·017	·046
	„ fortnightly		·041	·086
	Luni-solar „		·098	·007
	Solar-annual		·376	...
	„ semi-annual		·040	·040

Values of the Tidal Constants, Elephant Point, 1885.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885, or 2nd year's observations at the new site at Elephant Point; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885 observations:—

Short Period Tides.

A_0 = 11·745 feet.

S_1	$H = R =$	0·082	M_6	$R =$	0·270	Q_1	$R =$	0·019	T_2	$R =$	0·318
	$\kappa = \zeta =$	126°·48		$\zeta =$	330°·33		$\zeta =$	173°·03		$\zeta =$	92°·74
S_2	$H = R =$	2·397		$H =$	0·241		$H =$	0·024		$H =$	0·318
	$\kappa = \zeta =$	140°·08		$\kappa =$	337°·74		$\kappa =$	328°·93		$\kappa =$	92°·67
S_4	$H = R =$	0·088	M_8	$R =$	0·117	L_2	$R =$	0·292	$(MS)_4$	$R =$	0·307
	$\kappa = \zeta =$	176°·94		$\zeta =$	324°·04		$\zeta =$	289°·58		$\zeta =$	125°·26
S_6	$H = R =$	0·007		$H =$	0·101		$H =$	0·250		$H =$	0·296
	$\kappa = \zeta =$	262°·46		$\kappa =$	333°·93		$\kappa =$	131°·54		$\kappa =$	127°·73
S_8	$H = R =$	0·005	O_1	$R =$	0·261	N_2	$R =$	1·091	$(2SM)_2$	$R =$	0·112
	$\kappa = \zeta =$	284°·04		$\zeta =$	196°·80		$\zeta =$	98°·81		$\zeta =$	37°·04
				$H =$	0·323		$H =$	1·052		$H =$	0·112
				$\kappa =$	8°·36		$\kappa =$	85°·62		$\kappa =$	34°·57
M_1	$R =$	0·008	K_1	$R =$	0·650	λ_2	$R =$	0·184	$2N_2$	$R =$	0·213
	$\zeta =$	276°·58		$\zeta =$	188°·45		$\zeta =$	340°·15		$\zeta =$	113°·80
	$H =$	0·009		$H =$	0·737		$H =$	0·178		$H =$	0·205
	$\kappa =$	125°·30		$\kappa =$	19°·47		$\kappa =$	144°·48		$\kappa =$	84° 96·
M_2	$R =$	6·113	K_2	$R =$	0·536	ν_2	$R =$	0·142	$(M_2N)_4$	$R =$	0·213
	$\zeta =$	101°·48		$\zeta =$	293°·11		$\zeta =$	101°·49		$\zeta =$	55°·46
	$H =$	5·890		$H =$	0·716		$H =$	0·137		$H =$	0·198
	$\kappa =$	103°·95		$\kappa =$	135°·16		$\kappa =$	122°·10		$\kappa =$	44°·75
M_3	$R =$	0·028	P_1	$R =$	0·189	μ_2	$R =$	0·421	$(M_3K_1)_3$	$R =$	0·050
	$\zeta =$	153°·72		$\zeta =$	222°·63		$\zeta =$	288°·52		$\zeta =$	150°·76
	$H =$	0·026		$H =$	0·189		$H =$	0·391		$H =$	0·055
	$\kappa =$	337°·43		$\kappa =$	31°·59		$\kappa =$	293°·47		$\kappa =$	344°·26
M_4	$R =$	0·312	J_1	$R =$	0·053	R_2	$R =$	0·077	$(2M_2K_1)_3$	$R =$	0·072
	$\zeta =$	82°·80		$\zeta =$	256°·25		$\zeta =$	284°·00		$\zeta =$	179°·11
	$H =$	0·289		$H =$	0·064		$H =$	0·077		$H =$	0·076
	$\kappa =$	87°·74		$\kappa =$	102°·82		$\kappa =$	104°·07		$\kappa =$	353°·03

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·136	351°·30	0·120	6°·96
„ fortnightly „	0·075	184 ·93	0·120	24 ·28
Luni-solar „ „	0·254	55 ·25	0·245	52 ·78
Solar-annual „	0·873	220 ·03	0·873	141 ·07
„ semi-annual „	0·107	17 ·18	0·107	219 ·26

The mean level of the water (A_0) is 11·745 feet above the present zero of the gauge, which is 3·896 feet higher than the zero to which the heights were referred in 1884. The mean level of the water for that year was 12·418 feet above the present zero, or 16·314 feet above the original zero, thus there is a difference of 0·673 foot between the two years' determinations.

The main lunar tide (M_2) has an amplitude of 5·890 feet; in 1884 it was 5·876 feet. The epoch is also accordant, being 103°·95 against 101°·88.

The mean amplitude (H), 2·397 feet, of the main solar tide (S_2) agrees well with the previous year's value, 2·384; the epoch is also very accordant, this year's value being 140°·1 and that obtained in the previous year 139°·6. Its proportion to the main lunar tide 0·407, is almost identical with that in the preceding year; the theoretical proportion is 0·465.

The luni-solar semi-diurnal tide (K_2) is 0·122 of the main tide, or nearly the theoretical value, 0·127. Its epoch is about half an hour later than it was last year.

The amplitude of the smaller lunar elliptic tide (L_2) is 0·042 of the main tide, the theoretical value is 0·028, and that found in 1884, 0·075. The larger component (N_2) is nearer the value assigned by theory, being 0·179 against 0·194. In the previous year it was 0·164.

The lunar elliptic tide of the second order ($2N_2$) is 0·035 of the main tide, instead of 0·026, the theoretical value. In 1884 it was 0·048.

The two solar elliptic tides (R_2 and T_2) have been evaluated from the 1884 and 1885 observations for the first time. Their amplitudes are 0·013 and 0·054 of the main tide.

The evectional tides (λ_2 and ν_2) are 0·030 and 0·023 of the main tide, and agree well with the 1884 values. Theoretically they should be 0·007 and 0·038. The variational tide (μ_2) is 0·066 of the main tide, or nearly three times as large as the theoretical value 0·024. In 1884 it was 0·059.

The proportions of the diurnal tides to the main tide are as follow:—

		Elephant Point, 1885.	Theoretical.
Luni-solar	(K_1)	0·125	0·584
Lunar declinational	(O_1)	0·055	0·415
Solar „	(P_1)	0·032	0·193
„ elliptic	(Q_1)	0·004	0·080
Lunar „	(J_1)	0·011	0·033
„	(M_1)	0·002	0·036

Similar low values were obtained in 1884 for these tides.

Of the overtides the lunar quarter-diurnal (M_4) and the sexter-diurnal (M_6) are 0·049 and 0·041 of the main tide, which accord well with the 1884 values. The epochs are also very close to the 1884 values.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·050 against 0·053 in the previous year. The epoch is this year 6 minutes later.

The proportions of the other compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·009
$(2M_2K_1)_3$	0·013
$(M_2N)_4$	0·034
$(2SM)_2$	0·019

With the exception of $(MS)_4$ the quarter-diurnal $(M_2N)_4$ is the largest, being nearly 3½ per cent. of the main tide.

Regarding the long period tides, the lunar monthly is 0·020 of the main tide, which is also last year's value; but theoretically it should be 0·046.

The lunar fortnightly tide, which also is 0·020 of the main tide, is even more divergent from the theoretical proportion, 0·086. Last year the proportion was 0·032.

The luni-solar fortnightly tide is 0·042 of the main tide, instead of 0·007 according to theory. In the preceding year it was nearly the same, being 0·038. The epoch so far is very accordant.

The solar-annual tide is 0·148 of the main tide, or just 1 per cent. higher than the value for 1884. Its epoch is divergent from last year's value, being 24 days later.

The solar semi-annual tide is 0·018 of the main tide, or nearly half the theoretical value, 0·040; but it agrees closely with the value, 0·023, obtained in 1884. Its epoch is about 8 days later than it was last year.

Values of the Tidal Constants, Amherst, 1884-85.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1884-85, or fifth year's observations at Amherst; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1884-85 observations:—

Short Period Tides.

A_0=13·588 feet.

S_1	$H = R =$	0·137	M_6	$R =$	0·158	Q_1	$R =$	0·016	T_2	$R =$	...
	$\kappa = \zeta =$	132°·64		$\zeta =$	143°·26		$\zeta =$	246°·89		$\zeta =$	...
S_2	$H = R =$	2·700		$H =$	0·142		$H =$	0·020		$H =$	...
	$\kappa = \zeta =$	95°·11		$\kappa =$	250°·34		$\kappa =$	7°·37		$\kappa =$	...
S_4	$H = R =$	0·099	M_8	$R =$	0·024	L_2	$R =$	0·444	$(MS)_4$	$R =$	0·311
	$\kappa = \zeta =$	101°·27		$\zeta =$	79°·42		$\zeta =$	5°·20		$\zeta =$	29°·86
S_6	$H = R =$	0·002		$H =$	0·021		$H =$	0·373		$H =$	0·300
	$\kappa = \zeta =$	164°·48		$\kappa =$	222°·19		$\kappa =$	89°·84		$\kappa =$	65°·55
S_8	$H = R =$	0·002	O_1	$R =$	0·271	N_2	$R =$	1·238	$(2SM)_2$	$R =$	0·188
	$\kappa = \zeta =$	266°·99		$\zeta =$	357°·92		$\zeta =$	243°·73		$\zeta =$	49°·13
				$H =$	0·335		$H =$	1·194		$H =$	0·181
				$\kappa =$	347°·32		$\kappa =$	50°·50		$\kappa =$	13°·44

Short Period Tides—contd.

A_0=13·588 feet.

M_1	R=	0·031	K_1	R=	0·620	λ_2	R=	0·184	$2N_2$	R=	0·212
	ζ=	254°·93		ζ=	316°·02		ζ=	181°·48		ζ=	134°·48
	H=	0·038		H=	0·702		H=	0·178		H=	0·204
	κ=	92°·93		κ=	1°·12		κ=	132°·83		κ=	72°·32
M_2	R=	6·668	K_2	R=	0·729	ν_2	R=	0·241	$(M_2N)_4$	R=	0·213
	ζ=	29°·39		ζ=	186°·37		ζ=	85°·37		ζ=	41°·37
	H=	6·427		H=	0·973		H=	0·232		H=	0·198
	κ=	65°·09		κ=	96°·40		κ=	25°·41		κ=	243°·84
M_3	R=	0·034	P_1	R=	0·195	μ_2	R=	0·218	$(M_2K_1)_3$	R=	0·093
	ζ=	3°·78		ζ=	49°·79		ζ=	209°·75		ζ=	220°·85
	H=	0·033		H=	0·195		H=	0·202		H=	0·102
	κ=	237°·32		κ=	5°·61		κ=	281°·13		κ=	301°·65
M_4	R=	0·339	J_1	R=	0·023	R_2	R=	...	$(2M_2K_1)_3$	R=	0·042
	ζ=	324°·34		ζ=	143°·38		ζ=	...		ζ=	293°·57
	H=	0·315		H=	0·028		H=	...		H=	0·044
	κ=	35°·73		κ=	58°·60		κ=	...		κ=	319°·85

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·055	134°·59	0·049	3°·52
„ fortnightly „	0·067	156 ·79	0·107	33 ·68
Luni-solar „ „	0·069	105 ·00	0·067	69 ·31
Solar-annual „	0·713	12 ·37	0·713	146 ·54
„ semi-annual „	0·119	272 ·39	0·119	180 ·74

The mean level of the water (A_0) in 1884-85 is 13·588 feet above the zero of the gauge, which is the lowest value yet obtained.

The amplitude of the main lunar tide (M_2) is 6·427 feet which is higher than its value in former years. The epoch is 65°·09, or 2 minutes earlier than last year.

The main solar tide (S_2) is 2·700 feet in amplitude. In proportion to the main tide it is 0·420 or 4½ per cent. less than the theoretical value, 0·465. Last year it was also 0·420 of the main tide, and in former years it was slightly higher, but in no instance has it reached the theoretical proportion. The epoch is about 10 minutes earlier than last year.

The luni-solar semi-diurnal tide (K_2) is 0·151 of the main tide, or 2 per cent. greater than the theoretical value 0·127. The epoch is 96°·40, or nearly the same as it was in 1882-83.

Of the lunar elliptic tides, the smaller component (L_2) is 0·058 of the main tide, or twice as large as the theoretical value, 0·028 ; whilst the larger component (N_2) approaches the theoretical value, 0·194, being 0·186 of the main tide. These proportions agree very well with the values obtained in former years.

The lunar elliptic tide of the second order (2 N_2) is 0·032 of the main tide, or somewhat in excess of the theoretical value, 0·026.

The proportions of the two evectional tides(λ_2 and ν_2) are 0·028 and 0·036 of the main tide. According to theory they should be 0·007 and 0·038.

The variational tide (μ_2) is 0·031 against 0·024, the theoretical proportion. In the preceding year it was somewhat higher.

The proportions of the diurnal tides to the main tide are as follow :—

	Amherst, 1884-85.	Theoretical.
Luni-solar (K_1)	0·109	0·584
Lunar declinational (O_1)	0·052	0·415
Solar „ (P_1)	0·030	0·193
„ elliptic (Q_1)	0·003	0·080
Lunar „ (J_1)	0·004	0·033
„ (M_1)	0·006	0·036

Every year these tides have been found to be very much less than they should be by theory.

As regards the overtides, the lunar quarter-diurnal (M_4) and sexter-diurnal (M_6) are the largest, being 0·049 and 0·022 of the main tide, which are very near the former values; their epochs also agree very well with the previous determinations.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·047 of the main tide and is very close to the proportions obtained in former years. The epoch of this tide is again earlier than its preceding value.

The amplitudes of the other compound tides in proportion to the main tide are as follow :—

$(M_2K_1)_3$	0·016
$(2M_2K_1)_3$	0·007
$(M_2N)_4$	0·031
$(2SM)_2$	0·028

These values are very accordant with former results.

With regard to the long period tides, the lunar monthly is 0·008 of the main tide or about $\frac{1}{6}$ the theoretical value, 0·046 ; but this tide has always been small at this station. Its epoch is variable.

The lunar fortnightly tide is 0·017 of the main tide, theoretically it should be 0·086, but this tide also has always been found to be far below its theoretical value. Its epoch also is variable.

The luni-solar fortnightly tide is 0·010 of the main tide and is very accordant with last year's value, 0·008, and the theoretical value, 0·007. The epoch of this tide is also very irregular.

The solar-annual tide is 0·111 of the main tide. It is very accordant with the results obtained in former years. The epoch, 146°·54, agrees well with former values, with the exception of that obtained in 1882-83, which was 17 days earlier.

The solar semi-annual tide is 0·019 of the main tide. Theoretically it should be 0·040. The epoch of this tide also has always been irregular.

VALUES OF THE TIDAL CONSTANTS, AMHERST, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86, or sixth and final year's observations at Amherst; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations :—

Short Period Tides.

A_0=13·311 feet.

Tide	H = R =	κ = ζ =
S_1	0·131	121°·86
S_2	2·563	102°·09
S_4	0·075	107°·59
S_6	0·002	341°·57
S_8	0·003	244°·36

Tide	R =	ζ =	H =	κ =
M_1	0·052	266°·02	0·045	28°·99
M_2	6·652	291°·53	6·415	67°·26
M_3	0·033	56°·21	0·031	259°·81
M_4	0·293	120°·57	0·273	32°·03
M_6	0·169	201°·77	0·151	248°·96
M_8	0·026	56°·97	0·023	239°·89
O_1	0·252	254°·16	0·310	349°·30
K_1	0·653	321°·95	0·738	3°·88
K_2	0·566	207°·25	0·752	111°·49
P_1	0·212	56°·20	0·212	12°·27
J_1	0·037	74°·27	0·045	72°·50
Q_1	0·028	209°·69	0·035	347°·19
L_2	0·342	156°·57	0·314	78°·07
N_2	1·360	229°·57	1·312	47°·65
λ_2	0·224	322°·06	0·216	183°·97
ν_2	0·102	185°·51	0·099	55°·06
μ_2	0·350	21°·44	0·326	292°·90
R_2	0·174	283°·28	0·174	316°·23
T_2	0·352	291°·51	0·352	78°·55
$(MS)_4$	0·285	288°·41	0·275	64°·14
$(2SM)_2$	0·182	103°·64	0·176	327°·91
$2N_2$	0·179	200°·68	0·173	61°·11
$(M_2N)_4$	0·038	205°·64	0·035	159°·45
$(M_2K_1)_3$	0·112	170°·29	0·122	347°·95
$(2M_2K_1)_3$	0·035	83°·60	0·037	313°·14

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·007	332°·57	0·006	290°·22
,, fortnightly ,, ...	0·011	87 ·37	0·017	212 ·82
Luni-solar ,, ,, ...	0·071	81 ·98	0·068	306 ·24
Solar-annual ,, ...	0·886	332 ·61	0·886	105 ·54
,, semi-annual ,, ...	0·154	246 ·04	0·154	153 ·91

The value of the mean level of the water (A_0) as determined from this the final year's observations is 13·311 feet above the zero of the gauge. This is the lowest value at Amherst and the difference between it and the mean of the six years' results, 13·654, is about 4 inches. The highest value obtained in 1881-82 was 13·974.

The amplitude of the main lunar tide (M_2) is 6·415 feet which is very close to the highest value, 6·427 feet, obtained in 1884-85. The mean value is 6·320 feet or about an inch smaller. The epoch is very well determined, all the six years' values being very accordant; the mean value is 67°·4.

The main solar tide (S_2) is 0·400 of the main tide and is the smallest proportion obtained at this station for this tide; the mean value, 0·429, is 3½ per cent. less than the theoretical value, 0·465. The epoch is 102°·09 which agrees almost exactly with the mean value, 102°·03.

The luni-solar semi-diurnal tide (K_2) is 0·117 of the main tide; the mean value is 0·156 and the theoretical, 0·127. The epoch 111°·49 is the largest obtained, being 15° greater than last year's value which was almost identical with the mean, 96°·35.

Of the two lunar elliptic tides (L_2 and N_2) the smaller component (L_2) is 0·049 of the main tide, or nearly double the theoretical value; whilst the larger (N_2) is 0·205 or very close to the theoretical value, 0·194. The values have always been accordant and their means are 0·051 and 0·203 respectively. Their epochs are somewhat early this year.

The lunar elliptic tide of the second order ($2N_2$) is 0·027 of the main tide which is almost identical with the theoretical value 0·026. The values have been decreasing from the first year's value which was 0·052. The mean value is 0·039. The epoch is not at all regular.

The solar elliptic tides (R_2 and T_2) are 0·027 and 0·055 respectively of the main tide, the mean values being 0·035 and 0·068.

The proportions of the two evectional tides (λ_2 and ν_2) are 0034 and 0·015 respectively of the main tide. The mean values are 0·039 and 0·054 and the theoretical 0·007 and 0·038. The epoch of λ_2 is variable, but that of ν_2 is fairly regular.

The variational tide (μ_2) is 0·051 of the main tide. This tide has fluctuated from 0·031 to 0·071; the mean value is 0·045 or nearly double the theoretical proportion, 0·024.

The proportions of the diurnal tides to the main tide are as follow:—

		Amherst, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·115	0·584
Lunar declinational	(O_1)	·048	·415
Solar „	(P_1)	·033	·193
„ elliptic	(Q_1)	·005	·080
Lunar „	(J_1)	·007	·033
„	(M_1)	·007	·036

Thus it will be seen that the diurnal tides again have very small values in proportion to the main tide and the results are very accordant with all the former values.

With regard to the overtides, the lunar quarter-diurnal (M_4) is 0·043 of the main tide, which does not differ much from the mean, 0·052, and the sexter-diurnal (M_6) is 0·024 of the main tide which agrees very well with the mean, 0·021. The amplitudes of both these tides agree well with former values. The epochs of (M_4) show a gradual diminution year by year from 60°·3 to 32°·0 in 1885-86, and the epoch of (M_6) is well determined. The remaining overtides are as usual insignificant.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·043 of the main tide—a proportion which agrees well with former values, and the mean is 0·051. Its epoch has become earlier every year; in 1880-81 it was 90°·0 and this year it is 64°·1.

The proportions of the other compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·019
$(2M_2K_1)_3$	·006
$(M_2N)_4$	·005
$(2SM)_2$	·027

Throughout the observations at this station the compound tides with the exception of $(M_2 N)_4$ have been very accordant *inter se*. The proportion of $(M_2 N)_4$ to the main tide has varied between 0·053 in 1881-82 and 0·005 in 1885-86.

Regarding the long period tides, the lunar monthly is only 0·001 of the main tide instead of 0·046, the theoretical proportion, below which it has always remained. The mean value is 0·011. Its epoch is variable.

The lunar fortnightly tide is also insignificant in its proportion to the main tide, being only 0·003 instead of 0·086, the theoretical value, and the mean value is 0·013. Its epoch, also is irregular.

The luni-solar fortnightly tide is 0·011 of the main tide; the mean value 0·009 is almost the same as the theoretical value, 0·007. Its epoch also is very irregular.

The solar-annual tide is 0·138 of the main tide, the average being 0·119. Its epoch, 106°·5, is unusually early this year and does not accord well with the mean value, 136°·4.

The solar semi-annual tide is 0·024 of the main tide which agrees exactly with the mean of all the determinations, but is less than the theoretical value, 0·040. The epoch of this tide has not been well established.

Values of the Tidal Constants, Moulmein, 1885-86.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1885-86, or sixth and final year's observations at Moulmein; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1885-86 observations:—

Short Period Tides.

A_0=8·388 feet.

S_1	H = R =	0·074	M_6	R =	0·093	Q_1	R =	0·037	T_2	R =	0·264
	κ = ζ =	154°·09		ζ =	44°·71		ζ =	13°·70		ζ =	204°·76
S_2	H = R =	1·364		H =	0·084		H =	0·046		H =	0·264
	κ = ζ =	151°·41		κ =	218°·47		κ =	57°·33		κ =	100°·22
S_4	H = R =	0·073	M_8	R =	0·042	L_2	R =	0·338	$(MS)_4$	R =	0·742
	κ = ζ =	228°·02		ζ =	11°·34		ζ =	59°·56		ζ =	280°·05
S_6	H = R =	0·007		H =	0·036		H =	0·297		H =	0·715
	κ = ζ =	222°·05		κ =	123°·01		κ =	144°·17		κ =	217°·96
S_8	H = R =	0·000	O_1	R =	0·198	N_2	R =	0·739	$(2SM)_2$	R =	0·123
	κ = ζ =	198°·44		ζ =	49°·46		ζ =	122°·03		ζ =	338°·22
				H =	0·245		H =	0·713		H =	0·118
				κ =	53°·58		κ =	99°·45		κ =	40°·30
M_1	R =	0·026	K_1	R =	0·378	λ_2	R =	0·171	$2N_2$	R =	0·125
	ζ =	59°·22		ζ =	107°·71		ζ =	311°·04		ζ =	56°·63
	H =	0·026		H =	0·429		H =	0·165		H =	0·120
	κ =	71°·05		κ =	42°·60		κ =	170°·32		κ =	73°·56
M_2	R =	3·946	K_2	R =	0·231	ν_2	R =	0·344	$(M_2N)_4$	R =	0·093
	ζ =	177°·33		ζ =	108°·74		ζ =	247°·70		ζ =	88°·90
	H =	3·803		H =	0·309		H =	0·331		H =	0·086
	κ =	115°·25		κ =	158°·63		κ =	84°·25		κ =	4°·24
M_3	R =	0·030	P_1	R =	0·116	μ_2	R =	0·366	$(M_2K_1)_3$	R =	0·122
	ζ =	135°·14		ζ =	349°·93		ζ =	43°·24		ζ =	214°·60
	H =	0·028		H =	0·116		H =	0·339		H =	0·133
	κ =	42°·02		κ =	54°·42		κ =	279°·08		κ =	87°·40
M_4	R =	0·965	J_1	R =	0·012	R_2	R =	0·204	$(2M_2K_1)_3$	R =	0·105
	ζ =	300°·18		ζ =	177°·63		ζ =	147°·04		ζ =	119°·96
	H =	0·897		H =	0·015		H =	0·204		H =	0·111
	κ =	176°·01		κ =	71°·92		κ =	71°·57		κ =	60°·91

Long Period Tides.

	R	ζ	H	κ
Lunar monthly tide	0·417	41°·83	0·369	9°·33
,, fortnightly ,, ...	0·233	282 ·38	0·371	32 ·04
Luni-solar ,, ,, ...	1·103	343 ·21	1·063	45 ·30
Solar-annual ,, ...	2·128	125 ·19	2·128	150 ·71
,, semi-annual ,, ...	0·730	236 ·78	0·730	287 ·80

The mean level of the water (A_0) is 8·388 feet above the zero of the gauge. The average of six years is 8·507 feet.

The amplitude of the main lunar tide (M_2) is 3·803 feet, which agrees well with former values. The mean is 3·791 feet. Its epoch is well established, the average being 113°·6.

The main solar tide (S_2) is 1·364 feet in amplitude and is very accordant with former values and with the mean, 1·361. In its proportion to the main lunar tide it is only 0·359 instead of the theoretical value, 0·465. The epoch, 151°·4, is also very close to the former values and is slightly in excess of the mean, 149°·1.

The amplitude of the luni-solar semi-diurnal tide (K_2) is 0·309 of a foot, which is fairly accordant with previous values and with the mean, 0·327. Its proportion to the main tide is 0·081, the mean value being 0·086 and the theoretical, 0·127. Its epoch is well determined, its present year's value is 158°·6 and the mean 157°·6.

The smaller lunar elliptic tide (L_2) is 0·078 of the main tide, which is almost identical with the mean value, 0·079. The theoretical value is 0·028. The larger component (N_2) is 0·187, which closely approaches the theoretical value, 0·194. The average of six years' values is 0·177.

The lunar elliptic tide of the second order ($2N_2$) is 0·032, which is slightly in excess of the mean value, 0·025, and the theoretical value, 0·026.

The solar elliptic tides (R_2 and T_2) have been computed from the 1884-85 and 1885-86 observations. The smaller component (R_2) is 0·054 and the larger (T_2) is 0·069 of the main tide. The mean values are 0·039 and 0·055 respectively.

The two evectional tides (λ_2 and ν_2) are 0·043 and 0·087 of the main tide. They agree very well with the mean values, 0·043 and 0·072; but are very much higher than their theoretical values, 0·007 and 0·038, respectively.

The variational tide (μ_2) is 0·089 of the main tide. Theoretically it is only 0·024; but its values have always been very accordant, the average of the six years' determinations is 0·085.

The proportions of the diurnal tides to the main tide are as follow:—

		Moulmein, 1885-86.	Theoretical.
Luni-solar	(K_1)	0·113	0·584
Lunar declinational	(O_1)	0·064	0·415
Solar „	(P_1)	0·031	0·193
„ elliptic	(Q_1)	0·012	0·080
Lunar „	(J_1)	0·004	0·033
„	(M_1)	0·007	0·036

These tides have always had very small values and have been very accordant *inter se*.

Of the overtides, the lunar quarter-diurnal (M_4) is the most significant, being 23½ per cent. of the main tide. This proportion has been always obtained here. Its epoch is very well determined, this year's value is 176°·0 and the mean 172°·1.

The luni-solar quarter-diurnal tide $(MS)_4$ is 0·188 of the main tide, which is very close to the average value, 0·187. Its epoch is 218°·0, which accords well with former values and with the mean 213°·3.

The proportions of the other compound tides to the main tide are as follow:—

$(M_2K_1)_3$	0·035
$(2M_2K_1)_3$	0·029
$(M_2N)_4$	0·023
$(2SM)_2$	0·031

They agree well with all the values previously obtained.

The lunar monthly tide is 0·097 of the main tide, which is identical with the mean of the six years' determinations, but double the theoretical value 0·046· Its epoch is 9°·3, whilst the mean of the six years is 12°·5, but the values obtained during these years are rather variable.

The lunar fortnightly tide is 0·098 of the main tide, which is only slightly in excess of the mean value, 0·087, and the theoretical, 0·086. There has always been a fair agreement between the values of this tide; and its epoch is well determined.

The luni-solar fortnightly tide is 0·280 of the main tide, which agrees well with former values and with the mean value, 0·288; but theoretically it should only be 0·007. The epoch of this tide is well established, the mean value being 45°·0.

The solar-annual tide is 0·560 of the main tide, which is 5½ per cent. lower than the mean value, 0·615. The several years' values are not very accordant, but the epoch is well determined, its mean value being 148°·7.

The solar semi-annual tide is 0·192 of the main tide, which is much in excess of the theoretical value, 0·040; but this has always been found to be the case at Moulmein. Its epoch is fairly well determined, the mean value being 285°·9.

Memorandum by MAJOR A. W. BAIRD, R.E., F.R.S., *Deputy Superintendent, Survey of India, regarding certain tidal disturbances at the Head of the Bay of Bengal on the 11th March and 9th April 1885.*

The diagrams of the self-registering tide gauges at False Point and Dublat (Saugor Island), and at Diamond Harbour and Kidderpore (on the Hooghly), for the 11th March and 9th April 1885 shew unmistakably that considerable tidal disturbances took place on those dates at the stations named.

There are no irregularities to be found on the tidal diagrams at Port Blair for the dates specified; and as the depression or negative wave on the morning of the 11th March was of considerable magnitude (over 1 foot) and the elevation or positive wave on the night of the 8th or early morning of the 9th April was also very considerable, it would appear that the cause of the disturbance took place in the vicinity of False Point and Dublat.

Unfortunately there is no record of tidal registration at Vizagapatam on the above dates, as the observatory was removed to be set up at Cocanada after the completion of five years' work.

With regard to the disturbance of March 11th, it is evident that its effect was slightly felt at Dublat about 10-30 P.M. on the 10th March when it was almost low-water, and these slight disturbances continued all through the next rising tide, although they are not very marked; but about the time of high-water, a very considerable depression, amounting to at least 1·3 foot, occurred at 7-15 A.M. of the 11th March.

At Diamond Harbour the disturbance is only apparent by the very marked depression at 9-20 A.M. of the 11th March, and although the tidal curve on the afternoon of the 11th is obviously irregular, the tidal disturbances are not distinguishable as they are marked in the quick-rising normal tide.

At Kidderpore the effect of the disturbance is slightly apparent at 4-30 A.M. of the 11th, and again about 9-20 A.M., but the principal disturbance is seen at 0-15 P.M. of the 11th.

At False Point the tidal disturbance seems to have commenced at the low-water on the night of the 10th March, but the first marked feature is the great depression or negative wave at 5-30 A.M. of the 11th March; in magnitude it was about 1·2 feet.

Tabulating the time of arrival (in Calcutta time) of the lowest point of this depression we find it reached—

False-Point at 5-36 A.M., 11th March,
Dublat at 7-15 A.M., 11th March,
Diamond-Harbour at 9-20 A.M., 11th March,
Kidderpore at 0-10 P.M., 11th March.

The speed of this wave up the Hooghly was thus 2 hours and 5 minutes for the 38 miles between Dublat and Diamond Harbour, and 2 hours 50 minutes for the 42 miles between Diamond Harbour and Kidderpore.

The depression decreased in magnitude as it passed up the Hooghly from 16 inches nearly at Dublat to about 11 inches at Diamond Harbour, while at Kidderpore it was only about 2 or 2½ inches.

The magnitude of the depression at False Point and Dublat appears to be about the same, *viz.*, from 15 to 16 inches.

With regard to the tidal disturbances of the 9th April at Dublat the effect is first seen about 10-15 A.M. on the 8th April, but the principal feature is the very large rise—about 16 inches—at 11-50 P.M., and this followed by a fall of nearly the same magnitude about 1 A.M. of the 9th April.

At Diamond Harbour the disturbance is very marked at the low-water of the early morning of the 9th: the first great wave, equal to 2 feet in magnitude, reached Diamond Harbour at 1-30 A.M. of the 9th April.

The tidal disturbances at Kidderpore of the 9th April are almost precisely similar to those at Diamond Harbour; the crest of the first great wave reached Kidderpore at 4-5 A.M., and its magnitude was also about 2 feet.

It is very remarkable that this wave apparently increased in magnitude from Dublat to Diamond Harbour and did not decrease from Diamond Harbour to Kidderpore.

The tidal station at Dublat is on the east side of Saugor Island about 4 miles from the sea face: it seems reasonable to suppose that as the wave was greater at Diamond Harbour than at Dublat, it was generated either very much nearer Diamond Harbour than Dublat, or else that its direction of advance was straight up the Hooghly to Diamond Harbour.

The disturbance of the 9th April at False Point would appear to have commenced about 3 P.M. of the 8th and to have continued for at least 24 hours, the marked feature however is the wave at 11-55 P.M. [0-1 A.M., 9th, Calcutta time]; although its height was only some 3 or 4 inches, this wave obviously corresponds to that which arrived about the same time at Dublat—

The great wave arrived at False Point	at 0-1 A.M.,	9th	April	(Calcutta time).
Dublat	at 11-55 P.M.,	8th	,,	,,
Diamond Harbour . . .	at 1-30 A.M.,	9th	,,	,,
Kidderpore	at 4-5 A.M.,	9th	,,	,,

Thus the speed of the wave was 1 hour 35 minutes for the 38 miles between Dublat and Diamond Harbour, while it took 2 hours and 35 minutes to travel from Diamond Harbour to Kidderpore.

Comparing the speeds up the Hooghly of the waves of the 11th March and 9th April with that of the first great wave caused by the Krakatoa eruption, we find—

Negative wave of 11th March took	2 hours	& 5	minutes	for 38 miles from Dublat to Diamond Harbour.
Positive ,, 9th April .	1 ,,	& 35	,,	
,, for Krakatoa .	2 ,,	& 9	,,	
Negative wave of 11th March took	2 hours	50	minutes	for 42 miles from Diamond Harbour to Kidderpore.
Positive ,, 9th April ,,	2 ,,	35	,,	
,, Krakatoa . .	1 ,,	55	,,	

It is peculiar that the positive wave of the 9th April should have travelled much more quickly from Dublat to Diamond Harbour than the Krakatoa wave did, while from Diamond Harbour to Kidderpore the reverse was the case.

In the absence of information from a third station on the Bay of Bengal it is useless to attempt any elaborate calculations to determine the probable *locus* of the disturbance.

It would appear however as if a submarine depression caused the tidal disturbance of the 11th March, and that this was followed about a month later, *viz.*, the 9th April, by a submarine upheaval which caused a very considerable wave to pass up the Hooghly.

The chart of the soundings from the mouth of the Hooghly to False Point shew the depth of the water to be from 25 to 40 fathoms, and applying the table in "Airy's Tides and Waves, Encyclo. Met." it may be assumed that as the depression of the 11th March reached False Point about 1 hour and 40 minutes sooner than Dublat, that the *locus* of disturbance was about 80 miles nearer False Point than Dublat: whereas the positive wave of the 9th April having reached False Point and Dublat almost simultaneously, the *locus* of the disturbance might be supposed equally distant from both those places.

Taking the above into consideration with the fact of the very great wave at Diamond Harbour, while at Dublat it was less, it would almost seem as if the sub-marine upheaval took place at the Sand Heads opposite Balasore.

Upper Burma.

Extract from the Narrative Report of MAJOR J. R. HOBDAY *on the Survey Operations in the* NORTHERN SHAN STATES, *&c.—Season 1886-87.*

On the 7th November, I started with an expedition under Colonel Stedman to Thonzé in the Shan States, marching the first day to Tongbo. The following day we marched to Zibingalé, up a steep ascent to the Shan plateau, which has an elevation of 2,100 feet. It rained the whole way, and on arrival we found nearly the entire garrison, 190 odd out of a total of 200 including the commanding and medical officers, struck down with fever. It rained almost continuously for the four following days, compelling us to halt. On the 13th we continued our march to Sengaung, elevation 3,000 feet, and halted again on the 14th and 15th. On the 16th November we arrived at Pyin-ul-win, elevation 3,600 feet, where there is an open expanse on which now stands our most advanced post eastward from Mandalay. The minimum thermometer recorded 50° Fahr. at night. On the 17th we marched to Nyaungthakaw, elevation 3,500 feet, minimum thermometer recorded 45°. On the 18th we arrived at our destination, Thonzé, descending to an elevation of 2,000 feet. Here we found that the individual holding the place in the Myinzain's interest, by name Hein Se, had decamped to the neighbouring State of Mainlon. The town was strongly defended with stockades and outworks, moreover the river with its canals afforded additional strength. The whole position is surrounded with dense jungle, and one of the Goorkhas and a *khalási* of mine ran foul of some *panjis*, or bamboo spikes, which we afterwards found were widely scattered round the place, hidden in the grass. From the 19th to the 22nd I spent on my back, with as severe an attack of fever as Burma can produce and of which I had reminding recurrences at intervals of a fortnight or 3 weeks for 7 months afterwards.

Fortunately we were halted here till the 24th endeavouring, but without success, to bring the crafty Hein Se to terms. This enabled me to get on to my legs again. On the 22nd a deputation of Shans arrived on the scene from the Thibaw State, a wild motley crowd, armed with spears, matchlocks and what not.

We left Thonzé on the 24th and returned to Mandalay on the 28th by the same route. The advance was much impeded by numerous bogs, between Pyin-ul-win and Thonzé; moreover, most of the bridges crossing the streams had been distroyed and temporary structures had to be built to enable us to get along.

On the 8th January, I accompanied an expedition under Major Deshon, R.A., from Mandalay to the Shan State of Mainlon arriving at Lamaing on that day. From thence we continued to Zagabin, and Kaingyi, where we halted a day. On the 12th we marched to Taungdeik crossing the Madeya river and then ascending a very steep pass to the Shan plateau, elevation 2,600 feet. The edge of the plateau here is very distinctly defined by a long length of precipitous scarp, over which a very fine waterfall can be seen, close to the road. A good level track then brought us to Kalagwe, elevation 3,500 feet. From here the road or rather path leads down a steep pass to a valley, elevation 2,500 feet, and then crossing and recrossing a river some twenty or thirty times, we ascended by a steep climb to an elevation of 4,700 feet at Pazi, a small village on the crest of a high range which runs east and west. On the 15th we arrived at Mainlon, elevation 2,500 feet. Here we found a small body of troops had come down from the Ruby Mines, and after a small skirmish, had ejected the ruler a few days before our arrival, which was somewhat disappointing. Leaving a Sub-Surveyor with the column at Mainlon, I proceeded with the troops to the Ruby Mines, marching on the 17th January to Kyauktalon, along the valley of the Madeya river, where the road runs along the northern bank. On the 18th we marched into Mogok, the centre of the Ruby Mines district, elevation 4,100 feet, where I met Mr. Kennedy and Sub-Surveyor Faida Ali, who had accompanied the column from Kyan Nyat on the Irrawaddy. On the 25th I marched to Pyaungyaung, afterwards named Bernardmyo, elevation 6,000 feet, minimum thermometer registered 26° I returned to Mogok on the 27th January and proceeded the following day with a column under Major Skene of the Goorkhas by a new route to the Irrawaddy. On the 28th we reached Kathé, elevation 4,900 feet, beyond which the descent commences to Khabine (elevation 3,200 feet), and continues to Kinywa on the Kin Chaung, whence the road ascends to Shwenyaungbin, elevation 3,200 feet.

It then descends again to Nampan (elevation 2,800 feet) and Wapyudaung (elevation 1,700 feet). Thence the road runs level as far as Thabeit-Kyun on the banks of the Irrawaddy, which we reached on the 3rd February. Here I found a steam launch to take me to Kyaukmyaung and finally I got back to Mandalay on the 4th February.

The Ruby Mines are situated on a diamond-shaped plateau, of an elevation of from 4,000 to 5,000 feet; covering an area of about 18 square miles. There are lofty peaks to the north and east of the valley, the highest by name Taungmé rising to 7,800 feet. To the north-east, at the head of the valley, there is a long ridge running eastward for a distance of about 5 or 6 miles with an elevation of over 7,000 feet.

The mines are principally worked by a race called Maingthas, Chinese Shans, I believe, who come annually from the borders of Yunan to be employed by the local owners of the mines. At Bernardmyo there are one or two villages, peopled by a tribe called Leesaws or Kachins, I believe.

A very fine lake might be made at Bernardmyo by damming the narrow gorge which forms the outlet for the main drainage of the Engyauk valley. The hills at Bernardmyo have been considerably denuded of trees by the Leesaws and only have a growth of high coarse grass and bracken. The higher slopes, however, are clothed with evergreen forest. The soil is generally clay which necessitates the roads being paved in the swampy parts to render them practicable in the rainy season.

On the 26th February, I started with the escort accompanying the Tsawbwa of Thibaw to his capital in the Shan States after his month's residence at Mandalay. We reached Pyin-ul-win on the 2nd March and halted two days to make final preparations. From thence we marched to Bambwé (elevation 2,600 feet), Konsa (elevation 2,600 feet), Nammaw (elevation 3,300 feet), and Goteik (elevation 3,400 feet). Between Nammaw and Goteik we crossed a precipitous gorge forming the valley of the Namsan river.

The road leads from the plateau down a steep descent of 800 feet to a natural bridge of rock, about 600 feet in width, spanning the gorge, which here has perpendicular sides. On looking over the precipice, the river can be seen some 300 or 400 feet below, before it disappears under this natural bridge.

On our return journey, although the inhabitants tried to dissuade us, we endeavoured by a circuitous route to reach the orifice where the river disappears beneath the overlying sheet of rock, but after a long trudge to the bed of the river, at the junction of the Namsan and Nampan rivers, we still found ourselves some miles from our objective point, and after much wading and clambering over all kinds of obstacles, we were compelled to give up the attempt. From the bridge there is a very steep ascent of some 600 feet, the road being cut in steps on the face of the rock, and thus made practicable for pack animals and elephants.

A rude stone monument is erected on the bridge, to commemorate the work. A tablet on which there is Shan and Chinese writing, informs us that the road was made in 1862 by Chinese and Shan workmen, employed by the Tsawbwa of Thibaw and that it cost R20,000. From Goteik we marched to Pyaung-yaung (elevation 3,200 feet),—Kywegon (elevation 3,000 feet), Kinthi (elevation 2,000 feet), and Bawgyo (elevation 1,600 feet). Here we visited the salt wells, which are said to yield about 3½lb of salt per diem. The Tsawbwa receives half the earnings and the workers the other half. From Bawgyo, we followed the river Myit-nge, (or the Namtu as it is called in the Shan States) to Thibaw which we reached on the 14th March.

Half way between Bawgyo and Thibaw, we were met by a large retinue of officials and followers who joined the procession as we advanced. First of all came the heralds and pages, then the Tsawbwa and Mr. Bridges, the Political Officer, seated together on an elephant, followed by the queens on elephants; behind again the maids of honour on foot, who were joined by other women from the palace, decked with flowers and garlands. Then followed the troops mixed up with the populace who came out to greet us. The town of Thibaw was burnt and sacked during the Tsawbwa's absence by the Myinzain's adherents in 1886, but the palace, owing to some superstitious dread, was left untouched. The Tsawbwa, however, refuses any longer to live in it, and now resides in a bamboo palace constructed on a raft moored to the bank of the river Namtu, which flows past the town. We were all encamped on the bank close to this floating palace.

On the 19th March Captain Armitage, R.A., and I proceeded with a small party to Namyan on the south returning on the 22nd.

On the 23rd we visited Onbaung, the old capital of the Thibaw State, situated about 3 miles to the west of the present site. The position is an exceedingly strong one, surrounded by a high rampart and ditch. Some 300 years ago, a Tsawbwa of Onbaung became king of Ava, and on this account no Tsawbwa of Thibaw has been permitted since then by the Burmese Kings even to pass through Onbaung and the consequence is the place is deserted and covered with jungle. On the 29th Captain Armitage and I again started off, and reached Monglan to the east of Thibaw, elevation 2,500 feet, and from thence proceeded to Tati, on the main road to Lashio and Theinni. Here we were not allowed by the Tsawbwa's *Amat* or minister who accompanied us, to proceed across the river Namsan, as complications were feared with neighbouring States, so we retraced our steps to Monglan and proceeded in a southerly direction to Nammon, Hona (elevation 2,800 feet), Sounkye (3,000 feet) and Monkén. Here we halted to ascend Loikeu Hill (elevation 6,000 feet). On this hill we found villages inhabited by Taungshus. On 5th April we continued our route to Namlan, a large and prosperous village, and thence to

Simon, where we again met the Namtu river. Then we went to Onkok and returned to Thibaw on the 8th April. During my absence Sub-Surveyor Faida Ali was employed surveying to the north, but was not allowed to enter the neighbouring State of Taungbain, where tea is grown in great quantities by the Palungs who inhabit these hills.

On the 10th of April we commenced our return journey to Mandalay, Sub-Surveyor Faida Ali marching by an alternative route and meeting us again at Goteik on the 14th. From Nammaw, we marched across to Thonzé, and from thence to Sizon and Medaw (elevation 4,200 feet). Then to Nyaungthakaw and Pyin-ul-win, finally arriving at Mandalay on 25th April.

With the exception of the Goteik gorge we encountered no physical difficulties of any moment. Owing to recent disturbances the country appeared denuded of inhabitants who had migrated elsewhere. Deserted villages were numerous, and great difficulty was experienced in procuring supplies of any kind: the Shans are even more opposed to taking life of any kind than the Burmese, and it was almost impossible to procure fresh meat. Even at Thibaw, fowls and eggs had to be brought in from places some six marches distant.

The Shans I believe to be a peace-loving community and have only been incited to wage war one against another by the intriguing resident Burmese officials appointed from time to time by the Burmese Court. They are very fond of peddling and along every road one meets them hawking their wares. Every large village has its market day once or twice a week. They are grossly superstitious and given to exaggeration and they would infinitely sooner believe the profoundest falsehood than the truth.

Extract from the Narrative Report of LIEUTENANT H. M. JACKSON, R.E., *on the Survey Operations in the* SOUTHERN SHAN STATES,—*Season 1886-87.*

I started with one Sub-Surveyor and a Military Surveyor on the 30th of December from Myingyan on the Irrawaddy with some of the troops detailed for the "Southern Shan Column." We reached Hlaindet at the foot of the hills forming the lowest step or outer barrier of the Shan high-lands on the 10th of January. I was able to bring the triangulation up to these hills by observations from three very good stations *en route.* A road traverse was also carried on continuously, and some little detail work done about Mehtila and Hlaindet, where the military surveyor falling sick had to be left. At this latter place I took advantage of the delay caused by change of transport to ascend several of the frontier peaks in order to fix points to the front; but, owing to the thickness of the jungle and the confused formation of the hills, I was not very successful in this. However, I had to go on with the troops, and when we reached Myelat plateau, about 4,300 feet above sea-level, on the 28th, I found that, though I had not succeeded in a properly continuous triangulation, I had so many well-fixed points behind me within sight as to enable me to determine my position sufficiently well to carry on detail survey and triangulation to be afterwards connected. On the plateau above mentioned, a post was established at Pwehla and the column remained there until the 5th of February. One expedition, which I accompanied, was made about 20 miles to the north along the western skirt of the Taungmengyi, the backbone of the plateau, in which the older rocks first crop up. The Pwehla plateau or Myelat (as the district is called which holds this confederation of small States, of which Pwehla and Thamakan to the south are the chief) is a high tableland enclosed by limestone crags; its surface of red clayey soil broken up into low rounded hills, some bare, some covered with coarse grass. Most of it has been under cultivation apparently; and doubtless, when the country has quieted down, will be so again. Here and there in sheltered gullies or on hill sides less exposed to the west wind are clumps of bamboos; and on the higher parts the first pines are met with. These seem very much the same as the *chir* of the Himalayas. A little rice is grown in the bottoms; but most of the cultivation is dry and almost entirely in the hands of the Taungnus or Taungzus, a separate though nearly allied race to the Shans. They are swarthier, of more generally Mongolian physiognomy than the latter. Their women wear a peculiar dress. They are mostly industrious cultivators; whereas the Shan prefers wandering about the country with his pack bullocks, plundering his neighbours, or smoking, chewing and bragging, to any thing like steady work. The climate on the plateau was all that could be wished in January—almost too cold at night. From Pwehla we descended to the Heho valley, a bare kind of raised basin, drained mainly by one large stream into the Nyaungywe valley below. At a *zayát* by the side of the main river of the valley, we were met by the Nyaungywe Tsawbwa whose rescue from his enemies was one of the ostensible reasons for the expedition. The next day was spent in reconnoitring the said enemy's position and the same night and following day in circumventing and driving them away. After a few days' halt at the capital, Nyaungywe, about 8 miles to the south, a straggling village, built along the river, remarkable only for the brick "palace" of the Tsawbwa, we proceeded to the site chosen for the residence of the Commissioner, and the post now known as Fort Stedman, which is above the village of Maingsauk on the lower spurs of the hills forming the eastern side of the Inle Lake. The Balu Chaung—the river draining the upper parts of the valley —flows through the lake which is merely a shallow basin of some nine by two miles of clear water with sedgy edges, running into long stretches of marsh land at both ends. The villages round are many of them built out on piles over the water, their gardens being masses of floating grass secured by long bamboos driven through into the bottom. The lake people (who rarely leave the valley) lead an almost entirely aquatic life. The children, as soon as they can stand, learn to propel a big "dug out" after the manner of their fathers, standing on one leg and working with the other, the long paddle held like a leaping pole. The lake is full of many kinds of coarse fish, and in the winter months is covered with water-fowl. Its height above sea-level is about 3,000 feet, its depth is generally very uniform, on an average 6 feet, but in a few places 11 or 12 feet is attained. The water is beautifully clear, the bottom being covered by about 2 feet, of bright green weed. From the western side, draining the Pwehla plateau the Paungdaw river enters in an eccentric manner peculiar to Shan rivers through half a mile of limestone rock instead of by its natural bed. The entrance of the tunnel is a high archway in a sheer cliff of limestone and about 150 feet below the general surface of the ground; the exit is just large enough for the passage of the water. In its passage the river or part of it is, as can be plainly heard and indeed seen in places, running just below the surface of its former bed. Many feeders fall into the lake from the eastern hills; but, these are of no great length of course. Having worked the triangulation round about this valley, as far as the constant haze would admit, and put in some detail survey, I started with a boat expedition down the Paungdaw river towards Mobye. I was enabled to time the boat past measured distances on the lake so as to plot our course *en route* by a time traverse. This I checked by observations for latitude at two places (one of which was our turning point) and by back bearings; as our course was nearly due south, I think the results are fairly correct. The farthest point made was Peyakon, a former Burmese post. Here we found the Mobye Tsawbwa a well meaning but extremely garrulous old man, who received us in a very friendly way. He seems to have abandoned his ancient capital of Mobye in favour of this place, where he can cultivate his fields in peace without being troubled by the Red Karens. These children of the forest have a very bad character in these parts from their kidnapping and generally thieving proclivities; and, from the specimens we saw at Peyakon, we were not inclined to doubt this reputation. The river, 20 to 30 yards broad, runs between parallel hills on either side, whose spurs often jut out over it; there is only one place where it is too shallow for laden boats, and only one portage has to be made between the lake and Peyakon, a distance of 80 miles; about 10 miles beyond Mobye this river disappears underground in a kind of swamp, they say. The villages along the bank are frequent and many flourishing, especially Saga and Nantók, which are capitals of semi-independent petty States. Many smaller villages had been recently burnt by raiders from the hills when we passed. We returned to Fort Stedman by the same route. I found that my Sub-Surveyor had completed a good deal of detail survey, chiefly round the edges of the lake; but the necessity of going about in a narrow "dug out" and the impossibility of setting up the plane-table steadily on the half floating shore prevented rapid progress. The main body of the column now returned to Burma; and the remainder began to prepare for a look round at their neighbours. The Yatsauk Tsawbwa, our former foe who was driven from Nayaungywe territory, was also to be moved on. I started for this trip three days in advance for triangulating purposes to north and east. Our course was to be north to Yatsauk and then east to Maingpyin, thence south into the Hopon valley just to the east of the Nyaungywe valley. We made first for Pwehla before mentioned, thence to Pindya. From Pwehla to Pindya one crosses part of the watershed of the north and south running rivers, down into the valley of the first large north running stream, the Zawgyi, which rises near Pindya. This town, one of the most flourishing in these parts, lies on the edge of a small lake under the eastern skirts of the Taungmengyi about 4,000 feet above sea-level. This whole region is metalliferous. Bauzain to the south-east of Pindya, is the chief mining place at present. There lead and silver are worked but, apparently, to no great profit. Coal is also found under the Taungmengyi to the north on the western slopes, as also just below the plateau, in the Panlang valley at Min Kalaung. Specimens were obtained and burnt of this latter; but they were weather worn blocks, and so hardly gave a fair test; they appeared, however, wanting in bituminous constituents. I was unable to carry the triangulation along to Yatsauk and Maingpyin on account of the nature of the country passed through, comprising low-lying jungle covered hills, and to the hurried mode of our march which was necessary in order to surprise the Yatsauk Tsawbwa in his stronghold; but I carried on a traverse by compass, which was checked by observations for latitude at Yatsauk and an azimuth connected with a high peak of the Taungmengyi previously fixed from the west.

The rest of this work was similarly done until I got in the Hopon valley on to points intersected from the east wall of the Nyaungywe valley. I found my traverse fairly correct. We just missed the Yatsauk Tsawbwa, so after a short halt in his town (height above sea-level about 3,280) a straggling village on the Zawgyi river protected by a once strong fort built with brick wall and deep ditch on a small hill partly encircled by a natural moat, we proceeded across the river and a low range of hills to Maingpyin. Maingpyin seems to have suffered a good deal in recent disturbances and is now almost deserted, as are all the villages to the south of it, until the higher Hopon valley is reached by a gradual ascent through a very good pass between broken hills. I mapped the upper portion of the valley of the Tabet river around our camp at Hopon, and fixed some points for extension of triangulation on the Loisang range bounding the east of this valley. The Hopon valley here is fairly open and well irrigated naturally and artificially. It has evidently once borne a considerable cultivation; but recent raids by neighbouring chiefs and the requisitions of the "Limbin" Prince have stopped this and driven the people from their villages. The river Tabet Chaung is fed by several streams running underground from the higher hills to the east through tunnels in the limestone and emerging close to the centre of the valley near Hopon village under small craggy promontories. From the west and north the tributaries are fewer and small, being ordinary streams. The hills separating the Balu Chaung and Tabet valleys rise in the outlying peak of Myinmati to 6,600 feet. Those between the Tabet and Pon valleys to the east reach 7,500 feet. From Hopon we crossed the Loisang nearly east to Mainpon, a large village on the Pon river. The Tsawbwa was found engaged in hostilities with his neighbours of Legya. He was, in fact, in a state of siege; but, as the combatants had been for some weeks entrenched behind basket-work stockades continually firing away at each other, and the only acknowledged casualty was one messenger who was not personally interested in the proceedings, it may be imagined the affair was not serious. In fact, a little persuasion from the Assistant Commissioner and a square meal from the besieged induced the besiegers to depart without further ado. Mainpon is a flourishing little state; the fields below the town are cleverly irrigated by large bamboo water-wheels worked by the river. The Tsawbwa appears a very intelligent and energetic man and something of a sportsman: unlike most royalty in these parts he heads his army in the field. The Pon river rising some distance to the north in Legya, runs at first due north according to reliable accounts, then turning in a sharp curve makes south, enters the Mainpon valley from the north-west, and thence runs due south to form like the Thein and Ben rivers to the east, one of the principal tributaries of the Salween. From the Loihan hills bounding the east of this valley I did my best to throw cut points for triangulation to the east and south, and I mapped the country round about the town and neighbourhood. The main body of the expedition then started back to Fort Stedman. The remainder, *viz.*, an officer and 50 men of the 27th P. I. accompanied by a medical officer, the Assistant Commissioner and myself, proceeded across the Loihan towards Mone to secure the person of the Limbin Prince.

The descent from the pass to the village of Banpien was very steep, over smooth clay; in wet weather it is impracticable even for Shan pack bullocks. From Banpien on the Kong river we made due east across flat open country at first, and then through low rocky hills to Hepet. Fever prevented me from doing more than a very rough traverse *en route*, but I found myself there close to points fixed from the Loihan. From Hepet the road to Mone leads south straight down along the banks of the Namtwan river, through a narrow valley bounded by jungle-covered hills. Except in one place about half-way, where there are some rice-fields, there is no cultivation nor any village after leaving the neighbourhood of Hepet. Arrived in Mone we encamped under a large fig tree in the town. Little notice was taken of our arrival, though we came with the brother-in-law of the Tsawbwa who had been our *chaperone* for some time. There was no ill-feeling, however, and the ruling prince subsequently made himself as agreeable as his circumstances admitted. The people looked sickly and hungry. Here finding my work rather adrift, I measured a temporary base and made careful observations for azimuth and latitude and proceeded with a temporary independent triangulation. This rather prevented any detail work. Mone was apparently once a large and flourishing town but has now fallen into decay partly from continual disturbances, partly from the unhealthiness of its situation increased by the lapse of former rice-lands into wet waste. It is built on the side of a large marsh formed by the Namtwan and its affluents. On three sides of the town the spurs of the hills shut it in closely. The remains of the encircling walls however and several large pagodas bear witness to a more prosperous past. Evidence being accentuated by the present dirty squalid state of the bamboo houses, and the very unpalatial nature of the "palace." Here one is amidst a tropical vegetation again, cocoa palms have taken the place of pines and the voice of the *taktu* is heard in the land. The Tsawbwa of Mone is certainly the best-bred man we have met in the Shan country; he is of weak health however, and so relegates most of the practical business of his realm to the brother-in-law abovementioned. With two others of our party I travelled to Maukme which lies to the south about 24 miles—long miles to cover in one march as we did. The road leads up and through the hills on a fairly good line until the Maukme valley is sighted. Here one descends rapidly by a zig-zag into the rice-flats below.

We were received a mile outside the town by the "Pillars of the State" accompanied by a motley crew of variously armed warriors and thence escorted with all the barbaric honours of drum gong, cymbal and other instruments of music to the quartres prepared for us in a *zayát* at the further end of the town. We passed through the one long street of the town (nearly a mile long), the cause of much apparent wonder, and when we reached our lodgings our admirers were constant and untiring; however, they only looked. I could only hope for single rays or very acute intersections on any points near Maukme so I proceeded at once to observe for latitude. The next day I got in the general topography of the valley, and fixed peaks from a base measured on a long plain which I hoped to connect subsequently with Mone. The Tsawbwa paid us a visit in state during the course of the day. He was gorgeous in the extreme; he is a mere lad, but sufficiently at home on his throne. His ministers are very old men, wrinkled and grizzled by the cares of State. There was a somewhat Burmese air of luxury and show about this court. The Tsawbwa's gilded chariot too with six men in the shafts and others holding golden umbrellas over and round about him, showed a condition of luxury unlike anything we had previously seen. In the afternoon, whilst I was working about the valley, the others returned the Tsawbwa's visit. They were received and entertained in the presence of the old king who lay embalmed in state, surrounded by his widows attentively fanning the flies away from his late royalty. Under the bier a musical box discoursed popular airs, and helped to make things cheerful. My observations this night were interrupted by heavy rain. The next day at daylight we started back to Mone by the same road. Maukme is decidedly the most flourishing State we have seen, and the town the largest and most populous, and apparently the richest in this part of the country. The whole broad, flat valley is irrigated by many large channels and every available piece of ground is cultivated. The vegetation of the valley is more distinctly tropical than that of Mone. The river on which the town is built is called the Namyon; it comes in from the north-west and must carry down a considerable quantity of water.

Having returned to Mone and the arrangements for the transport of the Limbin Prince being complete, we started back westward after a final entertainment of tea and cheroots at the palace on which occasion the State geographer displayed a most excellent map of the Shan States in the style of that country. We left Mone by a road leading out over a low pass in the hills to the north-west. As soon as the Namtwan valley is left, a sandy, hilly country is reached, where the pine is again the most frequent tree. Crossing this tract the road leads due west into Mainzaik territory and a fairly cultivated valley. This is the valley that we crossed to the north at Banpien. On our way I tried to connect my Mone triangulation with some of my more western points; but, rainy weather having set in, I was not completely successful. The result was sufficient, however, to connect the mapping. Mainzaik appears a well (rice-) fed place; but I had not time to see much of it. Hence we ascended by a very steep road in very bad weather to a camping ground at the top of the Loihan. Unfortunately, at this camp I was just on the wrong side of a deep valley to get at one of my observed points.

The next day we descended into the Pon valley and camped near a small village some 3 miles down across the Pon river, which is about 50 yards broad and up to a horse's belly at the ford. From this the road continues about 4 miles down the valley, which is here very narrow and tortuous, the hills having a steep descent close to the river. The ascent of the Loisang, which is there steep and long, was made to a neck on the south of the highest peak of the range. We camped at a village some way down the other side, and next day reached and passed through Banyin at the foot of the hills, camping on the Tabet Chaung which is here broad and too deep to ford. The morrow we crossed the river on rafts and I was able to complete some plane-table work *en route*, though I had not time to fix or name all the villages that line the banks of the river in this part. After one night's halt on the skirt of the hill, we crossed by the pass below Myinmati Peak (which I again ascended *en route*), and eventually reached Fort Stedman. I had been ill for some time past and I had to lie up on return to this place. When I had sufficiently recovered I began my return journey to the plains.

At Pwehla I picked up the Sub-Surveyor who I found had done some very careful detail work round this place, where I had left him on our march to Yatsauk. From this I proceeded slowly patching up my imperfect triangulation to Hlaindet, whence I again ascended the highest of the frontier peaks near Eupa, cleared several long rays through the trees and succeeded in fairly well establishing my through connection. From Hlaindet the Sub-Surveyor and I proceeded with a road traverse along the foot of the hills from which these hills were sketched in as far as Thabyedaung. I was able also on the way to connect my southern triangulation directly with that of Captain Hobday's brought from Mandalay. We reached Mandalay on June the 22nd.

Report on the Survey of OLD PAGAN, UPPER BURMA, *by* LIEUTENANT H. M. JACKSON, R.E.

The city of Pagan seems to have been of considerable extent, as evidenced by the remains of the wall and ditch encircling it. Nothing, of course, now remains of the ordinary buildings of this city; they were presumably, like those of other cities of former and present times in these parts, built of perishable material. There is no doubt, I believe, that the city formerly extended further to the westward, where the river now runs, and part of it was probably on an island called, according to my guide, Nagamanda. It is easy to see that round the promontory on which the village of Nyaungu now stands, the river may have, and probably has, run a very different course not many years ago. The pagoda called Singyigôn, the furthest big pagoda to the north, appears to be still the most ornate. The gilding is well kept up; and, when I saw it on a festival day, crowds of people were praying round, and gorgeous tapestries decorated it from spire to basement. It is said to be, according to my informant, the oldest of all the pagodas, and to have been built by a king called Natha (?) 500 years ago. The Ananda pagoda, which is also still well kept up, is of entirely different design to the others. Its plan is in the form of a cross, on each arm of which is a kind of chapel, where, rising from floor to roof, his legs only visible from the entrance, a gigantic *Gotama* (saint) in gilded *bas-relief* presides. These figures are very conventional. The *tout ensemble* of this pagoda, especially when it is viewed from some little distance, is far better than that of any other. The pagoda itself is in good repair, though the enclosure walls are beginning to decay. It was, I am told, built by a king named Chaya (?) 300 years ago.

I could only spare one day at Old Pagan; so in the afternoon I walked out to the furthest large pagoda to the south, the Pailonjaw. This is of circular plan; it is of red brick and merely a massive ruin now encircled, as to the tiers of the dome, with green moss. The design is good, and it must have been a grand temple in its day. Standing on slightly rising ground and backed by the hills, it seemed, as the last rays of the setting sun rested on it, a worthy witness of the greater past.

These three pagodas that I have mentioned are, I think, the principal large pagodas existing; as to the others they are of various sizes and shapes, but two designs seem chiefly to predominate. I gathered that the smaller pagodas, none of which are kept in repair, are all of later date than the big ones I have described. This seems probable in a climate in which the permanence of a brick-building simply depends upon the state of the coating of cement or plaster outside it, though they bear an appearance of greater antiquity.

From the remains of (probably) the side of a gateway of the ancient walls, a fairly high mound from which most of the country round can be seen, I tried to find some idea of former arrangement in the confused mass of ruins on all sides, but unsuccessfully; and from the map it is evident that none existed, at least at the time the place was deserted. This latter event, according to my guide, occurred 180 years ago; but this is evidently absurd: however, I give his statement as a datum from which (for I presume the real date is approximately known) his other dates may be proportionally corrected. The town had existed for 400 years according to this man; and as to the reason for the fact of such a collection of pagodas, he told me a story to the effect that a king named "Noatamin" brought a very holy *pongyi* (priest) from China, and that in fulfilment of some oath or agreement, wherever the elephant which was ridden by the *pongyi* stopped and knelt down, there was to be built a pagoda. Apparently the elephant had a way of doing this; and, as he could not be expected to possess an eye for architectural arrangement, this legend also accounts quite satisfactorily for the lack of this quality in the building resulting.

I tried to interview the prince who still resides in Pagan in order to obtain some more reliable information. He belonged to the last semi-independent dynasty of Pagan, the members of which were turned into "pagoda slaves" by the conquerors. He is no doubt the man who knows most about Old Pagan; but, though through the Deputy Commissioner he had promised to come, he failed to put in an appearance, and I had not time to go to him. The names of the pagodas, &c., were all written down on the spot by this guide who was kindly deputed by Captain Eyre, Deputy Commissioner, for the purpose; they at least are correct.

Extract from the Narrative Report of COLONEL R. G. WOODTHORPE, R.E., *on the Survey Operations in the* KUBO VALLEY, &C.,—*Season 1886-87.*

I will now proceed to a brief narrative of our proceedings during the season. We reached Manipur on the 8th December and remained till the 13th, when, having made all arrangements for guides, small Manipuri guards and supplies, we separated, Mr. Ogle going to Sanaching H. S. and I to Munoi H. S. On the way Mr. Ogle started Bapu Jadu at his work. Mr. Ogle soon had Sanaching, Manchinbung and Kamong stations ready, and having observed to them from Munoi I went on to Tammu *viâ* Yangopopi *thana.* I reached Tammu on the 21st December and halted next day to pay up and discharge Manipuri guard and guides and fix the position of Tammu. On the 23rd I took the coolies up to a hill, Laiching, about 3 miles north of Tammu which afforded a good station and began to clear it. I was joined here by Mr. Ogle, and on the 25th we returned to Tammu to eat our Christmas dinner with the officers there—Major Dyce, D. A. A. G., North-East Frontier, Lieutenant Berkeley, 44th Regiment, G. L. I., Dr. Younan and Mr. Mitchel, a young C. E. in charge of the new cart-road between Manipur and Tammu. General Gordon, Commanding the North-East Frontier, had gone on to Kendat. On the 28th we again separated, Mr. Ogle returning to Munoi and Laiching to observe, while I went on to Auktaung, where I found Captain Stevens, who arranged for me to go to a high point above Kampa, which I intended to make our next forward station. As I wished to see General Gordon, who was to return on the 2nd January, I employed myself in the meantime in putting up crow's nests in a couple of lofty trees, one at Auktaung the other on a low range 3 miles to the east, from these I was able to fix my positions and do some topography. The General returned on the 3rd and I had a long talk with him about our work. Nothing had been settled then about the Kubo question, and he and Captain Raikes, Deputy Commissioner, Chindwin, were anxious that our operations should not include clearing some peaks on the Angoching range, where we had hoped to make stations, from which to extend our triangulation eastward. They thought that the suspicions of the Thaungdut Sawbwa would be aroused and that he would mistake our marks for boundary pillars. We eventually got a couple of points lower down on the range out of Thaungdut territory, but our work would have been a little better had we been able to clear the peaks we had first decided on. As there was no objection to my going to the peak above Kampa, I started on the 4th reaching the village in the afternoon. It had lately been visited by Chins who had utterly destroyed it; nothing but a few charred sticks remained of what had been rather a fine village. Dead half burnt buffaloes lay in unexpected corners, or in the jungle, poisoning the atmosphere, and I was glad to get away next morning. We did not reach the peak that day, but on the 6th I succeeded in finding it. There was not much clearing to be done, and it turned out an excellent and most useful point. It overlooks the whole of the Kubo valley on one side and on the other Kendat and a long stretch of the Chindwin. On the 12th I returned to Tammu having done all I could in the southern portion of the valley. At Tammu I again picked up Mr. Ogle, who had been doing some good work, and together we went to one of the points on the Angoching range already alluded to, returning to Tammu on 17th; on the 18th I took the opportunity of the return of some influential refugees from Kendat to their houses to send Bapu Jadu with them in boats down the Yu river to Kendat. He surveyed the whole of the stream with the subtense instrument and made a valuable addition to our maps. On the 21st Mr. Ogle left for Auktaung to survey the country between that place and Kendat by a road called the Minthami route and to do some more triangulation.

The 22nd was too wet a day to move, but on the 23rd I started with the General by the Sweja route for Auktaung on the Chindwin, which we reached on the 25th. Here we met Lieutenant H. Daly, Political Officer in charge of the Lekayain district, a very able and zealous young officer, whose head-quarters were at Poungbyin, and with him I started for Poungbyin. On the 26th we stopped for the night at a place called Kaia, and here cholera broke out among my coolies. Mr. Mitchel had had cholera among his Naga coolies while at work on the Sweja route; we stopped at one of his camps for the night, and must have picked up the disease there. The first case occurred at 8 P.M. just as we were going to dinner. Mr. Daly sent to the priests, who kindly placed one of their small houses at our disposal so as to remove the sick man from his fellows; the native doctor and I remained with him till 12, and just as I was going to sleep, a man lying immediately under that portion of the raised floor where my bed was, began to groan. Getting up, I found he also had been seized and I removed him to the *ziát* where the other poor fellow was lying. The doctor and I again did what we could till 2 A.M., without success. At 6 A.M. a third man was seized. The first two died in the early morning, the third lingered till the afternoon; a sepoy was also seized in the morning and we sent him up by boat with the sick coolies and the doctor to Poungbyin. All the arrangements for the dead and sick delayed us, and as we had a long march of 23 miles, a good deal of it through slush and mud, we did not get in till very late. The next day we halted to let the native doctor join us and to rest the coolies. Poungbyin is a largish village on the Chindwin, 70 miles above Kendat, and on the opposite bank is a large marsh and lake where wild fowl of all kinds literally swarm. Subadar Hema Chand, of the 44th G. L. I., stationed at Poungbyin, used frequently to go out for a comple of hours of an afternoon and return with a couple of geese, six or seven ducks of various kinds, not to mention snipe and such small game. He is a great shot either with gun or rifle; and somewhat rare for a native—brings down birds on the wing as easily as when sitting. On the 29th Mr. Daly and I with a guard of 50 men of the 44th under Hema Chand, started on a trip to the Uyu river; we marched up to Homalin by land, returning by river in boats, paying a short visit to the Tsawbwa of Thaungdut on our way down. He was very friendly and said we might explore any part of his dominions. On our return to Poungbyin on the 7th, we found that the place had been attacked two days previously and part of the village burned before the garrison under Captain Boileau succeeded in driving them off. The Berthon boat which I had with me on my trip to the Irrawaddy in 1885 was sent down to me with my Khasia coolies from Shillong where I had left it when I went to Gilgit, and it proved most useful on the Chindwin. It is easily carried by one coolie. I sculled myself nearly the whole of the 70 miles between Homalin and Poungbyin, and I was able to explore small creeks on the way, and going ahead could look about for good plane-table stations before the heavier boat, in which were my *khalásis* and plane-table, came up and thus time was saved. I had intended after this trip to have gone down to Kendat, but rumours of dacoits being in the neighbourhood induced Mr. Daly to organise two more little excursions eastward in the hope of catching some of them; and although we were disappointed in this, I was enabled to do a good deal of work. I finally reached Kendat on the 27th February where I found Mr. Ogle who had made all arrangements for commencing the triangulation of the Chindwin.

On the 1st March Mr. Ogle went down with Bapu Jadu to a point we had fixed a few miles down the river and pointed out the hills ahead which the *bábu* was to clear, and on the 2nd, having got all his men and boats together and a guard of the 6th B. L. I., he started off down stream, while Mr. Ogle went back to a station on the Minthami route to observe some necessary angles. Till the 6th I was employed at office work with the writer, and in advising about the curtailment of the stockade which was far too large for the garrison intended to be left there. On the 6th I left with Colonel Toker and Captain Raikes in a steam launch for Mingin, in which district a rebellion had just occurred, and there seemed a chance of being able to move about with the troops. However, this rebellion had collapsed and the leader, Budayaza, had been captured before we reached Mingin, and so I returned with Captain Raikes to Kaléwa. Thence he despatched messengers with presents to the Tsawbwa of Kale, whom he had been trying for some time to induce to make his submission. The message was to the effect that he and I, being now in the neighbourhood, would pay him a visit, if agreeable to him. Kaléwa is situated at the junction of the Myittha (the Manipur river) with the Chindwin, and is the port of the Kalé country. In consequence of the disturbances in the Mingin district, the Kendat authorities recalled Bapu Jadu, and finding that both he and Mr. Ogle were detained idling at Kendat, I asked Captain Raikes to employ the few days we had to wait for the answer from Kalé in taking me up to Kendat and starting the triangulation again. This, with his usual readiness to oblige, he agreed to, and once more work was resumed. It was now getting very hot and all the hill sides were wreathed in flames from jungle fires, the smoke from which rendered the atmosphere very dense, and greatly hindered our work henceforth. Through no fault of ours whatever we were just a month too late for the triangulation.

The country to the east of the Chindwin above and about Kendat consists of a confused mass of low hills, or table-lands, intersected by numerous ravines and water courses and enclosing small flat cultivated valleys. The only possible way of surveying this country is to traverse the small streams and village paths. These hills and plateaux seldom obtain a height of 500 feet above the general level of the plain, and are all of such an uniform elevation that it is of no use to make clearings for plane-table work. Below Kaléwa also, the country through which the Chindwin flows is so low, or broken up into such a confusion of low hills, that little or no topography could be done from any of our trigonometrical stations, and, as I before stated, military considerations prevented our leaving the river banks for any distance.

Kaléwa is very prettily situated on an elevated tongue of land between the Myittha and the Chindwin. The one street of the village runs along the ridge, gradually rising to a commanding eminence crowned with numerous graceful pagodas, idol houses and *ziáts*. Here the sepoys lived and I also had a *ziát* to dwell in—a nice airy building overhanging the river far below. The whole of the platform is of brick and formed a perfectly firm foundation for the theodolite in taking observations for latitude, and here I obtained the best results. Each pagoda spire is crowned with the usual *hti*, or gilt umbrella, with nine small bells attached to each; at night when a gentle breeze plays over the hill, the air is full of sweet sound, which rises and falls with beautiful effect. Often I lay awake at night listening with pleasure to these innumerable fairy tinklings high overhead, which mingled with my dreams when at last I slept. Around Kaléwa rise high peaks sloping to the south and east, but falling in abrupt precipices to the north. At night we could see the jungle fires creeping like snakes in long undulating lines up these steep slopes. I asked Captain Raikes' Burmese servant, how these fires originated. He said "at this time of the year the ground is covered with dead leaves and dry grass, rocks roll from above on to others below and strike sparks which set light to the inflammable dry vegetation." We were inclined to pooh-pooh this explanation at first, but further questioning of other entirely independent witnesses, always elicited the same reply.

When we went up to Kendat I had left instructions with my *chaprássi*, Jhanu, to go up to a conspicuous point about 3 miles from Kendat and 2,400 feet above it, and put up a mark; on my return I found he had not done so. He had started with the intention of getting up, but the day was hot and the climb a stiff one, and the guide took them by an unnecessarily roundabout route, probably from not clearly understanding where he was wanted to go. We could get no regular interpreters on the Chindwin; those we had brought from Manipur insisted on returning from Kendat, and after that we had to trust to any sepoy or frontier policeman who might have picked up a little Burmese. Captain Raikes kindly helped us with a man occasionally, but he himself was very short-handed and could not often spare him. To return—the sepoys were disgusted at having to climb hills, being principally long Pandis of the 16th and they dawdled and sat down frequently, saying they were not built to climb hills, and when Jhanu remonstrated and said if I had been there they would have been up in half the time, they replied irreverently "Bosh! Is he a bird to fly up this confounded hill?" And so Jhanu came back with his work undone. I therefore, on the night of our return to Kaléwa, requested the *subadár* commanding our 16th escort, a very nice gentlemanly man, to pick me out a few good walkers and we started next day at daybreak; crossing the Myittha took us some time and we left the opposite bank at 7 A.M. It was intensely hot, the slopes were very steep and covered with dry leaves and grass, slippery to a degree. The range is quite precipitous to the north and slopes at an average of 40° to the south, the ridge being a mere knife edge barely wide enough for foot hold; indeed where we put up the mark, we could not keep a footing till a little earth platform had been built up. We reached the top at 9·45 and flashed down to Kaléwa, to the intense astonishment of the sepoys who had gone with Jhanu. An idea of the steepness of the hillside may be formed when I say that when I had my lunch, a hole had to be dug for me to sit in and smaller ones for my heels, my feet being further supported by a log pegged up below them. I got the mark up and returned to Kaléwa in the evening.

The next day an answer came back from the Tsawbwa to the effect that raids by Chins, which were frequent just then, kept him at Indin, his temporary capital, and so he could not come to Kaléwa, but he should be delighted to see Captain Raikes at Indin if he would take the trouble to go so far; so we made all arrangements to start on the 15th March. I had my Berthon boat with me and it was the delight and admiration of all the Burmese. At Kendat and Kaléwa I frequently went out for a scull in the evening, and there were always several little naked urchins on the bank waiting for me, and when the boat was launched, they stepped in after me with as much calmness as if it was the regular ferry boat. Their confidence in me and my boat was highly gratifying. On the 15th we started, the whole party in boats, for Indin. On the way up we passed one or two villages which had been lately looted and burnt by the Chins, in dread of whom the villagers built huts on piles in mid-stream, or roof over boats lashed together in pairs and moored far out in the river; and to these temporary abodes they retire at night, as Chins have a dread of water and will not venture in any deeper than their knees. About 3 miles above Kaléwa is a large out-crop of coal, of which a good deal had been taken out for the steamers plying on the Chindwin. The bank had been undermined and further excavations were dangerous and had been stopped for the time when we passed up. I made a careful survey of the river as we went along. We reached Indin on the afternoon of the 17th and landed at a point about 3 miles off, whence a path to Indin cut off a great bend of the river; and here the Tsawbwa met us in great state with a procession of girls carrying vases of flowers on their heads, musicians, dancing-girls, matchlock-men, and spearmen and personal attendants bearing a gold umbrella over him. He mounted us on two elephants with funny little *howdahs* like a baby's dressing tray, with only space in each for one person, and conducted us in state to Indin, where we were installed in a very fine and commodious priest's house (*Poongyi Kyoung*). The next few days were spent by Captain Raikes in bringing his negotiations with the Tsawbwa to a satisfactory conclusion. At first nervous and suspicious, the latter soon acquired confidence in our good faith and became quite friendly. I visited a curious limestone hill about 7 miles off one day and got a good view of the valley; and from this and other points around Indin, I managed to secure a good deal of topography, though jungle fires and thick haze prevented my doing as much as I should have liked and could otherwise have done. While at Indin, my time was spent after dinner in taking stars for latitude, and Captain Raikes kindly assisted me greatly both then and on other occasions by recording for me. We were fortunate in meeting some influential Chin chiefs while we were there, and they had a long interview with Captain Raikes in which they agreed to use their influence in putting down raiding on the Tsawbwa's territory. We left Indin on the 22nd, well pleased with our visit, and reached Kaléwa on the 23rd. On the 27th we steamed down to Mingin, and on the way we saw Mr. Ogle's camp and anchored. He came on board for an hour and reported progress. I was very sorry to find he had been suffering from a bad attack of fever for a few days, but was recovering and had got on well with the work. On the 28th Captain Raikes very kindly sent the steam launch up to Mr. Ogle; and this enabled him to finish his work, as far as Mingin, by the 30th when he joined us.

On the 1st April we took Bapu Jadu up to a point suitable for a station and left him to clear it and pointed out some hills ahead which we wished him to clear, and then started in the steam launch, which thenceforward was at our disposal, to go up the river again to observe from all the stations which Mr. Ogle and the Sub-Surveyor had been putting up. We managed it in this way. There was no room in the launch for us to sleep comfortably, so we took the outer fly of Mr. Ogle's tent which was large enough to afford us both shelter, and was very quickly pitched and struck. At dawn we rose, got our few traps on board and started for the nearest station, having *chhota hazri* on board. I deposited Mr. Ogle and his party on the bank at the landing-place for his station and went on to mine, sending the launch back when I had landed. As soon as Mr. Ogle finished his work, he signalled to me, and I could then guess the time he would take to rejoin me; we then went on together. Sometimes though rarely we could visit two stations each during the day, but generally three altogether were all we could manage. We got back to Mingin on the 6th and waited a few days hoping to see the Sub-Surveyor's onward marks; we saw one but could not make out any clearings on the high range. I then received a letter from him saying he was in difficulties trying to find the point. He had been out in the jungle all one night with only 1½ *seer* of raw rice among his party (40 men) and no water. He wrote, "all night we are making mats, &c., for the mark, for we think that surely in the morning time we shall see the high hill." But when starting to "search the high hill" he found his men too tired to do much, and as they clamoured for water, the guide led them right down to the Chindwin on the opposite side of the range from their camp, and though they got water and a little more raw rice, they had a weary trudge back to camp, which they did not reach till 9 P.M. Mr. Ogle therefore started on the 10th to put things right. He returned on the 14th, and on the 15th and 16th we observed at stations near Mingin. On the 14th we received the first *dáks* we had had since 5th March, owing to confusion resulting from our postal line being changed from "*viâ* Manipur" to "*viâ* Mandalay."

On the 17th news came that a new steamer going down the river between Mingin and Alon had run aground, and it was doubtful whether our launch might not be wanted to assist the steamer. Our departure was therefore delayed a little, but we were able to start on the 18th, and observing at several stations on the way, reached Alon on the 21st, where we halted for one day to bring up arrears of correspondence, and then returned up the river observing. All our work above Alon was finished by the end of April, only a few points remained south and east which the Sub-Surveyor cleared. At Alon we lived on board a steamer, as accommodation was limited in the small bamboo matted hut which did duty for quarters and mess-house for the officers of the garrison. It had been very hot for some time past, the thermometer going up to 104°—106° frequently during the day. The anchorage was not as salubrious as it might have been, and the result was that I got a touch of fever in the first week in May. I was very anxious to visit Lepadaung H. S. to pick up some points I had previously observed to, and I went down one morning when I ought to have stayed in bed; we had a long walk across a barren, stony plain, and up a ravine where the breathless atmosphere was like a furnace, finishing up by a very steep climb of 700 feet. With Mr. Ogle's assistance, I finished the observations and got back to the steam launch, but I had to go to bed on my return to Alon and was on my back till the 24th, *i.e.*, nearly three weeks. I was moved up on the 15th to the officers' barrack.

Captain Sage very kindly giving up his little room to me, and all the officers, from Colonel Toker downwards, did what they could for me. The resources of the place were limited, there was no ice, no sodawater, no champagne, the commissariat bread was almost uneatable, and I lived on tea and indifferent soup for the three weeks. During this time Mr. Ogle was very busy visiting Chaukkah twice, having been disappointed by the weather of seeing all he wanted on his first visit. Some heavy storms having cleared the atmosphere he was more successful on the second trip. At last on the 24th May, a steamer came and took us all to Mingyan, where Captain Hobday met me. Mr. Ogle and I left for Mandalay on the 26th in the mail steamer and there, thanks to the kind care of General Sir G. White and Captain Hobday, I rapidly recovered strength, and after a fortnight's stay we proceeded down to Rangoon, picking up our party on the way down. We left Rangoon on the 22nd June and reached Calcutta on the 25th and Shillong on the 17th July.

On the whole the party was fairly healthy. We all suffered at times from fever and diarrhœa, but the attacks, till my last, were not very serious. As related I lost five men from cholera on the way to Poungbyin, and a few succumbed to pneumonia and dysentery.

Without our Khasia coolies we could not have finished our triangulation. They were always at hand, knew exactly what was wanted and carried better loads than the Burmans.

My thanks are due to all officers, military and civil, with whom our work brought us into contact, for their courteous and ready assistance to each member of the party. In the early part of the season I was indebted to General Gordon, Captain Stevens, and Mr. Primrose; and afterwards, when we crossed to the Chindwin, to Colonel Toker, Captain Raikes and Lieutenant Daly. I am more especially indebted to Captain Raikes, however, as his kindness in placing a steam launch at my disposal, and his valuable assistance in many other ways, enabled us to bring our work to a more speedy and satisfactory close than we could possibly have done otherwise.

TRANS-HIMALAYAN EXPLORATIONS.

Notes by COLONEL H. C. B. TANNER, *on Explorations in Bhutan and on the Lower Sangpo river.*

The little that has been added to our knowledge of Bhutan since the days of Captain R. Boileau Pemberton's mission to the court of the Deb Raja in 1837-38, may be summed up in a few words. On the west, Major Godwin-Austin, who accompanied Mr. Eden's mission in 1864, made a route survey from Daling in South-Eastern Sikhim to Punákha in Western Bhutan. In the east the "Pundit" traversed the outlying tracts of Men Táwang and Men Chhuna; to the south the party under Captain Harman fixed by trigonometrical observations such peaks as were visible from the plains of Assam and Bengal, and besides this, a small strip of country immediately adjoining Sikhim was sketched by Mr. W. Robert, of the Survey of India. Bogle's and Turner's missions to Tibet in 1774 and 1783 passed through Western Bhutan, but the geography furnished by Turner is meagre and Bogle gave none. We now, after a long interval of time, have the first additions to the geography of Bhutan in the shape of route maps and descriptive itineraries by explorer R. N. and a small route by P. A. who accompanied him, a short summary of which work was given in paragraph 267 of last year's Report. The diary of R. N. when published will be read with interest by geographers. It is so clear that a detailed abstract, such as is usually given with exploration reports, is not necessary, and a summary only will be given together with such marginal notes as may be requisite on the body of the reports.

The prime object of R. N.'s journey was the settlement of the Sangpo question; but though owing to political and tribal complications in Tibet and Bhutan he failed in this, he has yet brought back a very interesting piece of work. At Biákajong he joined Captain Pemberton's route with a disagreement of only 5 miles and at Se Shankar in Tibet he joined Lama U. G.'s route, where the discrepancy between the new value of its position as compared with the Lama's is only 7 miles.

In Western Bhutan R. N.'s work is of no great importance. It, however, ties together the traverses of Turner, Pemberton and Godwin-Austin, and besides, gives information in the gaps between their routes. P. A. has furnished details in the Há-Chhu (Har-Chhu of Godwin-Austin), but beyond this he has not done much.

Although R. N.'s party did not reach the Lower Sangpo, yet the narrative of K. P. gives a certain amount of information regarding that river; and as that person reached Onlet one stage from Miri Padam, the abode of the Miris and Padams, near the place where the Sangpo emerges from the Himalayas into Assam, I conceive that no further doubt should remain even in the minds of the most sceptical as to the identity of the great river of Tibet with the Dihang or Dihong, known lower down as the Brahmaputra.

R. N.'s party started from Darjeeling on the 1st November 1885 and he commenced his traverse at the Pango-La pass. From this point he travelled over new ground in Bhutan territory to the Túle-La pass, where he joined and followed the route taken by Mr. Eden's mission as far as a point about 4 miles south of Tumphiongjong, where he crossed the Ha Chhu into the Giába district. Continuing down the Ha valley he met Turner's route at Darbirjong (Darbi of the published maps) and followed it to Baxa Duár.

SKETCH MAP
TO ILLUSTRATE
COLONEL TANNER'S MEMORANDUM
ON EXPLORATIONS IN
BHUTAN AND TIBET
BY R.N. AND P.A.
DURING 1885-86

Compiled under the direction of Colonel C. T. Haig R. E. Dy. Surveyor General
Trigonometrical Branch, by Mr G. W. E. Atkinson, from all available sources

Outline by Mr G. W. E. Atkinson
Hill Shading by Mr G. W. E. Atkinson and H. Sindon
Typing by Mr G. W. E. Atkinson

Scale 1 inch = 12 Miles
10 5 0 10 20 30 40 Miles

Published under the direction of Colonel H. R. Thuillier, R.E., Surveyor General of India. December 1887

NOTE.—The routes of Explorers R. N. and P. A. are coloured red.
Additional routes previously explored are coloured burnt-sienna
Peaks fixed trigonometrically are shown thus ..... o
their heights being shown thus 5200
Heights fixed by Captain Pemberton's Mission are shown thus ..... (4326)
Heights fixed by R. N. are shown thus 5700

Photozincographed at the Trigonometrical Branch Office, Dehra Dûn.

R. N.'s companion P. A. entered Tibet by the Jelap-La pass and proceeded down the Ammo Chhu river to Assamtháng fixed by Mr. Robert in 1883. Here he struck up the small valley of Langmar Pochhu, which he left near its source by the Chhu-La pass. Crossing a valley and passing a lake or *tarn* he ascended and crossed the Miru-La (written Merugla in the Tibetan character) and proceeding down the Ha valley joined R. N.'s route near Battejong. The Miru-La was approximately fixed by Mr. Robert in 1883, and P. A.'s route has been made to originate from this point, the topography to the west being taken from Mr. Robert's sketch map. R. N. describes the inhabitants of the Ha valley and adjacent tracts as being kindly disposed towards strangers. They are termed Ha Pa by the Tibetans and talk a *patois* of Tibetan. The Ha Pa inhabit the Lachen and Lachung valleys in Sikhim, Chhumbi in Tibet, and the Giába district in Bhutan. Bhutanese or Duk Pa race occupy the central part of Bhutan and talk Duk Ye, a language distinct from Tibetan but written in the same character. The meaning of Duk Pa is "son of Thunder" (Boanerges), and the people are so called from their powerful physique and passionate and overbearing natures. R. N. met the Bhutanese or Duk Pa only below Giába on the Wong Chhu (Tchinchoo of Pemberton) and in Pumtháng.

The Wong Chhu or Tchinchoo is one of the seven great rivers of Bhutan and was described by Pemberton who crossed it near Tashichhujong, as follows—

"It flows through its entire extent from the capital to the Buxa Dooar through a limestone country by a great gap which for about 20 miles south of Woolakha (Olaka) appears to have been the consequence of a violent upheaving of the strata by which they have been made to dip away on either side from the river, the line of lowest level forming the present bed of the stream. The general character of this river more nearly resembles that of the Monas than the Machoo; like the former it rushes with great impetuosity over a bed almost entirely filled with large boulders of limestone and fragments of mica and talcose slate, which are the principal formations observable in the valley of the Tchinchoo."

And again—

"in one or two places the river may be forded but the attempt is attended with considerable danger from the slippery surface of the rocks in its bed and the extreme violence of the stream. After flowing in a nearly due south direction to the northern base of the Buxa hill, the river turns abruptly to the eastward, and again resuming its original direction makes its way to the plains, and under the name of Gudadhur falls into the Burhampooter river about 12 miles below Rangamatty."

From the Giába La pass, 9,800 feet, a very fine view was obtained of the Kulha Kángri and Chhumolárhi snowy group of mountains. The highest of this group called B by Mr. Lane was fixed by him in 1860 from stations of the Eastern Frontier Series, distant nearly 190 miles to the south-east. In 1884 Mr. Robert obtained cross rays to it from stations of the Assam Longitudinal Series, distant about 140 miles to the south-west; and the combined observations have secured the position of the peak very accurately. The resulting height, 24,740 feet, is perhaps true within 100 feet or nearer. This imposing mass of snowy mountains forming the northern boundary of Bhutan constantly attracted the attention of Captain Pemberton's party who called them the Gassa range: R. N. heard no such name applied to them, and as Gassa means simply encamping-ground, Pemberton is probably in error.

Owing to disturbances in Bhutan, R. N. was forced to relinquish the idea of striking across the country in a course south of and parallel with Pemberton's route. He therefore had to leave the hills at Baxa Duár Fort and re-entered them again at Dewangiri, the starting point of Pemberton's route through the Eastern Himalayas. Dewangiri is still practically a Bhutanese possession, where about 50 families of Duk Pa reside permanently. During the cold weather the Shingmis of Kurmed and Kurted bring their flocks down from the highlands to graze, when the place becomes of some little importance.

From Dewangiri up to the Diri Chhu, R. N. did not follow the old British military road, but travelled along the usual trade route. Signs of the Bhutan war are still evident in Kurmed, where old deserted terraces and ruined houses were frequently met with, and the military roads made by our forces between the Diri Chhu and Dewangiri may still be traced.

The party crossed the Dángmá Chhu river at Denma Sanpa, a substantial chain bridge about 350 feet long said to be of great antiquity. A figure of the maker is carved in relief on the stone face of the tower at the Indian end of the bridge, and this personage, by name Chabdong Nawang Namgyal, has now become an incarnation. The head of the Tashi Chhu Jong Monastery takes this title which is not hereditary. A curious custom mentioned by R. N. in connection with the Tashi Chhu Jong Monastery may here be noted. The priests who are in charge of the monasteries on the pilgrim's road which encircles Kailas Mountain in Western Tibet are supplied from this remote place in Bhutan.

Pemberton crossed the Dángmá Chhu river at Tashigong or Benkar and under the name of the Monas, thus describes it:—

"The Monas river, which at Tassgong or Benkar is called the Goomaree, appears to be the most considerable of all those which flow through Bhutan and receives either directly or indirectly the contributions of every minor stream which flows between it and Tongso. It is unfordable in any part of its course between Tassgong and its confluence with the Burhampooter river; and is crossed at the western foot of the Tassgong hill, by an iron chain suspension bridge of a structure almost exactly similar to those which have been so accurately delineated by Lieutenant Davis in the work of Captain Turner; * * * The valley through which the river flows runs nearly due north and south * * * * The breadth of the river at Tassgong is about 60 yards and its waters rush with irresistible fury and a loud noise over a bed composed of boulders and highly inclined strata of gneiss * * * The precise situation of the sources of this river appears to be unknown in Bhutan, but it is described as beyond the northern limits of that territory * * * The length of the course of the Monas from Tassgong to Jugigopa, the point at which it flows into the Burhampooter, may be roughly assumed at 121 miles, and as the level of this part of the plains is about 148 feet above the sea and that of the bed of the Monas below Tassgong not far from 1,900 feet, the total distance, divided by this difference of level of 1,752 feet, will give a fall in the bed of 14½ feet in a mile, which at once accounts for the extreme violence of its current, and the accelerated velocity with which it rushes into the Burhampooter, where this latter river has fallen to its lowest level. The inhabitants of that part of the country through which the Monas runs, in speaking of it, invariably allude first to the extreme violence of its stream, which they represent as quite impracticable for even light canoes, a very short distance within the lower ranges of the hills."

A confirmation of this description is given by the explorer in his narrative. On attempting to cross the very long chain bridge over the Dángmá Chhu which was here found to be about 300 feet wide, the party were promptly stopped and a short altercation ensued with the guard, whereupon R. N. happily thought of the passport he had procured, which here for the first time and hereafter on other occasions proved of talismanic service, for the barrier of opposition was immediately removed and the whole party allowed to proceed unmolested.

I must here note an extraordinary omission made by Pemberton in his description of the chief rivers of Bhutan. He makes no mention of the Kuru or Lama U. G.'s Lhobra (written Lhobrak in Tibetan), which now proved to be the largest in the country. R. N. describes the Kuru as being of far greater volume at Kuru Phasam than Pemberton's Monas at Denma Sanpa. The former receives the drainage of the tract between the Yamdok, Pho Mo Chang Thang, and Tigu lakes in Tibet, and of the glaciers of the Kulhá-Kángri and other great ranges, and the latter, though it drains a large extent of country, apparently is not fed by glaciers, proved by the fact that while the water of the Kuru was muddy, that of the Dángmá Chhu was so clear that the stones could be seen in deep water. Part of Pemberton's account of Bhutan appears to have been written from memory, for he describes the chief trade route from Bhutan to Lhasa as lying up the Goomaree, whereas Lama U. G. found no such practicable route branching off from any point east of the Monla Káchung La pass. Pemberton's map gives only a course of 10 miles to the Lhobra above Lingtsi Jong, where he crossed it, whereas its source is shewn by the Lama to be a good 80 miles above that place; and until the exploration of Lama U. G. all geographers followed Pemberton's mistake.

The tract between the Diri Chhu and the Thungsi La pass is occupied by a tribe called Chingmi, described by R. N. as a mixed race—half Bhutanese and half Men. They occupy Kurmed and Kurted, Men Chhuna and Men Táwang, and extend as far east as Gyala Sindong and Pemakoi. Their language, called Shimkye, is said by R. N. and K. P. to resemble to some extent that of the Abors below Pemakoi on the Sangpo.

The Chingmis are of amiable disposition, living in houses of better construction than their Bhutanese neighbours. The men wear no dress distinguishing them from the Bhutanese, but their women resemble in appearance and in the cut of their garments those of Garbiang in Kumaun. Unlike the Bhutanese, both sexes wear pigtails. In the whole of the Chingmi country the Bhutanese form the official class.

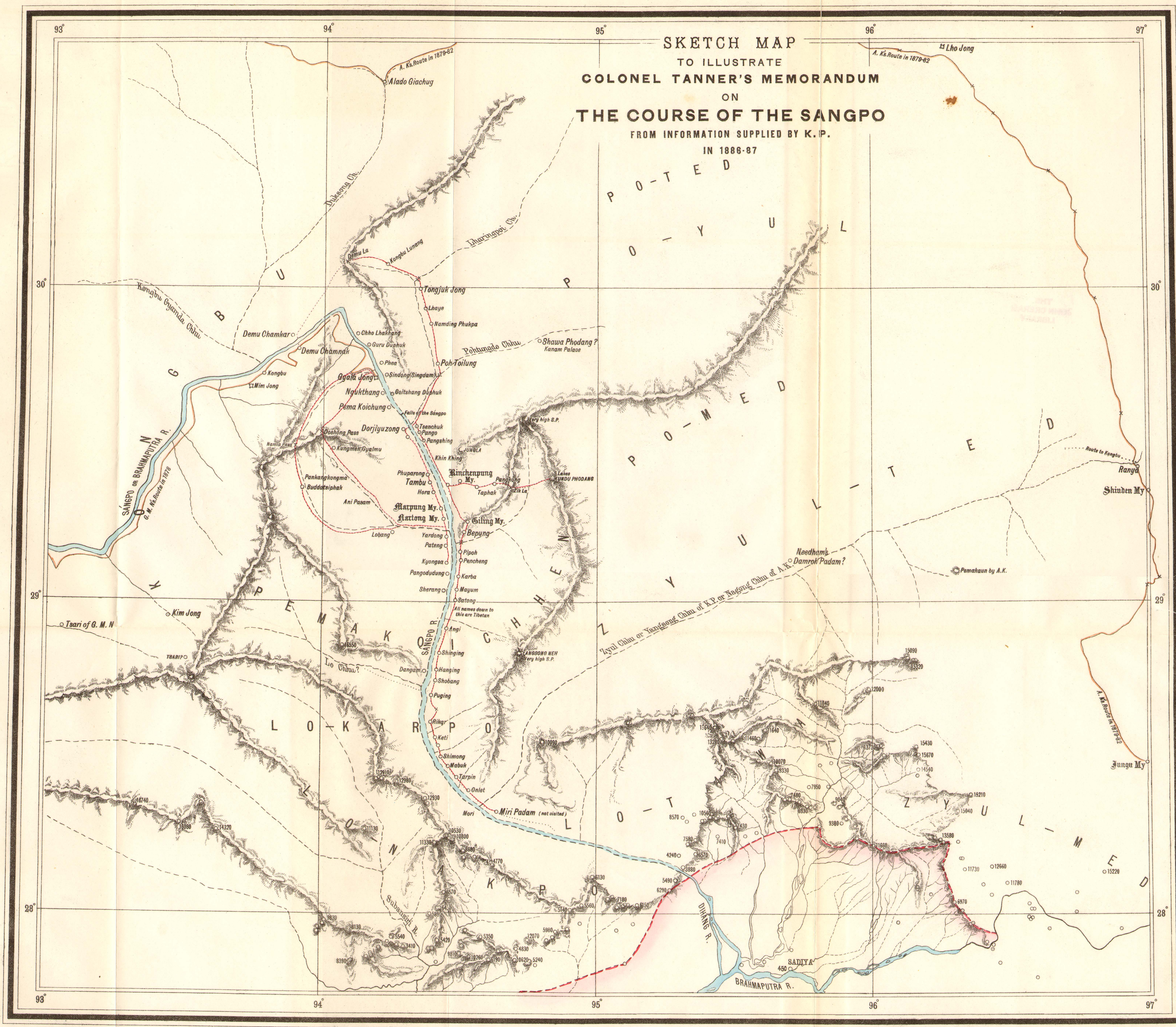
R. N. crossed the north-western border of the Chingmi country into that of the Bhutanese or Duk Pa at the Thungsi La pass (12,500 feet) whence a splendid view of the great snow peaks of the Kulha Kángri group was obtained. To the west the panorama of snowclad mountains extended to Chhumolárhi, but Kanchinjinga was unfortunately veiled in mist. To the east and north-east the snow peaks were unimportant. The position of this pass was fixed by magnetic bearings taken to Chhumolárhi and Kulha Kángri (B of Messrs. Lane and Robert). The sketch made by R. N. shows the position of the Monla Káchung La pass, which, as far as I can ascertain, is one of the most important on the common boundary of Bhutan and Tibet.

Biáka Jong (Beyagur or Juggur of Pemberton) on the Pumtháng river struck R. N. as being the finest fort he had seen anywhere. It is situated on a commanding point two or three hundred feet above the river with which it is connected by a covered way. The inhabitants are mixed Tibetans, Chingmis and Bhutanese, who carry on a considerable trade with Tibet and India.

The Pumtháng valley, by R. N.'s account one of the pleasantest in Bhutan, commences above Biáka Jong. It has much open cultivated ground and the altitude of the lower section is such that the climate is all that could be desired. The higher slopes are either dotted with *Abies Webbiana* or *Dumosa*, or have clumps and groves of those trees. At a lower altitude *Pinus excelsa* occurs. *Yaks* and all domestic animals are in plenty, and game abounds. Cross breeds called *Gyasa* are found in the forests of Kurmed and Pumtháng. The *shao* or great stag of Tibet was not heard of south of the Monla Káchung La pass, but the animals common to the higher regions were plentiful.

R. N. fixed the position of the Monla Káchung La pass (17,500 feet) by observations to Kulha Kángri, and then ascending into Tibet joined the traverse of Lama U. G. at Se, where the usual barren country always found in more elevated Tibet was reached. He found *phapar* (? oats) growing at an estimated height of 14,500 feet. This is probably the same grain that is met with in the most elevated cultivation in North Kashmir territory. The Duk Pa race extend northward to Se, beyond which the true Tibetans or Ped Pa occur.

The exploration ceased at Se Shangkar, and R. N. was obliged to make his escape from that place, and after a toilsome journey through Lhobrak crossed out of that



Compiled under the direction of Colonel G. T. Haig R. E. Dy. Surveyor General
Trigonometrical Branch, by Colonel H. C. B. Tanner S. C., Depy Supdt. of Survey

Outline by Mr G. W. E. Atkinson
Hill Shading by Mr H. Sindon
Typing by Mr G. W. E. Atkinson

Scale 1 inch = 12 Miles
10 5 0 10 20 30 40 Miles

Published under the direction of Colonel H. R. Thuillier, R.E., Surveyor General of India. December 1887.

NOTE.—The routes along which K. P. has supplied information are coloured red.
Additional routes previously explored are coloured burnt-sienna
Peaks fixed trigonometrically are shown thus .... ○
their heights being shown thus 6290

Photozincographed at the Trigonometrical Branch Office, Dehra Dún.

region by a high pass and eventually reached Men Táwang, crossing the Tashiyáng Chhu and Dozam Chhu *en route*, travelling the whole distance from the border of the Lhobrak country through a desolate high region inhabited only in favourable seasons by shepherds.

R. N.'s notes on the people of Bhutan together with a short vocabulary of the Chingmi language by Lama U. G. is given at the end of this memorandum. The Chingmis are not mentioned by Pemberton, nor have I seen the tribe noticed in any of the existing reports on Bhutan. The Ha Pa of R. N. cannot be identified with the Rangtang or Tebula of Pemberton's fifth and seventh classes, though from the position of Sanglah in Western Bhutan, R. N. states his opinion that the Sanglah and Ha Pa may be identified.

The Chingmis were met by K. P. in and around Pemakoi and by Lama Serap Gyatsho, a Mongolian Lama, who resided many years on the Lower Sangpo, whose account of Pemakoi together with K. P.'s narrative will be published hereafter.

In July 1880 a Chinese *lama* of Giardong was despatched by the late Captain Harman from Darjeeling to Tibet with orders to explore the country below Gyala Sindong and trace the great Sangpo to the plains of India, or failing this, to throw marked logs into the stream at the lowest point reached. It was intended that due notice should be given by the Lama to Captain Harman of the period during which the logs were daily to be cast into the river, so that he might set watchers at the place where the Dihang (Dihong) debouches into Assam, and thus prove the identity or otherwise of the great river of Tibet with the Brahmaputra.

K. P., a native of Sikhim, who had previously accompanied the explorer G. M. N. to Gyala Sindong and who has since traversed Bhutan with R. N.'s party, was sent with the Chinese *lama* as assistant, and his narrative shows how the proposed arrangements for casting the logs into the Sangpo fell through owing to the delinquency of the *lama*, who having sold K. P. as a slave in the Pemakoi country, decamped to his home in China.

K. P.'s narrative was taken by Lama U. G. as dictated to him by that individual, and the explorer states that the dates and distances given may be relied on as fairly true. He has been cross-questioned and examined by myself regarding his statements, and I have no doubt that his account is a *boná-fide* story of his travels. Lama U. G. and R. N. place complete reliance in K. P.'s statements, the outcome of which may be briefly summed up in a few words. K. P. reached Onlow or Onlet a short stage from Mir Padam, or Miri Padam, a village situated on a *dun* or plain on the Sangpo, a resort of traders from Assam, and the abode of the Miri and Padam tribes, who are known to ourselves to inhabit the country near the place where the Dihang breaks through the hills into Assam. K. P. was informed at Onlet that Miri Padam was about three days' journey or 35 miles from the nearest plains of India. K. P.'s sketch of the Sangpo from Gyala Sindong to the plains placed Miri Padam 24 miles east and a little south of the position in which it will be found on the sketch map accompanying these notes. After the sketch maps had been made by Lama U. G. we discovered in the records of the Assam Survey Party three plane-table sections by Captain Harman of the country adjacent to Sadiya which appear to give the junction of the Dihang with a large river coming from the north-east, and this large river I have assumed to be A—K's Nagong Chhu or K. P.'s Yangdong or Zyul Chhu. The general direction of the Sangpo for many miles of its course, as estimated by K. P., agrees very nearly with that of the Dihang as estimated by Captain Harman, and these two authorities are considered sufficient to authorise the alteration of the course of the Sangpo as given on the map accompanying the report on A—K's explorations to that shown on the annexed sketch map.

Mr. Needham, the Political Officer at Sadiya, writes to me that he has never heard of Miri Padam, but that the most northerly abode of the Abors who call themselves Padams, is "at Damroh Padam, situated north and a little east of Sadiya just behind the first high range of mountains." By adopting this position, Damroh Padam on the new map would be rather high up on the Yangdong river unless K. P. and Captain Harman are altogether wrong in the course they assign to the Sangpo. The explorer, however, says that he is quite certain that the haze of the plains of India was seen from Onlet in an easterly direction when looking down the river.

The Lharingpoi river is shown on the map accompanying the report on A—K's explorations (under the name of the Kongbo Giámdá Chhu) as entering the Sangpo at the corner of the great bend above Gyala Sindong, but K. P. and G. M. N. both agree in making the junction many miles lower down at Pango. The Kongbo Giámdo is said by A—K to join the Sangpo 20 miles above Gyala Sindong,* and the junction has now been made opposite Kongbu, where Captain Harman shows a large river coming in from the north. The great bend of the Sangpo was visited by G. M. N. who makes no river enter the Sangpo at that point, A—K's information regarding the junction of the Kongbu Giamdo with the Sangpo is therefore probably at fault.

K. P. describes the falls of the Sangpo below Pemakoi as a cascade of some 150 feet in height, and mentions the prismatic colours of the spray hanging over the dark basin or lake below the cliff. This rock is called Sinje Shejal, where there is a shrine.

The Chingmis mentioned by R. N. and an admixture of Tibetans occupy the Pemakoi Chhu tract, which extends to Dangam below which Tibetan names and Tibetan influence cease. Below Dangam the people are called Lo or 'utterly barbarous'.† There is no restriction to travel in the Lo country till Miri Padam is reached, beyond or to the

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* The position of Gyala Sindong must be accepted with great mistrust. G. M. N.'s traverse "ends in air" and he is not an entirely trustworthy explorer.

† Not Lho as stated by A—K, which means 'south.'

Indian side of which no one appears to be allowed to cross from the Tibetan side. There is some confusion regarding the southern limits of the Po or Poh country which appears to join the northern boundary of Pemakoichhen. Po is managed by a council of Elders. The Raja of Poyul lives at Kanam in a palace called Shawa Phodang. Lama Serap Gyatsho mentions that the authority of this Raja has now become nominal only.

The Pemakoichhen district ceases at Dangam, whence the country of the independent and "quite barbarous" Lo Karpo commences. Tibetan names of villages and Tibetan influence cease at Dangam. An examination of the words in the short vocabularies of the Po, Lo and of the Chingmis might serve to identify these tribes under the names by which they are probably known to our officials in Assam. K. P. is the authority for the three lists given, and with slight errors they may perhaps be correct. The word "Chingmi" has only once come before me—it is affixed to a village of that name in Bhutan on the map of Bhutan, dated Calcutta, November 1874, and falls in the Chingmi country. The late Sir C. MacGregor is the authority for most of the new work that appeared on that edition, and to the Quartermaster-General's Department is due the credit of unravelling to a certain extent the great confusion which previously existed in the delineation of the course of the chief rivers of the country.

R. N.'s and K. P.'s narratives afford a considerable addition to our knowledge of the great unknown tract which surrounds the holy shrine of Tsari, which is said by K. P. to be situated on a ridge which discharges its drainage partly into the Lo river and partly into a river which flows into India; it is some 30 or 40 miles south of the Sangpo. This tract extends to the Sangpo on the north, India on the south, the Pandit's route to Men Chhuna on the west, and the Lower Sangpo on the east, and it seems very desirable that in the interests of geography we should not rest satisfied with the limited extent of our information of a country which lies so close to our doors.

The explorer R. N. made notes of the manners and customs, &c., of the people of Bhutan, and perhaps it would not be amiss to enter here what he noticed, though withal they be but fragmentary and meagre.

The Bhutanese, whether of high or low station, when on a journey, are never without a long sword of native manufacture, three wooden cups packed one within the other, and all put away in the breast pocket, and a handkerchief. The majority of the people are given to drinking intoxicating liquors made from different kinds of grain; they are also much addicted to eating the betel-nut with *pán*, and also chillies in large quantities. As a rule, they are all bad-tempered and are easily provoked.

On the occasion of a feast given by the Deb Raja, all below the rank of Jongpons are obliged to eat outside the palace, but those above that rank and of that rank are entitled to partake of the feast seated in the royal presence, squatting on terraced platforms, and each with those of the same rank, not promiscuously.

On the occasion of the Deb or one of the powerful chieftains travelling in the country, the news is sent along the line to be travelled over, and all villagers *en route* are compelled to burn fires to purify the air, as well as scented wood, so that the olfactory nerves of those dignitaries may not be offended by any malodorous exhalations on the roadside. Long processions are formed by their retainers, and this is the order of march observed on such occasions: first pass on the luggage carriers, then soldiers in various-coloured clothes, then follow the flagbearers and fife and drum players and beaters, then a long string of horses and mules richly caparisoned, then the *zinkaps* or lower officials, then two buffoons in gay attire with gaudy-coloured silks follow capering, dancing, and beating small drums, and then follows the Raja or chieftain, and after him a large following of *zinkaps* and others. When arrived at any place of importance small ordnance are fired off in honour of the traveller.

The *lamas* of the country wear caps, while all others wear *pagris*. Shoes of leather attached to long gaiters or stockings of wool are what are worn in the country. The males of the country wear their clothes only down to the knees, and ornaments are eschewed by the male population. The females wear their clothes down to the ankle and are very much given to ornament wearing. Both men and women as a rule shave their heads. Women enjoy perfect freedom in their movements and are not kept indoors.

Marriage ceremonies (where money is spent) are confined to the richer portion only of the population. Children are betrothed in many cases in early infancy, and the father of the bridegroom elect is expected to give money in proportion to his rank and means, and that of the girl betrothed. Sometimes as much as the equivalent of R800 is given. With this money jewels and clothes are purchased, and the girl is adorned with them, and then sent to the house of the parents of the boy. The women, who inhabit the tract known as Chingmi, dress differently from their sisters of Western Bhutan and do not shave their heads, but wear their hair.

Guns—muzzle-loaders—are manufactured in Bhutan as well as imported from Nepal. Flintlocks as well as percussion cap guns are used. The native-manufactured swords are formed of highly tempered steel and are very pliant. The shields of the country are proof against guns of local manufacture. When two powerful chiefs are at open feud with each other, they as often as not stake their respective claims on the issue of single combat.

Polyandry, since the days of Captain Pemberton, has been very largely on the decrease and can no longer be said to be a favourite custom in Bhutan.

The villagers in the country are taxed in local produce for the support of the Government. Bridges and roads are constructed and maintained by the villagers in the locality where they exist, the Government furnishing the implements only.

There is no gold currency in the country, only silver and copper coins circulate in Bhutan; portion of it is coined by the Government, and a large quantity of Tibet coin is in circulation also.

The chief monasteries in Tibet are:—

(1) Daiphung containing 7,700 priests, who wear yellow caps.
(2) Seráh „ 5,500 „ „ „ „ „
(3) Gádin „ 3,300 „ „ „ „ „
(4) Sákya, number of priests not ascertained; they wear red caps.
(5) Samiye „ „ „ „
(6) Tashilhumpo containing 2,000 priests, who wear yellow caps.

The chief monastery in Bhutan is Tashichhujong, containing 300 priests, from whom the chief *lama* of the Kailás monasteries as well as all the *lamas* for all the principal ones in Bhutan are chosen. In all the chief monasteries in Tibet and Bhutan, all the priests wear red frocks or gowns, and the cap is a distinctive badge of the monastery to which they are attached. There are certain officials who have particular duties to perform. The following enumerates the officials and their duties, *viz.*,—

(1) Chief *lama*, over all others.
(2) *Dorjelopan*, sacred interpreter.
(3) *Uje*, leader in prayers.
(4) *Chhútimba*, moderator, monitor, and responsible head.
(5) *Chinyer*, treasurer.
(6) *Kunyer*, image-keeper and protector.
(7) *Tenyur Yarpa*, keeper of the sacred records.
(8) *Chabdil*, holy water distributor.
(9) *Tungpa*, conch blower to summon priests to prayers.

The modes of salutation in Tibet and Bhutan are curious if not ludicrous; they are as follow:—

The Tibetan mode of salutation to a superior is in taking off the cap from the head and protruding the tongue and then backing a few steps; it is called "*chabul.*"

The Bhutanese fling a strip of several yards of narrow silk (2 feet wide) to their superior, retaining one end in hand, the other end is then held by the person honoured, and after a short interval the whole strip is withdrawn; this is termed "*tharta.*"

All nuns in Tibet and Bhutan are called "*auni*," and when they meet each other shake hands in salutation; this is called "*gori.*"

Priests remove the red *chaddar* from their shoulders and present it to the person saluted; this is known as "*zenkhe.*"

The seven largest rivers in Bhutan are the following: Ammo chhu, Kuru chhu, Dángáma chhu, Pumtháng chhu, Tongsa chhu, Wong chhu, and lastly the Di chhu.

The Pho chhu is not inconsiderable and may well be added to the above seven, making the eighth.

Vocabulary of the Chingmi (Tshingmi) language written in Tibetan by Lama U. G. and translated by explorer R. N. and Norpu.

English.	Chingmi.	English.	Chingmi.
I	Chang.		
You	Nán.	*Numerals.*	
Here	Tháh.		
What	Hang.	1	Thoor.
Good	Lekpu.	2	Ngik tsen.
House	Pháika.	3	Sa-um.
Butter	Si.	4	Fee.
Road	Lom.	5	Ga.
Rice	Khu.	6	Khung.
Little	Ta Sir.	7	Zum.
Salt	Encha.	8	Yen.
Marwa (beer)	Yu.	9	Gu.
Stay	Chhoiná re (?).	10	Sey.
Pounded maize	Pharang.	11	Song Thoor.
Man	Song.	12	Song Ngiktsen.
Go	Dighee.	13	Song Sa-um.
Drink	Chamshu.	14	Song fee.
Buy	Ngo na.	15	Song ga.
Slowly	Ngu dung.	16	Song khung.
Water	Jum (?).	17	Song zum.
		18	Song yen.
		19	Song gu.
Pemakoi dialect of Chingmi.		20	Khay Thoor.
Cow	Big.		
Little	Dah.		
Water	Tsi.		
Cooked rice	Khwen Kharang.		
Cooked maize	Ashum Kharang.		

Vocabulary of the Chingmi language.

English.	Chingmi.
Where are you going	Nan o di le ya.
I am coming here	Chang thah ou pha ya.
What is your name	Nan ka ming hang duk pa ya.
My name is Kintub	Chang ka ming kuntub duk pa ya.
Now you stay here (ordinary)	Meaning Farewell. Nan chhui na roh.
Now you stay here (respectful)	Nan chhui sukchu na.
Now you stay in sound health (respectful)	Nan leg pu chhui Naro.
I am going to my house	Chang phayi ka dilay.
Please lend me a house	Chang ka phayi thur nga bedong.
I will stay here	Chang tha*h* chhoi lay.
Have you got rice	Nan ka khu chakka mo*h*.
Kindly sell some rice for me	Changkha khu dah sir Tshonginoroh.
What price do you want for it?	Nan rin hanga le mo.
I want some salt as the price of it	Chang ka rin enchaga lay.
Wait a little and I will give you some *marwa* (beer)	Nan da sor chhoina jong you bidong.
Sit and you stay here (farewell-respectful)	Nan leg pu chhoi Naroh.
Will you take rice?	Nan kharang sa lay mo.
Will you drink water	Nanri jum lay mo.
I won't take rice but I will eat some flour	Chang kharang mi say bok bi sa lay.
I won't drink the *marwa* of maize	Chang a shom u man jam pa la.
I will drink *marwa* (beer)	Kongbu u jam bey.
Have'nt you got butter	Nan ka sima-lah mo.
Will you drink tea	Nan chae jam be mo.
Have you got tea?	Nan ka chae chakka mo.
I have got (some) tea	Chang ka chae chakka ya.
Bring it here and I will drink	Thah phaye jing jam dong.
You had better sleep here	Nan thah yikchu lay.
Don't tell a lie	Nan zoma yikchu na roh.
You must speak properly	Nan koku lekpa yikchu lay.
Shew me the road	Chang ka lom tonchu na ro*h*.
I don't know this road	Tah ka lom changma siwa la
Please let me go	Chang ka thah chhuna.
There is not a good road	Tah lom leg pu ma lah.
The road was broken by the slip	Lom chakpa kyab pa la*h*.
I don't know everything	Chang hang rang ma siwa la.
I know	Chang siwa la.
Am coming	Oo phaya.
Will go	Di leya.
What says	Hang tak paya.
Sit here	Chui Naro.
Lend me	Nya bi thong.
Will give	Bi dong.
Sit for a moment	Da san (?) chhona.
I have an uncle, so I am going to visit him	Chang-yolu-aku-thur chaka yu aku, rum ka thile.
Will you buy salt?	Ancha ngo leu mo.
What will you take in return for the salt?	Ancha ku rin hung-gale mo.

NOTE.—Some give nam instead of nan for the interrogative.

Vocabulary—A few sentences of the language of the Kham Pobas who inhabit the tract called Po between Pema Koichhen and the Province of Kham.

English.	Kham Poba.
Have you come back?	Ya khore kyo gyosin.
What have you to say?	Kyo chi dzo gyu yole re.
I have come to see you to-day.	Nga thasong kyo ser shaong le yi.
Are you well?	Kyo kutsi nyungshi tang bu a yo.
Yes, I am quite well.	Tha, song nga khum zung bu yo.
Sit a little.	Yo rang seng tso duk.
I have no time to sit, I have to go somewhere.	Tha song nga duk long me, nga ána sha-do-gole da
Where have you come from?	Khyo tha song-ghale-ongle yi.
Where are you going?	Khyo Gha-sha do-gyu-yi.
What do you want?	Khyo chi-gole yi.
What is the name of this place?	Konyu the ningla chi dzo le-yi.
Is there a road there (to that place)?	Ana lum yole ayi mi-la-yi.
Bring a cup of water for me.	Nga la tha-song chhu phorba ghangbinle.
Bring my horse.	Ya khore ta ti-sho-ogo.
Put the saddle on the horse.	Ya tchga yamu tsuk-tang ogo.
Light the lamp.	Koré la-ong-chik pago le-du.
Is there a bridge over the stream?	Kore chhu-chen the-la sumpa yole áda.

This language differs slightly from Tibetan. NOTE—Khyo is written kho by some.

Vocabulary—A few words of the language of the Lobas (the Lo Karpo, Lo Nagpo, and Lo Tawa), who inhabit the Lower Sangpo south of Bepung.

English.	Loba.
Cow	Bha-mon.
Water	Amish.
Fire	Ashish.
Hog	Marshu shu.
Food	Dokay.
Wine (beer ?)	Apongshi.
Sit	Dolungka.
Go	Kaju.
Come	Sha.
Name	Mirangka.
Hand	Alak.
House	Earangshi.
Stream	Amish.
Eye	Amik.
Cotton	Opot.
Copper vessel	Shang goshi.
Salt	Aloshi, Ancha.
Sun	Donyi.
Moon	Polok.
You	Noshi.
Eat	Dolama.
Bring	Lato mepa.

There are no horses, mules or asses in the Loba country.

DRAWING OFFICE, CALCUTTA.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

Statement showing the work performed during the year 1886-87.

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS.
General Maps.		I. M.	
India. Engraved	6	1 = 32	Additions to date.
Do. Ditto	4	1 = 64	Changes to boundaries and additions to Railways up to date.
Do. In relief	...	1 = 32	Cast in Plaster of Paris.
Do. Lithographed	6	1 = 32	New edition.
Do. Contour	6	1 = 32	Corrected for lithography.
Do. Military	6	1 = 32	Showing all military stations and cantonments with railway lines, large rivers, and towns; published.
Do. Skeleton	2	1 = 64	Showing only district boundaries corrected to date; published.
South-West Asia	6	1 = 32	Outlined and shaded in England, names and sites being inserted from most reliable sources. The sheet in hand takes in Teheran, Mashhad, Astrabad, and Ispahan.
Afghanistan	4	1 = 24	South-East section in hand.
Atlas Sheets.			
Nos. 11 S. E., 14 S. W., 15 N. W., 21 S. W., 23 S. E., 23 N. E., 35 S. W., 36 N. W., 37 S. W., 42 S. E., 48 S. W., 50 S. E., 50 N. W., 57 N. W., 57 S. W., 77 S. W., 78 N. W., 88 N. E.	...	1 = 4	Outline and names for engraving.
Nos. 12 N. W., 14 S. E., 15 N. W., 19 S. E., 20 S. E., 23 S. E., 30 N. W., 36 S. W., 37 N. W., 38 N. W., 42 S. E., 43 N. W., 43 N. E., 50 N. E., 60 N. E., 61 N. E.	...	1 = 4	Hills brush-shaded for engraving.
Nos. 114 S. W., 114 S. E.	...	1 = 4	For heliogravure; published.
Nos. 14, 119, full plates	...	1 = 4	Additions to railway and change of boundary.
Provincial Maps.			
Mysore State	1	1 = 16	Without hills, published by photozincography; will eventually be engraved on copper.
Upper Burma	1	1 = 16	Without hills, compiled from Captain Hobday's ¼" reconnaissance sheets; published.
Ditto	1	1 = 16	With hills, compiled from Captain Hobday's ¼" reconnaissance sheets; published.
Rajputana Agency	2	1 = 16	Unsurveyed portions about Jeysulmere completed from best available materials and lithographed; published.
Gujarat	1	1 = 16	Compiled from 1 and 2-inch surveys, brought up to date; is being engraved.
Punjab and its dependencies	4	1 = 16	Corrected according to instructions received from the Punjab Government; is being engraved.
Province of Assam	1	1 = 16	Additions to date from recent surveys.
Divisional Maps.			
Burdwan	2	1 = 8	Compiled on the ¼-inch scale from latest materials for reduction to one-half; drawing finished.
Patna	8	1 = 8	
Bhagalpur	2	1 = 8	Compiled on the ¼-inch scale from latest materials, for reduction to one-half; drawing in hand.
Rajshahi	4	1 = 8	
District Maps.			
Darjeeling	1	1 = 4	Being compiled from recent 2-inch surveys, in hand.
Cachar	1	1 = 4	Prepared for lithography by transfers from copper and corrected to date; in hand.
Nowgong	1	1 = 4	
24-Pergunnahs	1	1 = 4	
Khoolna	1	1 = 4	
Chumparun	1	1 = 4	
Burdwan	1	1 = 4	
Jubbulpore	1	1 = 4	

DRAWING OFFICE, CALCUTTA.

Section I.

Statement of work—continued.

Title of Map.	Number of Sheets.	Scale.	Remarks.
District Maps—continued.		I. M.	
Nuddea	1	1 = 4	Corrected to date and sent to Lithographic Office.
Khoolna	1	1 = 4	
Jessore	1	1 = 4	
Sonthal Pergunnahs . . .	1	1 = 4	
Moorshedabad . . .	1	1 = 4	
Sarun	1	1 = 4	
Standard Maps.			
Upper Burma (N.-E. Trans-Frontier Series)— Sheets 15 S.E., 15 N.E., 23 S.W.	...	1 = 4	Compiled by Captain Hobday from surveys, reconnaissances and local information. Names printed and maps finished in Drawing Office; published.
Upper Burma (S.-E. Trans-Frontier Series)— Sheets 1 N.E., S. E., 2 N. E., S. E., 4 N. W., S. W., 5 N. W., S. W., 6 N. W.	...	1 = 4	
Central India & Rajputana—	483	1 = 1	Marginal sheets being completed.
Sheets 367, 400, 401 . .	...	...	Published.
„ 385, 386, 388, 402, 403, 404, 405, 415, 416, 417.	...	...	In hand.
North-Western Provinces & Oudh—	221	1 = 1	
Sheets 56A, 56B. . . .	...	...	Published.
Bombay— Gujarat	63	1 = 1	Drawn for reduction to 1-inch scale.
Sheets 119, 214, 216 . .	...	...	Completed heading, foot-notes, references, &c.; published.
Cutch	37	1 = 1	
Sheets 52, 53, 70, 71 . . .	...	...	Completed heading, foot-notes, references, &c.; published.
Administration Report Maps.			
Berar Assigned Districts— Ellichpur, Amraoti, Akola, Basim, Buldana, Wun.	6	1 = 8	
Coorg	1	1 = 8	
Central Provinces— Chanda, Bastar, Wardha, Chhindwara, Saugor.	19	1 = 8 and 1 = 16	
Punjab— . . . . . Kohat, Dera Ismail Khan, Delhi	31	1 = 8	
Bengal— . . . . . Hill Tipperah, Manbhoom, Durbhunga.	48	1 = 8	
Rajputana— . . . . . Ajmere, Merwara.	2	1 = 8	
North-West Provinces— . Garhwal, Fatehpur, Ghazipur, Merwara.	37	1 = 8	
Oudh— . . . . . Sitapur, Fyzabad, Hardoi, Kheri.	11	1 = 8	

DRAWING OFFICE, CALCUTTA.

SECTION I.

Statement of work—continued.

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS.
		I. M.	
ASSAM—Garo Hills, Khasia and Jaintia Hills, Lakhimpur.	11	1 = 8	
Index Maps.			
Standard sheets, Bombay Presidency	1		
Standard sheets, Sind	1		
„ „ Madras Presidency	2		
Standard Sheets, Burma	1		
Reconnaissance Sheets of Burma	1		
Survey Operations in Mirzapur	1		
Ditto Madras	1		
Ditto Gujarat	1		
Ditto Baluchistan	1		
Statistical Maps.			
India. Tea	2	1 = 64	33 } copies coloured by hand from data supplied by Revenue and Agricultural Department.
Do. Jute	2	1 = 64	6 } copies coloured by hand from data supplied by Revenue and Agricultural Department.
Do. Coffee	2	1 = 64	11 } copies coloured by hand from data supplied by Revenue and Agricultural Department.
Do. Rice	2	1 = 64	Corrected and sent for chromolithography.
Do. Surgarcane	2	1 = 64	Ditto ditto.
Do. Railway feeders	6	1 = 32	Additions and corrections up to date being made.
Do. Canals	6	1 = 32	Additions and corrections up to date being made.
Do. Railways	6	1 = 32	Coloured and brought up to date for use of His Excellency the Viceroy.
Miscellaneous Maps.			
Western Afghanistan	1	1 = 24	Showing routes taken by Dr. Aitchison; drawn and original supplied to Foreign Office.
Burma	1	1 = 12	A tracing made for Foreign Office.
Central India	1	1 = 32	Specially prepared for Sanitary Commissioner, Central India; published.
Bengal, Behar, Orissa and Chota Nagpore	1	1 = 32	Specially prepared and original supplied to Sanitary Commissioner, Bengal.
Bengal, Behar, Orissa and Chota Nagpore	2	1 = 16	Specially prepared and original supplied to Sanitary Commissioner, Bengal; published.
China (skeleton) showing Customs and Treaty Ports	1	1 = 96	Prepared and original supplied to Revenue and Agricultural Department.
North-Western Railway	1	1 = 32	Prepared for the Manager of the North-West Railway, published.
Vernacular Maps of Northern Afghanistan	5	...	For Foreign Office; published.
Northern Afghanistan	2	1 = 8	Prepared for Captain Yates, showing his routes.
Hills around Naini Tal	1	1 = 8	Prepared as an index to Panorama of snows from Naini Tal.
Physical Atlas of India	21	...	Coloured for Foreign Office.
Boundary between Garo Hills and Mymensingh	2	2 = 1	Examined and corrected for reproduction by photozincography; published.
Jacobabad to Chaman and adjoining countries	1	1 = 16	Portions of Sheets $\frac{21}{22}$, + $\frac{29}{30}$ of North-West Trans-Frontier; published.
Guide map of Simla and Jutog	2	6 = 1	Corrected for second edition.
Skeleton Map of India	2	1 = 64	Specially prepared for Home Department.
Province of Assam	1	1 = 24	One copy for Revenue and Agricultural Department and one for Superintendent of Forests showing inner line of boundary of districts Darrang, Sibsagar, Lakhimpur, and Cachar.
Do. do.	1	1 = 24	Cholera map for Deputy Surgeon-General.
Trace of boundary between Sind and Marwar.	1	1 = 4	One copy for Resident, West Rajputana, and one copy for Deputy Commissioner, Thar and Parkar.
CHARTS—Triangulation Charts of Mysore	...	1 = 4	Four were completed by inserting latitude, longitudes and azimuths; published.

DRAWING OFFICE, CALCUTTA.

SECTION I.

Statement of work—concluded.

TITLE OF MAP.	Number of Sheets.
Maps examined.	
General and Provincial Maps	29
Original Atlas Sheets or portions of sheets	40
Divisional Maps	2
District Maps	5
Original Standard Maps	87
Trans-Frontier Maps	9
Index Maps	5
Statistical Maps of India	38
Special and Miscellaneous Maps	54
Tracings of Original Maps	4
Engraved proofs of General and Provincial Maps	21
Engraved proofs of Atlas Sheets in various stages	113
Photo-Electro proofs of Atlas Sheets	5
Lithographic proofs of General and Provincial Maps including Index Charts	8
Lithographic proofs of Atlas Sheets and District Maps transferred from copper-plates	34
Lithographic proofs of Special and Miscellaneous Maps	41
Photographic proofs of Standard Sheets, Large Scale Plans, and various other Maps	297
Projection and Examination of graticules and plotting of points	25
TOTAL	825

N.B.—In addition to the above, many miscellaneous jobs such as tracings of charts, supply of geographical data to various officials calculation of areas, examination of the proof sheets of "Survey of India Notes" and of Narrative Reports of Survey Parties as to the correct orthography of names, &c., have been performed by the Examining Section.

DRAWING OFFICE, CALCUTTA.

SECTION II.—REVENUE.

Statement showing the work performed during the year 1886-87.

Title of Map.	Number of Sheets.	Scale.	REMARKS.
STANDARD MAPS.		I. M.	
Punjab.			
District Hissar	14	1 = 1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheets 243, 244, 257, 258, 259 and 260	...	...	Final press order given.
Sheets 241, 242, 256 and 261	...	...	Marginal sheets completed and sent to press.
Do. do.	43	2 = 1	All published.
District Rawalpindi (Kahuta Forest)	42	4 = 1	
Sheets 160 $\left(\frac{\text{N.E.}}{2, 3, 4}, \frac{\text{S.E.}}{1, 2, 3, 4}\right)$, 161 $\left(\frac{\text{N.E.}}{1, 2, 3}, \frac{\text{S.E}}{2, 3, 4}\right)$, 162 $\left(\frac{\text{N.E.}}{1, 2, 3, 4}\right)$, 183 $\left(\frac{\text{S.W.}}{3}\right)$, 185 $\left(\frac{\text{S.W.}}{2, 3, 4}\right)$, and 186 $\left(\frac{\text{N.W.}}{1, 2, 3, 4} \frac{\text{S.W.}}{1, 2, 3, 4}\right)$	...	...	Fair sheets and proofs examined. Publication deferred pending settlement of Forest boundaries.
Sheets 160 $\left(\frac{\text{S.E.}}{2, 3}, \frac{\text{N.E.}}{3, 4}\right)$ and 160 $\left(\frac{\text{N.E.}}{3}, \frac{\text{S.E.}}{2, 4}\right)$	...	...	Proofs examined and sent to press for corrections and insertion of Forest boundaries supplied by executive officer.
Districts Jullundur and Ludhiana	12	1 = 1	Drawn on the 2″ scale for reduction by photography to the 1″.
Sheets 250, 251, 252, 253 and 268	...	...	Passed with final press order with the exception of No. 253 which is being completed up to margin.
District Delhi	7	1 = 1	Examined and final press order given for reprint.
Sheets 298, 299, 319, 320, 321 and 322	...		
North-Western Provinces and Oudh.			
Meerut Division	35	1 = 1	Drawn on the 2″ scale for reduction by photography to the 1″.
Sheets 23, 36, 37, 52 and 53	...	...	Marginal sheets completed and under examination. 30 sheets published.
Sheets 23 (N.E., S.E.), 36 (N.W., N.E., S.W., S.E.), 37 (N.W.), 52 (N.W., N.E., S.W., S.E.), 53 (N.W., N.E., S.W., S.E.)	119	2 = 1	Proofs examined. Publication deferred pending receipt of lists giving the correct spelling of village names. 104 sheets published.
District Gorakhpur— Sheets 191 (S.W., S.E.), 192 (N.W., N.E., S.W., S.E.), 206 (N.W., N.E., S.W., S.E,), 207 (N.W., N.E., S.W., S.E.), 208 N.W., N.E., S.E.), 216 (N.W., S.W.), 217 (N.W., S.W.)	16	1=1	Drawn on the 2″ scale for reduction by photography to 1″. Skeleton sheets showing trijunctions of villages were received during this and previous years. Portions of Sheets Nos. 192 N.W., 207 N.E., S.E., S.W. and 208 N.E. have been pentagraphed from the 16″ plans and inked up. Nos. 216 and 217 have been drawn and completed. The latter is a marginal sheet.
District Mirzapur	18	1=1	Drawn on the 2″ scale for reduction by photography to the 1″.
Sheets 183	...	...	Drawn, examined and sent to Press.
Sheets 198, 199 and 212	...	...	Drawn and examined, awaiting completion to margin.
„ 169, 182, 184, and 197	...	...	Under examination.
„ 170 and 171.	...	...	In hand.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—continued.

Title of Map.	Number of Sheets.	Scale.	Remarks.
Standard Maps—*contd.*		I. M.	
District Mirzapur—*contd.*			
Sheets 168 N.E., 169 $\left(\frac{N.E.}{E.}, \frac{N.W.}{W.}\right)$, 182 $\left(\frac{N.W.}{W.}, \frac{N.W.}{E.}\right)$, and 184 $\frac{N.E.}{E.}$	...	...	Field sections received from No. 14 Party to be incorporated with the 1″ standards.
Districts Benares, Ghazipur and Ballia .	16	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheets 194, 208, 209, 217, 218, 219, 220 and 221	...	...	Examined with 16″ plans, corrected and press order given.
„ 195	...	...	Marginal sheet completed.
„ 210, 211	...	...	Examined with 16″ plans, corrected and sent to press.
„ 180, 181, 182, 196, and 197 . .	...	...	Preliminary examination completed and under correction.
Oudh	65	1=1	
Sheets 86, 87, 116, 119, 122, 132, 133 and 134	...	...	Press order given.
„ 102, 104, 117 and 118	...	...	Sent to press for correction. 36 sheets published.
Bengal.			
District Cuttack	16	1=1	
Sheets 194, 195, 196	...	...	A portion of the district being specially drawn for the Irrigation Department. At present in abeyance.
District Jalpaiguri	14	1=1	Nine sheets published last year.
Sheets 293, 294, 315, 338 and 339 . .	...	...	All published.
District Mymensingh, Nos. 343, 344, 345, 346 and 364.	23	1=1	Proof received from Press and sent to District officials for corrections and additions. No. 344 sent to press for omissions to be supplied.
Bombay.			
Konkan	...	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheet 160	...	...	Examined. Publication deferred until the portion of Dharampur State is surveyed, when it will be sent to the field party for completion.
Sheets 135 and 161	...	...	Press order given.
„ 134 and 168	...	...	Examined, corrected and sent to Press.
South Maratha Country	...	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheets 172, 173, 204, 275, 276	...	...	Examined, corrected and sent to Press.
„ 203, 238, 239 and 270	...	...	Press order given.
Burma.			
Districts Bassein, Henzada, Prome, Tharrawaddy, Hanthawaddy, Pegu and Shwegyin	...	1=1	Drawn on the 2″ scale for reduction by photography to the 1″ scale.
Sheets 178, 179, 180, 181, 227 and 228 . .	...	...	Drawn in this office, examined and passed with press order.
„ 140, 182, 183, 184, 185 and 186 .	...	...	Examined and press order given.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—continued.

TITLE OF MAP.	Number of Sheets.	Scale.	REMARKS.
		I. M.	
Sheets 322, 323, 324 and 325 . . .	...	...	Examined and press order given, with the exception of No. 324 which awaits return of proof from District Officer.
" 141 and 231	...	...	Redrawn and sent to Press.
" 232	...	...	Redrawn and under correction.
PLANS OF CITIES, CANTONMENTS, &C.			
Benares City including Sikrol and Pandipur Cantonments.	4	8=1	Plotted and pentagraphed. Drawing of one section in hand. At present in abeyance.
Government Cattle Farm, Karnal . .	4	16=1	Final press order given.
INDEX MAPS.			
Standard Sheets, North-Western Provinces and Oudh.	1	...	Drawn and sent to Press.
Standard Sheets, Central Provinces . .	1	...	Ditto.
Do. do. Bengal	1	...	Ditto.
Survey Operations in the Punjab . . .	1	...	Ditto.
Cadastral Survey in District Bilaspur . .	1	...	Ditto.
Do. do. Tarai . .	1	...	Ditto.
Do. in districts Kamrup, Darrang and Nowgong.	1	...	Ditto.
Cadastral Survey in District Akyab . .	1	...	Ditto.
Do. in districts Bassein and Thongwa.	1	...	Ditto.
Survey of the Town of Calcutta . . .	1	...	Ditto.
Cadastral Survey in Sankarpur Estate . .	1	...	Ditto.
Do. do. in Angul Estate . .	1	...	Ditto.
Traverse Survey in Districts Seoni and Chhindwara.	1	...	Ditto.
Traverse Survey in Districts Saugor and Narsinghpur.	1	...	Ditto.
Sheets of the Hooghly River Survey . .	1	...	Ditto.
Examination of Proofs.			
Photo-zincographed maps	361		
Lithographed maps	38		

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—continued.

DESCRIPTION OF WORK.	REMARKS.
Computations examined.	
Districts Ajmere and Merwara, Seasons 1883 to 1886.	
District Benares, „ 1882 to 1884.	
Traverse Data, &c., supplied.	
Oudh Forest, District Kheri	To Superintendent, Forest Surveys.
District Hanthawaddy along District Thongwa (12 pages).	To Deputy Superintendent of Surveys.
Bahawalpur State along Jacobabad and Rohri (28 pages).	For Superintendent, Sind Survey.
Main Circuit, Nos. 3, 4, 10 and 11, District Mirzapur along unsurveyed portion.	To Deputy Superintendent of Surveys.
Main Circuits, Nos. 2 and 3, District Bassein, along unsurveyed portion.	To Deputy Superintendent of Surveys.
48 villages of Mirzapur	Ditto ditto.
Certain Bombay villages	To Survey and Settlement Commissioner, Punjab.
4 villages	To the Collector of Patna.
8 „	Do. of Pubna.
7 „	Do. of Sarun.
3 Frontier Circuits of Sylhet	To Surveyor.
Triangulation data and description of G. T. S. along Sylhet and Tipperah boundary	Ditto.
Field Area Statement of 1 village, District Pegu .	To Superintendent of Survey and Registration.
Values and description of Level Bench-marks in Bahraich.	To Executive Engineer, Oudh and Rohilkhand Railway.
Latitudes, longitudes, and azimuths of Topographical Survey Stations in Raipur.	To Assistant Superintendent of Surveys.
Latitudes, longitudes, and azimuths of Topographical Survey Stations in Bilaspur.	Ditto ditto.
Latitudes, longitudes, and azimuths of Topographical Survey in Sambalpur.	Ditto ditto.
Alphabetical and statistical statement of Bhagalpur (28 pages).	To the Collector of Bhagalpur.
Miscellaneous.	
Preparation of a statement showing area and cost of all the districts and Native States in the Punjab.	For Secretary, Government, Punjab.
Preparation of a statement of Waste Land Blocks in Hoshangabad.	For Deputy Commissioner.
Computation of rectangular co-ordinates for the projection of Districts Bassein, Gonda and Sirsa.	
Computation and plotting for the settlement of disputed boundary between Bahawalpur State and Dera Ghazi Khan.	
Computation and plotting for a congregated map of certain villages of District Pubna.	For Collector of Pubna.
Preparation of area statement of District Mirzapur by perganas.	
Preparation of a statement showing area and cost of Districts Moradabad, Muttra, Agra, Hamirpur and Banda.	For Revenue Board, N. W. P.
Calculation of areas by *parganas* of 2″ sheets Nos. 3, 7, 23, 37, 183, 194, 208, 209, 210, 219, 220, and 221, N. W. P.; Sheets Nos. 241, 242, 243, 256, 257, 258, and 261, Punjab; Sheet No. 68A., Deccan.	
Preparation of tables and returns for Annual Report.	
Calculation of areas of offsets of the villages of Districts Ajmere and Merwara, as also preparation of Alphabetical Indexes, &c., &c.	In progress.
Revision of areas of Districts Bahraich, Gonda and Kheri according to present boundaries.	

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of work—concluded.

TITLE OF MAP.	Scale.	REMARKS.
Tracings.	I. M.	
Seven village plans of Pargana Chunar, District Mirzapur.	2=1	For Collector.
Sheets Nos. 11 and 12, Tahsil Gurgaon, District Gurgaon.	4=1	For Deputy Commissioner.
Sixty-two village plans of District Sarun bordering on District Gorakhpur, with index.	4=1	For Deputy Superintendent of Survey.
One village plan of Pargana Gayhutta, District Pubna.	4=1	For Collector.
Five village plans of Pargana Mulki and Ghiaspur, District Monghyr.	4=1	For Collector of Patna.
Skeleton tracing of portion of sheet 216, District Monghyr.	1=1	Ditto ditto.
One village plan of Pargana Nathpur, District Bhagalpur.	4=1	For Collector.
Boundary along unsurveyed portion of Colonel Anderson's work, District Mirzapur.	2=1	For W. H. Patterson, Esq.
Twenty-three village plans of District Sarun bordering on District Gorakhpur, with Index.	4=1	For Major Sandeman.
One village plan of District Sylhet .	4=1	For Assistant Surveyor.
Sheets Nos. 6 and 7, District Gurgaon	4=1	For Deputy Commissioner.
Two village plans of Pargana Chunar, District Mirzapur.	4=1	For W. H. Patterson, Esq.
Five Cadastral plans of District Dehra Dun.	16=1	For Colonel Haig, Deputy Surveyor-General.
Portion of M. C. No. 30 D. Survey .	1=1	For Collector of Mymensingh.
Portion of Sheet No. 4, District Pubna.	1=1	Ditto ditto.
Seven villages of Pargana Esuphshahee, District Pubna.	4=1	For Collector of Pubna.
One village plan of Pargana Barabaju, District Pubna.	...	Ditto ditto.
Portions of Parganas Barabaju and Mehmanshahee comprising Thanah Sherpore, District Bogra.	1=1	For Magistrate of Bogra.
Portion of Sheet No. 168 S.E., District Mirzapur.	2=1	For W. H. Patterson, Esq.
Two villages, Ganges Deara Survey	4=1	For Collector of Patna.
Portions of Sheets Nos. 80, 83, 84 and 85 of District Bareilly bordering on District Tarai.	4=1	For Deputy Superintendent of Surveys.
Six village plans of Pargana Esuphshahee, Barabaju and Kagmari, District Mymensingh.	4=1	For Collector of Mymensingh.
Portion of map of District Pooree, season 1840-41.	1=1	For Collector.
Portion of maps of British and Native territories in Bundelkhand.	1=1	For Executive Engineer, Charkhari State.
Two village plans of District Umballa	4=1	For Settlement Officer.
One village plan of District Bhagalpur.	4=1	For Deputy Commissioner, Sonthal Parganas.
Eighteen sheets of Bahawalpur State along Sind.	4=1	For Superintendent, Sind Revenue Survey.
Parganas Gurla, Tarreya and Mokrunpur, District Goalpara.	2=1	For Deputy Commissioner.
Sheets 78, 79 and 80, District Karnal	4=1	For Superintending Engineer, Western Jumna Canal.
Sixteen sheets Ganges Deara Survey	4=1	For Superintendent, Way and Works, Eastern Bengal State Railway.
Sheets Nos. 231 N.W. and S.W., and 232 N.W. and S.W., District Henzada.	2=1	For Captain A. Carpenter, Marine Survey.

DRAWING OFFICE, CALCUTTA.

SECTION III.—CADASTRAL.

State of Publication of Cadastral Maps on the 30th September 1887.

Districts.	Number of Sheets. Maps prepared. Up to 30th September 1886.	Added during past 12 months.	Total up to 30th September 1887.	Published. Up to 30th September 1886.	By Surveyor-General's Office during past 12 months.	Total to 30th September 1887.	Remaining to be published.	Remarks.
North-West Provinces.								
Agra	2,942(*a*)	...	2,942	2,942	...	2,942	...	
Azamgarh	930	...	930	930	...	930	...	
Ballia	1,394	...	1,394	1,394	...	1,394	...	(*a*) Figures of previous return have been changed to agree with final results.
Banda	3,317	...	3,317	3,317	...	3,317	...	
Basti	3,010	1,535	4,545(*b*)	199	1,291	1,490	3,055	
Benares	1,816(*a*)	...	1,816	1,810	6(*c*)	1,816	...	
Bijnor	31	...	31	31	...	31	...	
Dehra Dun	701	...	701(*b*)	651	...	651	50	
Ghazipur	3,050	...	3,050	3,050	...	3,050	...	
Gorakhpur	3,243	1,629	4,872(*b*)	1,123	1,231	2,354	2,518	(*b*) These figures are liable to alteration until publication has been completed.
Hamirpur	2,926	...	2,926	2,926	...	2,926	...	
Jaunpur	3,434	...	3,434	3,434	...	3,434	...	
Moradabad and Tarai	4,023	...	4,023	4,023	...	4,023	...	
Muttra	1,658	...	1,658	1,658	...	1,658	...	
Mirzapur	3,645(*a*)	...	3,645	3,638	...	3,638	7	
Tarai	346	...	346	346	...	346	...	(*c*) Includes 5 sheets of Benares City survey on the 32-inch scale.
TOTAL	36,466	3,164	39,630	31,472	2,528	34,000	5,630	
Burma.								
Akyab	1,861	441	2,302(*b*)	647	662	1,309	993	
Bassein	3,076	...	3,076	3,076	...	3,076	...	
Hanthawaddy and Pegu	4,601	...	4,601	4,601	...	4,601	...	
Henzada	1,391	...	1,391	1,391	...	1,391	...	
Prome	847	...	847	847	...	847	...	
Tharrawaddy	1,363	...	1,363	1,363	...	1,363	...	
TOTAL	13,139	441	13,580	11,925	662	12,587	993	
Bengal.								
Patna and Gya	3,054	...	3,054	3,054	...	3,054	...	
Pooree (Khorda Estate)	4,565	...	4,565	4,565	...	4,565	...	
Shahabad	4,924	...	4,924	4,924	...	4,924	...	
Mozufferpore	...	1	1	...	1	1	...	
TOTAL	12,543	1	12,544	12,543	1	12,544	...	
Assam.								
Kamrup	1,675(*a*)	...	1,675(*b*)	1,023	652	1,675	...	
Sylhet	61	...	61	16	...	16	45	
TOTAL	1,736	...	1,736	1,039	652	1,691	45	
Central Provinces.								
Raipur	43	...	43	43	...	43	...	
TOTAL	43	...	43	43	...	43	...	
GRAND TOTAL	63,927	3,606	67,533	57,022	3,843	60,865	6,668	

Abstract of work performed during 1886-87.

Province.	Number of Sheets. Examined and rendered suitable for Photo-zincography.	Traced and examined for Zincography.	Proof copies examined previous to press orders.	Coloured and subsequently examined.	Remarks.
North-West Provinces	1,863	817	2,583	2,528	Scale 16 inches=1 mile.
Burma	296	60	502	662	Ditto ditto.
Bengal	1		1	...	Ditto ditto.
Assam	401	234	652	...	Ditto ditto.
TOTAL	2,561	1,111	3,738	3,190	

ENGRAVING OFFICE, CALCUTTA.

Statement showing the work performed during the year 188 -87.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks.
	Sq. In.	Letters cut.	Sq. In.	
Indian Atlas.	...	...	...	Scale 1 inch = 4 miles.
Quarter Sheets (new) completed.				
6 S. E.	...	1,264	...	Produced in heliogravure, title, imprint, and outside lettering cut.
12 N. W.	18	3,380	61 H 8 marsh	Completed.
14 S. W.	...	1,166	...	Produced in heliogravure, outside lettering engraved.
15 S. W.	...	1,150	23 H.	Completed to margin.
18 S. E.	...	455	19 S. H.	
20 S. E.	...	698	10 H. 23 S.H.	
50 N. E.	7	13,189	7 H.	
Total	25	21,302	101H 42 S.H. 8 marsh.	
Quarter Sheets (new) in progress.				
11 N. W.	18	1,480	...	Scale and outside figures cut, outline in progress.
11 S. E.	50	98	...	Outline completed as far as material supplied, writing about to be put in hand.
11 S. W.	130	2,214	...	Ditto ditto.
12 N. E.	5	...	..	Slight additions to outline, completed.
14 N. E.	...	412	...	Outline and writing completed as far as material supplied.
14 S. E.	...	3,586	...	
15 N. W.	16	4,612	...	
16 N. W.	...	3,910	...	Writing in progress.
16 S. W.	...	8,056	...	
19 S. E.	...	102	15 H.	Well advanced, almost completed.
21 S. E.	...	110	...	Slight corrections completed.
21 S. W.	...	1,382	...	Outside figures and new scale cut.
22 N. E.	2	8,024	...	Reprojected, new border and scale cut, outline and writing completed as far as material supplied.
23 N. E.	36	2,290	...	Reprojected, new border and scale cut, outline and writing in progress.
23 S. E.	38	1,675	...	Water-lining, additional outline and writing completed, as far as material supplied, hills just commenced.
24 N. E.	5	...	...	Additional outline completed as far as material supplied.
27A S. W.	3	515	...	Border and outline completed as far as material supplied, writing in progress.
28 S. E.	...	5,169	...	Electrotyped from the full plate, border engraved, corrections in progress.
28 S. W.	12	4,9 7	26 H.	Electrotyped from the full plate, border, new scale, outside figures and additions completed, under examination.
35 S. W.	...	1,336	40 H.	In progress.
36 N. W.	2	44	...	Slight corrections to outline and writing, completed.
37 N. W.	1	9,860	...	Outline and writing completed as far as material supplied.
37 S. W.	...	3,091	...	Writing completed as far as material supplied.
38 N. E.	...	412	...	
38 N. W.	...	158	...	Slight corrections, completed.
39 N. E.	...	4,537	...	Writing in progress.
39 N. W.	...	50	152 H.	Hills well advanced, in progress.
39 S. E.	...	...	134 H.	
Carried over	318	68,080	367 H.	

ENGRAVING OFFICE, CALCUTTA.

Statement of work—continued.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks.
	Sq. In.	Letters cut.	Sq. In.	
Quarter Sheets (new) in progress—continued.				
Brought forward .	318	68,080	367 H.	
40 N. W.	...	260	...	Writing in progress.
42 S. E.	...	5,089	...	Writing completed as far as material supplied.
43 N. E.	...	4,083	...	
43 S. E.	...	66	...	Slight corrections, completed.
48 N. E.	...	13,698	...	Outline and writing completed to margin, waiting hill drawing.
48 N. W.	10	...	...	Border cut and outline completed, as far as material supplied.
48 S. W.	...	2,748	...	Outline and writing completed, as far as material supplied.
50 N. W.	172	...	...	Outline well advanced, in progress.
50 S. E.	150	11,384	8 S. H.	Well advanced, writing almost completed.
57 N. W.	110	...	...	Outline completed as far as material supplied.
57 S. W.	42	...	...	
59 N W.	126	1,882	...	Outline completed as far as material supplied, writing in progress.
59 S. E.	128	66	...	
59 S. W.	232	5,941	...	Outline completed to margin, writing in progress.
60 N. E.	27	19,467	...	
60 N. W.	...	10,963	...	Outline and writing completed to margin, numerous lakes shaded, hills just commenced.
60 S. E.	129	7,479	...	Outline completed to margin, writing well advanced, in progress.
60 S. W.	221	1,235	...	Outline completed as far as material supplied, border and outside figures cut, writing about to be put in hand.
61 N. E.	...	3,292	...	Outline and writing completed to margin, lakes shaded, waiting hill drawing.
61 N. W.	110	525	...	Outline completed as far as material supplied, outside figures cut, writing about to be put in hand.
68 N. W.	...	2,609	...	Writing in progress.
75 S. E.	...	1,875	...	
76 N. E.	...	125	...	Slight additions finished, waiting hill drawing.
76 S. W.	...	2,000	...	Additional writing cut, waiting hill drawing.
77 N. W.	...	...	...	Lakes shaded, outline and writing completed to margin, wating hill drawing.
78 N. E.	...	...	...	Reprojected, lakes shaded, completed as far as material supplied.
78 N. W.	79	...	...	Border cut, outline completed as far as material supplied, writing in progress.
78 S. W.	6	5,963	...	Outline completed as far as material supplied, writing in progress.
88 N. E.	...	6,589	...	Writing in progress.
88 S. E.	40	4,886	...	Outline completed as far as material supplied, outside figures cut, writing in progress.
103 N. W.	...	376	...	Outline completed as far as material supplied, outside figures cut, writing about to be put in hand.
103 S. W.	...	707	...	
114 S. E.	59	6,350	...	Outline completed as far as material supplied, writing in progress.
114 S. W.	4	4,670	...	Outline and writing completed to margin, hills about to be put in hand.
125 S. E.	...	12,295	...	Writing well advanced, in progress.
Total .	1,963	2,04,703	367 H. 8 S. H.	

ENGRAVING OFFICE, CALCUTTA.

Statement of work—continued.

Title of Map.	Outline.	Writing.	Hills and Sand.	Remarks.
	Sq. In.	Letters cut.	Sq. In.	
Additions and Corrections to Quarter Sheets.				
8 N. E.	...	10	...	Slight corrections, completed.
9 S. E.	10	400	...	Electrotyped, sandhills being taken off the matrix plate.
12 S. W.	2	18	...	Slight additions and corrections, completed.
20 N. E.	...	10	...	Slight corrections, completed.
22 S. E.	...	876	...	Corrections and additions, completed.
32 S. E.	...	265	...	
32 S. W.	...	59	...	Corrections to district names, completed.
33 N. E.	...	275	...	
33 N. W.	...	10	...	
36 S. E.	...	237	...	
37 N. E.	...	237	...	
38 S. W.	...	400	...	Heavy corrections to spelling, heights, &c., being carried out on the matrix plates.
39 S. W.	...	500	...	
45 S. E.	...	38	...	Slight corrections, completed.
48 S. E.	...	354	...	Corrections to outline and writing, completed.
51 N. E.	...	270	...	
53 N. W.	...	165	...	
53 S. W.	...	367	...	
66 S. W.	...	42	...	
67 S. E.	2	150	...	
70 S. W.	14	562	...	
71 N. W.	...	617	...	
71 S. W.	...	476	...	
91 N. E.	...	575	...	Slight corrections, completed.
91 S. E.	...	50	...	Electrotyped, corrections to boundaries and district names.
91 S. W.	...	1,135	...	Corrections and additions to railways, boundaries and district names, completed.
92 N. E.	...	318	...	Corrections and additions to boundaries and district names, completed.
92 N. W.	3	423	2 H.	Heavy additions and corrections to boundaries and district names, completed.
92 S. E.	2	50	...	
93 N. E.	...	50	...	Corrections and additions to boundaries and district names, completed.
93 N. W.	...	308	...	
95 N. W.	...	122	...	
105 S. E.	...	10	...	Slight corrections, completed.
126 N. W.	...	360	...	Additional railway engraved.
127 N. E.	20	50	...	Corrections and additions to boundaries and roads.
127 S. E.	20	50	...	
Total	73	9,839	2 H.	
Additions and Corrections to full Sheets.				
25	...	...	78H	Hills repaired, completed.
28	...	531	...	Additions and corrections engraved.
40	...	...	22H	Hills being repaired.
46	...	9,250	...	Writing recut, both hills and writing completed, the plate having undergone thorough repair.
47	...	...	143H	Hills being repaired, plate well advanced, in progress.
50	16	119	...	Additions and corrections to roads, canals and railways, completed.
65	...	...	211H	Hills being repaired, in progress.
79	..	16	...	Slight additions, completed.
94	30	2,987	...	Heavy additions and corrections to boundaries, roads and district names, in progress.
121	41	1,637	...	Ditto ditto, completed.
Total	87	14,540	454H	
New Plates projected, Borders cut, &c.				
57 N. E.	...	...	...	New border being cut, in progress.
75 N. E.	...	...	...	Projected, border being engraved, in progress.
75 N. W.	...	...	...	
75 S. W.	...	...	...	Projected.

ENGRAVING OFFICE, CALCUTTA.

Statement of work—continued.

Title of Map.	Number of sheets and scale.	Outline, square inches.	Number of letters cut.	Hills(H) Sand (S), square inches.	Remarks.
General Maps.					
India	6 1 inch=32 miles.				
Sheet 1 . .	...	102	148	10H.	Corrections and additions both on original and duplicate plates, large portion stoned off, re-projected, outline cut, writing in progress.
„ 2 . .	...	1	36	10H.	Hills engraved on duplicate plate, with slight additions to outline and writing.
„ 3 . .	...	25	58	155H.	Additional outline engraved, hills well advanced, in progress.
„ 4 . .	...	10	1,792	5H.	Corrections to outline, writing and hills completed.
„ 5 . .	...	...	325	...	Corrections to boundaries, railways and names both on the original and duplicate plates, completed.
„ 6 . .	...	...	10	...	Slight corrections, completed.
India	2 1 inch=80 miles.	...	58	...	Slight corrections, completed.
India	1 1 inch=96 miles.	...	34	...	
India	1 1 inch=128 miles.	...	58	...	
India	1 1 inch=256 miles.	...	32	...	
Himalaya route map .	1 1 inch=32 miles.	...	34	...	Slight additions, completed.
Total .	......	138	2,585	180H.	
Provincial Maps.					
Bengal	2 1 inch=16 miles.	...	1,236	201H.	Corrections to outline and writing, hills almost completed as far as material supplied, in progress.
Bengal	1 1 inch=64 miles.	...	36		
Rajputana . . .	Ditto	2	149	5H,13S.	Additional outline, writing and hills completed.
Central Provinces . .	Ditto	2	103	...	Corrections to outline, and writing in progress.
Punjab	4 1 inch=16 miles.	328	4,717	...	Outline completed, writing in progress.
Assam	1 1 inch=16 miles.	30	1,102	15H.	Additional outline, writing and hills completed.
Mysore	Ditto	129	688	...	Projected, border cut, outline well advanced, in progress.
Gujarat . . .	Ditto	...	...	...	Projected and awaiting material.
Orissa	Ditto	...	56	...	Slight additions, completed.
Oudh	Ditto	...	56	...	
Sind	Ditto	...	34	...	
Berar	1 1 inch=8 miles.	...	38	...	
Punjab	1 1 inch=32 miles.	37	1,600	...	Heavy corrections to outline and writing, completed.
Divisional Maps.					
Bhagalpur . . .	1 1 inch=16 miles.	...	36	...	Slight additions, completed.
Burdwan . . .	Ditto	...	36	...	
Chittagong . . .	Ditto	...	36	...	
Chota Nagpore . .	Ditto	...	34	...	
Carried forward .	......	528	9,957	221H,13S.	

ENGRAVING OFFICE, CALCUTTA.

Statement of work—concluded.

Title of Map.	Number of sheets and scale.	Outline, square inches.	Number of letters cut.	Hills (H) Sand (S), square inches.	Remarks.
Divisional Maps—*contd.*					
Eastern Districts, Dacca .	1 1 inch=16 miles.	...	36	...	Slight additions, completed.
Western Districts, Dacca .	Ditto	...	36	...	
Patna	Ditto	...	36	...	
Presidency . . .	Ditto	...	36	...	
Rajshahi and Cooch Behar	Ditto	...	36	...	
Plans of Cities and Cantonments.					
Simm's Plan of Calcutta .	4 14 inches=1 mile.	...	36	...	
Simla and Jutog, plan of .	1 3 inches=1 mile.	...	135	...	Corrections to outline and writing on two plates.
Administration Report Maps.					
Bengal	1 1 inch=80 miles.	3	837	...	Projected, border, outline and title engraved, writing about to be put in hand, being electrotyped, in various stages.
North-Western Provinces and Oudh . . .	Ditto	23	959	...	
Charts.					
Index Great Trigonometrical Survey . .	...	...	450	...	Additions, completed.
Miscellaneous.					
The Viceroy's appointment plate . . .	...	...	400	...	Slight alterations, completed.
Standard symbols for the Revenue Survey . .	...	...	2,775	...	Engraved.
Archæological Survey .	...	...	874	...	Two plates in heliogravure, lettering cut for Photo. Office.
Map Headings . .	...	...	361	...	Two plates, additions completed.
Imprint plates . .	...	...	1,050	...	Three plates, new plate engraved, old ones corrected.
Vernier scales . .	...	...	606	...	Five scales figured for Mathematical Instrument Office.
Theodolite Circle . .	...	...	599	...	One circle figured for Mathematical Instrument Office.
Scale of Gunter's chains 8 inches=mile . .	...	...	326	...	Completed.
Heliogravure plates .	...	...	804	...	Two titles cut for Photo. Office.
Total .	...	604	20,349	221H. 13S.	

Abstract of Work.

Engraving.	Plates.
Atlas sheets completed	7
Ditto in progress	63
General maps, plans, &c.	69
Repairs, corrections, and additions . .	46
Projections engraved, borders cut, &c. .	4
Total .	189

Copper-plate printing.	
Impressions taken	10,967
Proofs pulled	470
Transfers pulled	284
Total .	11,721

Steel-facing.	Plates.
Double elephant plates steel-faced .	19
Ditto ditto steel-removed .	38
Quarter plates steel-faced . . .	51
Ditto steel-removed . .	87
Miscellaneous plates steel-faced . .	17
Ditto ditto steel-removed .	5
Total .	217

Square inches of hill etching . .	1,388
Ditto of jungle etched . .	8
Ditto of outline . . .	2,890
Number of letters engraved . . .	273,318

PHOTOGRAPHIC OFFICE, CALCUTTA.

Extract from the Narrative Report of LIEUTENANT-COLONEL J. WATERHOUSE, *Assistant Surveyor General,—Season 1886-87.*

OUT-TURN.—Owing to a large decrease in the number of original subjects received for reproduction, the out-turn of work for the year is considerably below the average. In the Zinc-printing Section, the number of copies printed of ordinary departmental and extra-departmental maps and plans also shows a falling off as compared with the number of original sheets received. Of cadastral maps the average number of copies printed of each original sheet is slightly in excess of last year, though the total, both of original sheets and printed copies, is much less. The number of prints turned out by the helio-gravure and photo-collotype processes and of hand-engraved plates electrotyped is greater than in any previous year.

ORIGINAL SUBJECTS.—The total number of original maps and plans received for reproduction in the Normal Sections of the Office was 1,185, as against 1,518 in the preceding year. Of these, 719 were the regular departmental maps and 466 were received from other departments. In the Cadastral Sections, 3,618 original sheets were received, of which 2,502 were reproduced by photozincography and 1,116 zincographed from tracings.

NEGATIVE SECTION.—During the year, the number of negatives taken was 4,369, inclusive of reversed negatives and transparencies, of which 1,154 were of departmental maps, 713 extra-departmental maps and plans and 2,502 cadastral maps.

The processes employed in this section have for the most part remained unchanged throughout the year. The method of intensifying with bromide of copper and nitrate of silver was abandoned on account of the expense, but has lately been tried again with improvements which make it much cheaper in working and it is now being used very successfully in the Cadastral and Normal Sections and will be further reported on in due course next year.

Some experiments were made with the view of introducing a cheap substitute for the benzole crystal varnish with which all negatives that require to be kept for any length of time are coated. The varnish is prepared by dissolving shellac in a solution of borax and carbonate of soda. The formula was given in the *British Journal of Photography* for April 22nd 1887 and is as follows:—

Bleached lac (ordinary best pale shellac will answer)	32 parts.
Borax	8 "
Carbonate of soda	2 "
Glycerine	1 to 2 "
Water	320 "

The borax and carbonate of soda are dissolved in 160 parts of hot water and the lac, broken into small pieces, is added. The containing vessel is then placed over a clear fire and stirred until the lac is dissolved. The solution is allowed to cool partially and then filtered, after which the glycerine is added and the bulk made up to 320 parts. After a few days, a sediment separates out, and the solution should again be filtered till clear and bright This varnish, though very suitable for gelatine negatives, for which it was originally recommended, was found scarcely strong enough for collodion ngatives, with the very tender films resulting from intensification with bichloride of mercury followed by hyposulphite of soda and ammonia. With the addition of more shellac it may perhaps be found suitable for the negatives intensified with bromide of copper and silver. It has the advantage of exceeding cheapness, costing only about 4 annas a litre, while the comparatively cheap crystal varnish costs R3-8 per litre and alcoholic varnishes are still more costly.

In July this section lost the services of Mr. J. Mackenzie, the Head Photographer, who was compelled by failing health to retire on an invalid pension after 25 years' service. During the whole of this period Mr. Mackenzie had been attached to the section, and the perfection to which the processes had been brought is in a great measure due to his industry and skill. On his retirement Mr. G. G. Dempster held charge of the section from the 16th July until the 12th August, when Mr. H. Haward returned from privilege leave and was placed in charge.

PHOTO-TRANSFER SECTION.—The number of photo-transfers printed was 4,299, of which 1,775 were departmental and extra-departmental maps and plans and 2,524 cadastral maps.

A new method of preparing the transfer paper with arrowroot was introduced during the year, which has the advantage of being very much cheaper than the method of coating with gelatine usually adopted, and of giving results quite as good, if not better.

Bank post paper is coated in the usual way with two coats of the following mixture:—

Arrowroot	140 parts.
Bichromate of potash	70 "
Water	3,500 "

In the cold weather the bichromate may be increased to 90 parts. After exposure to light the prints are coated with transfer ink in the press as usual, the transfer ink used being composed of—

Hard retransfer ink (plate to stone)	100 parts.
Litho-chalk ink	100 to 140 "
Palm oil	7 "

After inking in, the prints are washed off with hot water—hotter than is required for gelatine transfers, but in the cold weather it has been found better to use cold water for soaking and washing off, only finishing with hot to remove the soluble arrowroot. Under favourable conditions the arrowroot transfer prints go down well on the zinc and give almost clearer and sharper transfers than gelatine, but considerable trouble has been found in working the process from the difficulty of clearing the prints from soluble arrowroot which appears to spread over the lines while the prints are hung up to dry or during transfer and prevents the transfer ink from taking properly on the zinc. It may also be stated that whereas the arrowroot was found to give better transfers than gelatine in the hot weather and rains it has not done so in the cold weather. Efforts are being made to overcome these difficulties without having to revert to gelatine which is over 40 times more expensive.

Some experiments were made by Mr. Harrold with Sergeant-Major Husband's process known as "Papyrotint," briefly described in last year's report, by which grained transfers suitable for printing from stone or zinc are prepared from half-tone negatives. Mr. Harrold has succeeded in obtaining fairly good results from a modification of the process which may be described as follows:—

Thick bank post paper is floated for about a minute on a solution of—

Gelatine (opaque No. 2)	6 parts.
Common salt	1 „
Water	46 „
Glycerine	1 „

and hung up to dry in a temperature of about 100°F., and when dry, coated a second time. When again perfectly dry, the paper is sensitised in a bath of bichromate of potash consisting of—

Bichromate of potash	10 parts.
Common salt	5 „
Ferridcyanide of potash	2 „
Water	300 „

The paper is floated on the solution for one minute and dried by heat in the usual way when it is ready for printing. The length of exposure depends on the quality of the negative. A good clear negative requires about one minute in bright sunlight or six minutes in the shade. When printed, the paper is soaked in cold water for a few minutes, then dried between sheets of blotting-paper and rolled up with the ink ordinarily used for coating photo-transfers or with an ink of the following composition—

White virgin wax	1 part.
Stearine	1 „
Common resin	1 „
Chalk printing ink	8 parts.

This mixture should be reduced to the consistency of cream with spirits of turpentine and a small quantity spread on the print with a sponge. An India-rubber roller is then charged with the same ink, but of a slightly thicker consistency than that which is applied with the sponge, and the print is rolled up in the usual way. It can then be washed and put down on zinc or stone like an ordinary photo-transfer. If a coarse grain is required it can be easily obtained by using a thicker coat of gelatine on the paper.

The process has not yet come into regular use, but could be used in cases where collotype or heliogravure would be too slow or not otherwise applicable. For general purposes the method of transfer from heliogravure plates prepared with a coarse grain, as noticed under that section, appears likely to be more useful.

Silver Printing Section.—There was not a very great demand for silver prints during the year. The number printed was 1,308, including 485 prints of Major Durand's Afghan Boundary Commission sketches, supplied to the Foreign Department; two complete sets of prints of Mr. C. L. Griesbach's negatives, made for the Director, Geological Survey, and 277 prints of Mysore Topographical Survey sheets supplied to the Mysore Government.

For ordinary office purposes, reductions of standard sheets, &c., silver printing has been almost entirely replaced by the cheaper cyanotype process, by which 128 prints were produced. This section was also employed in preparing albums of photographs of the Gilgit Mission, for the Viceroy and Foreign Office, and of the Exhibition photographs for the Revenue and Agricultural Department.

Photo-collotype Section.—In this section 6,608 prints were made from 30 plates. The number of prints is much larger than last year, though fewer plates were prepared. The style of work turned out maintains its high quality and would compare favourably with that done in European establishments.

The work done by this process during the year includes several plates of inscriptions for the Archæological Survey; copies of coins and of a broken clay seal for the Asiatic Society, taken from the originals; and a plate of *Ficus Roxburghii*, for the Superintendent of the Royal Botanical Gardens, from a very dense paper negative taken from nature by Dr. D. D. Cunningham. Nearly all the subjects were of unusual difficulty and showed well the capabilities of the process.

Owing to the section being fairly well employed throughout the year, not much experimental work was done, but trials were made of Husnik's method of employing zinc plates as a substitute for the thick glass plates used as support for the gelatine printing surface. The plates did not stand printing well and gave no advantage over the ordinary process.

HELIOGRAVURE SECTION.—The work done by Mr. A. W. Turner in this section shows a very satisfactory increase, and both processes, photo-electrotype and photo-etching, have been worked steadily and successfully throughout the year. The number of plates reproduced by photo-electrotype was 22, or 12 more than last year, and 23 plates were reproduced by the photo-etching process. The total number of prints was 292, chiefly copies of a plate of a very well executed drawing of the Central Bay of the Temple at Ittigi (Archæological Survey of Western India) for the Technical Art Series of the Government of India. In addition to these, however, 1,185 copies of three plates were printed in the copper-plate presses of the Engraving Office.

Photo-electrotype.—There has practically been no change in the working of the photo-electrotype process during the year. It has given very good results for fine line work, as in the case of the pen-and-ink drawings of the Archæological Survey of Western India, which have been reproduced in consultation with Sir Edward Buck and Dr. Burgess for a Technical Art Series, for the use of Art Schools and also for the illustration of Dr. Burgess' Archæological Survey Reports. Transfers of them are also to be sent to Mr. W. Griggs for the illustration of the *Indian Art Journal.* Four of these drawings have been reproduced during the year, besides two of the Madras Archæological Survey. A sheet of the Andaman survey on the ¼-inch scale has also been reproduced by direct reduction of two standard sheets on the ½-inch scale. It is intended to reproduce all these sheets in this manner and avoid the expense of hand-engraving. A quarter sheet of the Atlas of India, No. 6 S.E., has also been reproduced in this manner from a pen-and-ink drawing specially prepared for the purpose. Another quarter Atlas sheet, No. 14 S.W., with brush-shaded hills, was also reproduced from the original drawing by this process, the gelatine relief being treated with waxed emery powder, as described in the Annual Report of this office for 1881-82. This method is much more suitable than the photo-etching process for reproducing originals of this kind where brush-shading is combined with outline. The drawing in question had been rubbed with India-rubber and reproduced rather coarsely, but in other respects the reproduction was successful. Further experiments were tried with the method referred to in last year's Annual Report for obtaining half-tone transfers to zinc or stone by using a coarse sand grain and making a thin electrotype merely for transfers. The results were good and the process seems likely to be of service for the cheap reproduction of photographs in half-tone.

A new autogravure tissue, prepared by the Autotype Company, which I brought out from London, was tried in the early part of the year. The gelatine coating of this tissue contains a quantity of plumbago and black oxide of manganese with the object of giving a relief image with a sharp grain that will electrotype well without the further application of plumbago and not require any granulation with waxed sand or emery. It was not found, however, to work very well, the great opacity of the manganese preventing the light from penetrating sufficiently deep to obtain the required relief, and consequently the prints, whether in line or half-tone, were dull and flat.

Photo-etching.—Mr. Turner devoted most of his attention during the year to the photo-etching process and has made considerable improvements by following the method of etching the plates with a succession of baths of perchloride of iron solution of gradually diminishing strength, which I saw in use at the Military Geographical Institute at Vienna in 1886. The plates prepared by the process as originally tried here were found to stand very little printing, it being seldom possible to pull a sufficient number of proofs before steel-facing without seriously injuring the finer details. Moreover, in line subjects there was always a slight want of sharpness.

In the Vienna process the early stages of the operations are almost exactly the same as in the method we had worked out here (see Annual Reports for 1883-84 and 1884-85) with the exception that the dust-grain on the copper-plate is fixed by heat instead of by fuming with benzole or oil of lavender. Mr. Turner has, however, adopted the fixing by heat with advantage. The main difference is in the etching. We used only one bath, but in Vienna four are used, prepared by dissolving 68, 67, 66 and 65 parts of perchloride of iron respectively in 50 parts of water. These solutions are kept in bottles numbered 68, 67, 66, and 65.

The solutions are poured into four porcelain trays side by side, and the plate, having its back and the blank margins of the picture protected with black varnish, is immersed in the first or strongest solution for about five minutes, so as to etch the deepest shadows in the parts where there is little or no gelatine, and then transferred in succession to Nos. 2, 3, and 4 solutions, being kept for about five minutes in each, the progress of the etching being carefully watched meanwhile. After passing through the last bath the plate is plunged into cold water and washed till free from perchloride of iron.

The gelatine film having been removed by gently rubbing with a muslin or cotton rag, the plate is dried and washed with benzine to remove the resinous grain and varnish from the face. It is then turned over carefully and laid face downward on a sheet of clean paper and the varnish removed from the back. The face of the plate is next carefully rubbed over with fine whiting and ammonia, dried and polished off with a little spirit.

This method of cleaning the plate after etching has been found by Mr. Turner to be very useful.

The above solutions of perchloride of iron are considerably stronger than the etching solutions hitherto used in the office, and consequently they admit of the gelatine film being much thinner, which gives a much sharper image in biting. Mr. Turner has found that even stronger solutions can be used with advantage, and he is now using solutions at 45°, 40°, 36°, and 27° Baumé, as recommended by Professor W. Roese for the photo-typographic etching process noticed below. The specific gravities of the solutions, at the temperature of 63·5° F., are 1,4421, 1,3746, 1,3250 and 1,2254 respectively, the percentage of anhydrous perchloride being about 47, 41, 37, and 27. A solution made up to 48° B. was tried, but at this strength the thinnest possible film of gelatine formed a resist which the perchloride could not penetrate, even after prolonged soaking. The slight scum of gelatine which is almost always present, especially in the hot weather, formed as perfect a protection to the copper as a strong solution of asphalt. For ordinary subjects, therefore, a solution of this strength is practically too strong, but it might be found very useful for etching pure line subjects in relief if an image could be obtained absolutely free from any trace of gelatine in the parts required to be eaten away. With fresh tissue in the cold weather it might perhaps be done. For line subjects solutions of 45° and 40° B. need only be used, if the image is thin, and this gives a very sharp clean etching. For half-tone subjects, the strongest perchloride (45°) should not be left on for more than one minute after it first attacks the copper; the 40° solution may remain on 3 or 4 minutes; the 36° solution about 2 minutes, and the 27° may remain until it just reaches the highest lights, not, as a rule, more than one minute. The use, however, of the varying strengths of perchloride is a matter purely of practice. Almost any effect can be obtained by varying the length of time the plate is exposed to solutions of different strengths. Temperature must also form a very important factor in the working of the process. Another point experimented upon by Mr. Turner is the quantity of powdered asphalt requisite to give the plate the necessary grain, and he has found that provided the powder is very fine a much larger quantity can be used than he had previously used, with the effect of making the plate much stronger and obviating the danger of the finer tints wearing away before steel facing.

Too coarse a grain gives a woolly image and too small a quantity of it may give a plate from which a few good proofs can be taken, but which will not stand the wear and tear of printing for any length of time.

Plates etched by this process require no touching up beyond a little oil rubbing, which can easily be done without the assistance of a skilled engraver. They require careful, though not necessarily slow, printing. In fact, it is probable that more impressions could be got off in a day from one of these plates than from a hand-engraved plate when once the correct method of handling them has been acquired. Difficulty is still found in obtaining good results by the photo-etching process from a subject combining line and half-tone work together, such as brush-shaded maps with names and topographical details in outline, but Mr. Turner hopes to be able to overcome this in time.

The plates produced by the photo-etching process during the year include two very delicate drawings in pen and ink for the Scientific Memoirs, Indian Medical Department; two district maps, with hills, Hazára and Simla; two plates of a cocoanut grove, reproduced from the original negatives for the Government of Madras, and a medallion portrait of Her Majesty the Queen-Empress.

Photo-typographic etching.—Mr. Turner has also made further trials of photo-typographic etching processes, principally of a new method described in the *Jahrbuch für Photographie und Reproductions Technik*, for 1887, as practised by Professor Roese at the State Printing Office at Berlin, which gives exceedingly fine results.

The process is almost exactly the same as for *intaglio* photo-etching, the only difference being that a gelatine *positive* image is transferred from autotype pigment tissue, No. 103, on to the copper plate grained in the usual manner with asphaltum powder, the graining being repeated twice or three times if necessary. Instead of copper, brass plates may be used with the advantage of being cheaper. They are easily obtained of uniform texture and in this respect and in their resistance to wear are better than zinc, which is not suitable for this method. The perchloride of iron solutions for biting are of four or five different strengths—45°, 40°, 36°, 30° and 27°B. Distilled water should be used, but a little alcohol may also be added. The etching is performed in the same way as for the *intaglio* process, the plates remaining in each bath for a longer or shorter time as necessary, but as a rule about two to three minutes in each. During the etching the original should be referred to as a guide for comparison. For type-printing the depth of etching which would be sufficient for *intaglio* plates is not enough. The plate must therefore be rebitten until the proper depth is obtained. The rebiting is also done with perchloride of iron; the plate being carefully rolled in with wax-ink composed of—

Good printing ink	2 parts.
Bees' wax	1 „
Crude resin	1 „
(melted together)	

Of this ink, 100 parts are melted with 20 parts of turpentine and some asphalt.

Some of this composition is spread on a stone and the plate is carefully rolled in with it by means of a glue or leather roller or with a metal roller made of zinc, by which he finest parts remain open, and attention should be given that only the extreme surface should be touched with the ink, leaving the depths free for the etching to work upon. The plate is then etched with perchloride, the operation being repeated as often as necessary to reproduce the required depth. Subsequent retouches can be made with the burnisher for strengthening shadows and with the roulette for bringing up lights or the converse of the *intaglio* process. The rolling up requires great skill and intelligence. The printing also is difficult, especially for printers who have no experience of such blocks.

The results produced by this method at the State Printing Office, Berlin, and also at the Military Geographical Institute in Vienna, where a similar method is worked, far surpass those produced by any other process of photo-typography, and I should be glad if we could successfully work it here. The trials made with it were most promising, but it will require further working out, and it is to be feared that it will be difficult to find printers here capable of dealing with these delicate blocks.

Electrotyping.—There has been a considerable increase in the amount of electrotyping done during the year, and 21 matrices and duplicates have been prepared, in addition to the photo-electrotyped plates, and include 5 double-elephant plates of 3 sheets of the 32-mile map of India; 8 plates of 6 quarter-sheets of the Atlas of India and matrix and duplicate of a small Provincial Map of Bengal. In the cold weather some difficulty was found in working the tray batteries in consequence of the sulphate of copper crystallising out at night, but by testing the solutions occasionally with the hydrometer and by taking out the boxes of sulphate of copper crystals at night, the solution was kept at a proper point of saturation, (about 29° B.,) to prevent the formation of crystals in the depositing trough.

ZINC PRINTING SECTION.—The number of plates printed off by the Normal establishment during the year was 774, the number of pulls being 129,556 and of copies 161,781. During the early part of the year there was considerable activity in the Normal branch of the section, all the presses being constantly employed, but towards the close of the cold weather there was a large decrease in the number of requisitions received, both for departmental and extra-departmental work. The latter half of the year was one of unusual slackness and some difficulty was experienced in keeping the zinc printing establishment supplied with work. A similar scarcity of work prevailed also in the Cadastral branch throughout the year. The total number of plates printed in this branch was only 3,744, the number of pulls being 116,081 and of copies 108,832. It should be remembered, however, that the out-turn of work in both branches of the section during the preceding year was abnormally large, the actual printing work done being much in excess of that done during any previous year.

ORTHOCHROMATIC PHOTOGRAPHY.—During the year I have devoted a good deal of attention to the methods of orthochromatic photography by which coloured maps, drawings, paintings and other coloured objects can be reproduced with much more correct effect of light and shade than can be done by the ordinary processes; tints containing more or less yellow or orange, which even in very pale shades reproduce black in an ordinary photograph, appear light when the orthochromatic plates are used, while tints of blue which reproduce as white, even in apparently deep shadows of the drawing, are reproduced with their proper value as shadows.

In 1873, Dr. H. W. Vogel of Berlin published his discovery of the fact that bromide of silver plates stained with certain dyes became more sensitive than similar plates unstained for the region of the spectrum absorbed by a solution of the dye used for staining the films, and that by this means the sensitiveness of such plates to the yellow and red rays could be enormously enhanced; and he showed that by placing a yellow transparent screen in front of the lens a band of yellow paper on a blue background could be photographed as white on a dark ground instead of black on a white ground; or the exact converse of the usual order of things.

Early in 1875, I made some experiments in this direction in connection with the preparations for photographing the spectrum of the corona at the total solar eclipse of April 5th by the party at the Nicobar Islands, of which I was in charge. Having met Dr. Vogel on that occasion, I was led to continue the experiments, partly on scientific grounds, but more particularly with the more practical object, for our purposes, of reproducing coloured maps and drawings. During the course of this work I found that one of the dyes I was trying, a very fluorescent pink dye called eosin, at that time only quite recently discovered by Baeyer and Caro, possessed the power of enhancing the sensitiveness of collodio-bromide or bromo-iodide of silver plates used either wet or dry, to the yellow and green rays of the spectrum to a far greater extent than any other dye previously tried by Dr. Vogel or myself, except cyanin, which, however, is not so suitable for general work. Having omitted to use the yellow screen, I did not, however, find the addition of the dye of much advantage for copying coloured drawings and shortly afterwards had to give up the experiments for more practically important work in the office.

In 1882 Messrs. Taillefer and Clayton, of Paris, took out a patent for preparing isochromatic dry gelatine plates containing eosin in combination with ammonia, the latter addition being one of the special points of their patent. These plates practically solved the problem of obtaining dry plates with great sensitiveness to the yellow rays, suitable for copying coloured paintings and drawings. Since then Dr. Eder and other experimenters have investigated the subject very fully, and it seemed desirable to try these methods, so as to have the means of reproducing coloured maps or drawings when required, which, however, is not often the case.

My first trials were with some of the French isochromatic plates, which M. Taillefer was kind enough to give me for trial when I was on furlough in 1886. Some of the smaller ones gave very good results for the reproduction of water-colour drawings, and I was also able with them to obtain some very successful photographs of the fireworks and illuminations on the occasion of the celebration of Her Majesty's Jubilee in February. Their exceeding sensitiveness for yellow light may be judged from the fact that lights from oil lamps at the distance of two miles were reproduced distinctly with an exposure of only five minutes, and several of the photographs of fireworks, with practically instantaneous exposures, showed distinctly the paths of rockets, &c.

The larger plates of the same manufacture were not so successful, and as it is always doubtful whether these imported stained plates will keep well, especially in such a trying climate. To ensure success the plates must be prepared here, I therefore tried the formulæ, Dr. Eder, of Vienna, and other friends were kind enough to give me when last in Europe, by which ordinary dry plates can be rendered colour-sensitive when required by bathing them in an ammoniacal solution of erythrosin, an alkaline salt of tetraiodfluorescin which is of a bluer shade than the ordinary eosins which are salts of tetrabromfluorescin.

After many trials the following formulæ were found to give the best results.

(i) Process without silver—

Bathe the dry plates for about one or two minutes in a solution of erythrosin containing about 1 part of the dye in 10,000 parts of water with 1 to 2 per cent. of ammonia added. A preliminary bath of weak ammonia at about 1 per cent. is recommended, but I have not found it necessary.

(ii) Process with silver—

This is a modification of the formula recommended by Messrs. Mallmann and Scolik, in the *Photographische Correspondenz* for 1886, No. 315. It gives exceedingly sensitive plates with fairly good keeping properties and appears in some respects preferable to the method without silver, though the latter gives very good results and is much less troublesome. 50 c.c. of an erythrosin solution, 1 : 1000 in water, are heated in a water bath by candle-light or in the dark room, and nitrate of silver solution is dropped in as long as a precipitate falls. The precipitate is allowed to settle, the supernatant liquid decanted off, fresh distilled water added, and the precipitate thrown on a filter and washed with distilled water until the washings show no milkiness with hydrochloric acid. When this point is nearly reached, the dye will begin to dissolve and with some samples the precipitate is very soluble ; it is important, therefore, to use samples of erythrosin, or, preferably, the pure tetraiodfluorescin, which give an almost insoluble precipitate with nitrate of silver. (My best samples of these dyes have been obtained from Dr. T. Schuchardt, of Görlitz.) When all free silver has been removed, the precipitate is washed in the filter with 2 to 4 c.c. of strong ammonia mixed with 20 c.c. water. This generally dissolves the precipitate entirely and easily, but should it not do so, the ammonia solution can be passed through over and over again till all the dye is dissolved. Water may then be passed through the filter to make up 200 or 300 c.c., forming a bath in which the plates are bathed for one minute. Using the medium quantity of ammonia and water, the stained plates show a strong bluish pink colour when dry and retain a good deal of colour through developing and fixing till all the hyposulphite is washed out, when the dye also disappears.

Dry plates thus prepared seem to differ a good deal in their keeping properties. Some have kept well for over two months in the rains in a dark slide. Others, on the contrary, have shown fog round the edges in a few days. Keeping in ordinary grooved wooden or metal boxes is not to be recommended.

The plates must be prepared and developed in a very weak red or orange light and kept in the dark as much as possible.

For developing Marion's Britannia developer generally answers well and in many cases may be reduced to half-strength.

For work in this country dry plates should, if possible, be selected which will stand developing and washing without ice. Wratten and Wainwright's appear to be on the whole the most satisfactory, and for copying purposes the "ordinary" are better than the "instantaneous." Swan's plates are also very good, but are too soft for use in the hot weather.

In order to obtain the maximum of orthochromatic effect in copying coloured subjects with much blue or yellow in them, it is necessary to use a yellow screen to cut off the blue rays. The simplest and best way of doing this is to place a piece of thin structureless collodion (a collodion made with equal parts acetate of amyl and alcohol, with 1 to 2 per cent. of pyroxyline, has given me good results) stained yellow with a suitable yellow dye, such as chrysoidin, aurantia or uranin, in a double diaphragm made of thin sheet brass and used in place of the ordinary diaphragm of the lens. When using the yellow diaphragm the exposure must be increased about three times.

I have found that the same effect may be produced with greater advantage by throwing a beam of yellow light on to the picture while being copied. When sunshine is available an ordinary mirror covered with a film of gelatine, coloured with a suitable yellow dye, as above, may be used. The exposure is not longer than ordinarily required and the result is more harmonious than when the yellow diaphragm is used, the reds being

ORDINARY PLATE.

Bright yellow pagri.

Green pagri with orange pattern.

Dark grey cape and crimson vest.

Skirt, orange, with red chequers.

Photo-Collotype.

GROUP OF BURMANS.

Reproduced on an ordinary gelatine dry plate, unstained, from the original water-colour drawing by Colonel R. G. Woodthorpe, R.E., C.B.

Exposure 15 seconds.

ORTHOCHROMATIC PLATE.

Pink pagri with bright yellow flowers.

Blue coat.

Buff jersey.

Bright lemon yellow skirt with white lines.

Survey of India Offices, Calcutta, March 1888.

GROUP OF BURMANS.

Reproduced on an ordinary gelatine dry plate stained with erythrosin-silver. Yellow light thrown on from a looking-glass covered with a film of gelatine coloured with chrysoidin. Exposure 12 seconds.

particularly improved. The method has the further advantage that the focus and sharpness of the image is not interfered with, as it is when yellow screens are applied to the lens, though when thin collodion screens are used in place of the diaphragm, this is exceedingly slight.

So far as at present known erythrosin is the most suitable dye for producing orthochromatic effect with gelatine dry plates, in the reproduction of yellow, but it has the defect of not increasing the sensitiveness for red. To improve it in this respect the addition of cyanin has been recommended, but then the general sensitiveness of the plate is greatly reduced. With plates so prepared and with plates prepared with a mixture of erythrosin and resorcin blue, the sensitiveness for red was slightly increased.

Dr. Vogel has recommended a mixture of chinoline red with cyanin (chinoline blue), known as azalin. This also works well, but has the same defect of want of general sensitiveness as the mixture of erythrosin and cyanin.

I have also tried the effect of dyes which have been found by Dr. Eder, to yield plates specially sensitive to the red rays of the spectrum, such as napthol blue, neutral violet, cœrulein, malachite green, iodine green, also gallocyanin (which I have found to have a strong sensitising effect for the red end of the spectrum, almost as much so as cœrulein) resorcin blue, Coupier's blue and azo blue, but none of these by themselves have given any useful result for copying purposes. The green dyes seem to make the plates indifferent to colour and the yellow screen has no effect. The blue dyes, as a rule, lower the general sensitiveness of the plates without much exalting the colour sensitiveness for yellow or red, and with some it is difficult to get clean-working plates.

In my earlier experiments, in 1876, with dry collodion plates, it was found that annatto, either in the emulsion or employed as a preservative, gave very great sensitiveness to all parts of the spectrum, as well as very sensitive plates for ordinary purposes. I have tried it again with gelatine and find a certain amount of improvement in colour sensitiveness, but not nearly so marked as with collodion. This dye requires further investigation.

Among red dyes, I have tried congo red, which gives a certain amount of sensitiveness for yellow, but not nearly so much as the eosins; roseine, which with collodion shows marked sensitiveness for yellow, does not do so with gelatine, and roshydrazin, which with the spectrum shows an increase of sensitiveness for yellow, but for copying shows only a very slight orthochromatic effect, being most sensitive, even with the yellow screen, for violet and blue.

Just before the close of the year some interesting results were obtained by photographing the spectrum on unstained plates with coloured screens in front of the slit of the spectroscope. Yellow screens give a particularly well marked increase of sensitiveness for the yellow and red rays. I found that this action had also been noted by Drs. Eder and Draper. A photograph of a petroleum lamp spectrum through a solution of tetraiodfluorescin on an unstained plate also produced a very marked increase of sensitiveness in the yellow, corresponding to the rise of sensitiveness of plates stained with the dye. Violet and green screens showed, in like manner, bands of increased sensitiveness in the red. Some trials were also made in copying coloured drawings, &c., on unstained plates through coloured screens, but further experiment is necessary to ascertain definitely what can be done in this direction.

I have found in the course of this enquiry that very different results are obtained from plates of different make. The causes of these differences have not yet been ascertained.

Altogether between 300 and 400 stained plates have been taken on the spectrum and in copying chromolithographs, water colour drawings and colour scales, with few exceptions, quite independently of my office work. I hope to continue these researches and report further progress. For present practical purposes the method of staining the plates with erythrosin-silver and throwing yellow light on the picture during exposure will answer. A photocollotype copy of a very highly coloured water-colour drawing by Colonel Woodthorpe, C.B., reproduced by this method, is attached, with a copy done on an ordinary plate. The difference between the two methods will be seen from a comparison of the bright yellow turban of the standing figure, and the skirts of the seated figures—in one case bright yellow with white stripes and in the other orange and red—in the two photographs. In the orthochromatic plate they are light and full of detail, and in the ordinary plate dark all over.

SOLAR PHOTOGRAPHS.—From time to time during the year, as opportunity offered, I have resumed experiments made in former years with collodion plates, in taking photographs of the sun in the eclipse camera on dry gelatine plates deeply stained with roseine and violet dyes, in the hope of being able to secure traces of the corona, as done in other ways by Dr. Huggins in England and by Mr. Gill at the Cape of Good Hope. This appears to be only possible when the sky is perfectly clear and free from haze, and such days have been very few during the past year. On the 8th May I got some photographs which when enlarged about three times show faint traces of detail round the sun which might be coronal. In some subsequent photographs something similar appears, but too faintly for comparison. There is always such a strong chance of error from defects in the optical arrangements, that the results must in any case be doubtful, unless they can be compared with photographs of the corona taken during an eclipse. I had hoped to have obtained some photographs that could have been compared with photographs of the corona taken during the total solar eclipse of August 19th, but the weather here about that time was very unfavourable for such work and even few successful photographs of the eclipse seem to have been taken. With better arrangements and further experience in the working of stained plates and coloured screens it may, perhaps, be possible to obtain something more definite.

I have prepared a short treatise on the preparation of drawings for reproduction by photography, in which I have gathered together all available information on the subject of black and white drawings in pen and ink or shaded in monochrome and hope to be able, with the permission of Government, to publish it for departmental and general use.

NEW BUILDING.—Little progress was made in providing accommodation for these offices during the year, but on the question of fittings for the new offices arising, it was, in consultation with the Superintendent of Works, considered desirable to alter the proposed arrangements entirely, retaining the same accommodation generally, but placing the Photographic Office to the south and the Lithographic Office to the north in a quadrangle, the glass-house being placed on the upper storey at the back of the quadrangle. This arrangement will be very much better and more convenient. New rough plans had consequently to be prepared and the preparation of the list of fittings required postponed until the new plans were properly drawn out. At the close of the year they were not completed.

From the above it will be seen that although the general out-turn of the office has been comparatively small, the year has not been an inactive one, and considerable progress has been made in various directions.

PHOTOGRAPHIC OFFICE, CALCUTTA.

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo.-transfer Prints.	Photozincographic Printing. Zinc Plates transferred.	Photozincographic Printing. Zinc Plates printed.	Photozincographic Printing. Pulls.	Photozincographic Printing. Copies.
		M. I.	M. I.								
General Maps.											
Contour Map of India		...	...	...	6	...	...	...	4	400	200
Countries on either side of the North-West Frontier of India		...	...	...	...	...	...	...	1	100	100
Railway Map of India		...	...	...	...	...	...	...	24	1,218	1,218
Total		...	...	...	6	...	...	...	29	1,718	1,518
Provincial Maps.											
Central Provinces		16=1	32=1	...	...	...	...	...	1	150	150
Divisional Maps.											
Presidency Division and Sundarbuns		4=1	8=1	4	4	...	4	1	1	50	50
District Maps.											
(*North-Western Provinces*), Ghazipur; (*Punjab*) Amritsar, Bannu, Delhi, Dera-Ghazi-Khan, Gurgaon, Jhang, Jhelum, Jullundur, Karnal, Lahore, Montgomery, Peshawar, Rawalpindi and Shahpur.		4=1	4=1	15	52	...	52	16	...	...	...
(*Assam*) Garo Hills		4=1	2=1	1	1	...	1	1	...	...	...
Khasi and Jaintia Hills and Lakhimpur		4=1	8=1	2	2	...	2	1	...	...	...
(*Bengal*) Hill Tipperah, Manbhoom, and Tipperah; (*Bombay*) Bassein; (*Central Provinces*) Chanda, Jubbulpore, Sambalpur, Saugor, Upper Godavari, and Wardha; (*Hyderabad*) Akola, Amraoti, Ellichpur, and Wun; (*North-Western Provinces*) Agra, Basti, Fatehpur, Fyzabad, Ghazipur, Gorakhpur and Moradabad; (*Oudh*) Hardoi, Kheri, and Sitapur; (Punjab) Rawalpindi; (*Rajputana*) Ajmere and Merwara.		8=1	8=1	28	25	...	25	11	...	...	...
(*Assam*) Sylhet; (*Bengal*) Balasore, Beerbhoom, Bogra, Bonai, Dacca, Durbhunga, Furreedpore, Garjat States, Gya, Hooghly, Howrah, Jessore, Konai, Lohardugga, Mayurbhanja, Monghyr, Moorshedabad, Mozufferpore, Mymensingh, Noakholly, Orissa, Pubna, Rajshahye, Sarguja; Sundarbuns and 24-Pergunnahs; (*Bombay*) Bakar; (*Central Provinces*) Chhindwara; (*North-Western Provinces*) Ballia, Banda, Bareilly, Basti, Benares, Etah, Etawah, Jalaun, Muttra, Saharanpur and Shahjahanpur; (*Punjab*), Jhelum, Kohat, Montgomery and Muzaffargarh; (*Rajputana*) Chang.		8=1	8=1	47	35	...	35	9	8	2,250	7,200
(*Bengal*) Burdwan, Cuttack, Dinagepore and Pooree; (*North-Western Provinces*) Garhwal.		6=1	8=1	5	5	...	5	2	2	200	500
(*Bengal*) Cooch-Behar, Darjeeling, Hazaribagh, Jalpaiguri, Jashpur, Khoolna, Lohardugga, Maldah, Midnapore, Nuddea, Patna, Sarun, Shahabad, Singhbhoom, and Sonthal Pergunnahs; (*Central Provinces*) Balaghat, Betul, Bhandara, Bilaspur, Damoh, Hoshangabad, Nagpur, Narsinghpur, Nimar, Raipur and Seoni; (*North-Western Provinces*) Bijnor, Budaun, Bulandshahr, Hamirpur, Meerut, Mirzapur, Pilibhit and Tarai; (*Oudh*) Bahraich, Gonda, Lucknow, and Rae-Bareli; (*Punjab*) Bannu, Hazara, Hissar and Shahpur;	...	...	...	...	...	...	...	...	15	4,350	8,750
(*Bengal*) Burdwan, Chittagong Hill Tracts, Cuttack, Dinagepore, Furreedpore, Howrah, Korai, Maldah, Mayurbhanja, Midnapore, Monghyr, Mozufferpore, Pubna, Pooree, Rajshahye, Sarguja, Shahabad, Singhbhoom, and Sonthal Pergunnahs; (*Central Provinces*) Balaghat, Betul, Bhandara, Chhindwara, Damoh, Nagpur, Narsinghpur, Nimar and Raipur; (*North-Western Provinces*) Banda, Benares, Bijnor, Garhwal, Jalaun, Pilibhit, Saharanpur, and Tarai; (*Oudh*) Gonda and Rae-Bareli; (*Punjab*) Hazara and Shahpur.	...	...	...	...	...	...	...	...	14	700	2,100

OFFICE, CALCUTTA.

during the year 1886-1887.

Silver and other Printing.			Heliogravure and Electrotyping.					Photocollotype.		Value.	Remarks.
Silver prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electrotyped.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	115 5 7	Reprint.
...	...	...	...	...	...	...	...	...	...	46 11 8	
...	...	...	...	..	...	...	...	...	...	434 12 5	Reprint.
...	...	...	...	...	...	...	...	...	...	596 13 8	
...	...	...	...	...	...	...	...	...	...	19 3 3	
...	...	...	...	...	...	...	...	...	...	68 3 2	
...	...	...	...	...	...	...	...	...	...	697 2 11	
...	...	...	...	...	...	...	...	...	...	13 3 3	
...	...	...	...	...	...	...	...	...	...	27 14 5	
...	...	...	...	...	...	...	...	...	...	318 9 10	
...	...	...	...	...	...	...	...	...	...	659 11 6	
...	...	...	...	...	...	...	...	...	...	83 11 11	
...	...	...	...	...	...	...	...	...	...	423 3 11	
...	...	...	...	...	...	...	...	...	...	57 9 7	Reprint.

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Protozincographic Printing. Photo-transfer Prints.	Protozincographic Printing. Zinc Plates transferred.	Protozincographic Printing. Zinc Plates printed.	Protozincographic Printing. Pulls.	Protozincographic Printing. Copies.
District Maps—*contd.*		M. I.	M. I.								
(*Bengal*) Bhagalpur, Orissa Tributary Mahals, Sundarbuns and Tipperah; (*Central Provinces*) Mandla; (*North-Western Provinces*) Agra, Dehra Dun, Etah, Etawah, Gorakhpur, Moradabad, Muttra and Muzaffarnagar; (*Oudh*) Sultanpur; (*Punjab*) Rawalpindi	. . . . .	...	8—1	...	...	...	...	...	4	1,300	2,900
(*Punjab*) Hazara and Simla	. . . . .	16—1	18—1	2	2	2	...	...	...	...	...
Total	. . . . .	...	...	100	122	2	120	40	43	8,800	21,450
Plans of Cities and Cantonments.		" ft.	" ft.								
Baroda City and Environs	. . . . .	1=200	1=200	...	...	...	...	...	16	2,400	2,400
		M. I.	M. I.								
Dalhousie Sanitarium	. . . . .	1=10	1=6	...	...	...	...	...	1	50	50
Dungarpur Environs and Kherwara Cantonment	. . . . .	{1=6 1=12	1=6 1=12	... ...	... ...	... ...	... ...	... ...	3 1	450 75	450 75
Moulmein Cantonment	. . . . .	1=16	1=12	1	2	...	2	1	20	1,000	1,000
Rangoon Town District	. . . . .	...	...	...	...	...	...	..	9	900	900
Simla, Sheets 1 to 4, 6 to 8, 12 and 13	. . . . .	...	1=24	...	...	...	...	...			
Total	. . . . .	...	...	1	2	...	2	1	50	4.875	4,875
Standard Maps.											
Andaman Islands.											
Sheets 1, 5, 6, 7, (3 and 11) 9, 10 and 16	. . . . .	{2=1 1=4	2=1} 1=4}	10	40	...	40	10	10	1,250	1,250
Assam.											
District Cachar— Sheets 57, 68, 69, 70, 80, and 81	. . . . .	1=1	1=1	...	...	...	...	...	...	600	600
Baluchistan.											
Sheets 1, 2, 21 $\frac{\text{S.E.}}{4}$ and 22 $\frac{\text{S.E.}}{2}$	. . . . .	{2=1 1=2	2=1} 1=2}	4	16	...	16	4	4	600	600
Bombay.											
Sheets 170 and 171	. . . . .	1=2	1=1	8	8	...	8	2	2	300	300
,, 134, 172, and 204	. . . . .	1=2	1=1	12	12	...	12	3	... 2	... 300	... 300
,, 133 and 239	. . . . .	...	...	...	...	...	...	...			
Kolaba, Ratnagiri, Habsan and Bhor State— Sheets 141, 167 and 169	. . . . .	1=2	1=1	12	12	...	12	3	3	450	450
Districts Satara and Sholapur— Sheets 238 and 270 Districts Ratnagiri and Satara— Sheet 203 District Tanna— Sheets 81 $\frac{\text{S E.}}{1,2,3,4}$, 133 $\frac{\text{S.E.}}{1,2,3,4}$, ,, 134 $\frac{\text{N.E.}}{1}$, $\frac{\text{S.E.}}{1,2,3,4}$, 136 ,4 ,, 159 $\frac{\text{S}}{3}$ and 160 $\frac{\text{N.E.}}{3}$, $\frac{\text{N.W.}}{1,3}$, $\frac{\text{S.E.}}{1,3,4}$ and $\frac{\text{S.W.}}{1,2,3,4}$	. . . . .	...	...	...	...	...	...	...	33	1,575	1,575
Districts Tanna, Nasik and Jawhar States— Sheets 135 and 161 District Satara— Sheet 239 District Ratnagiri— Sheet 173 Districts Ratnagiri and Kolaba— Sheet 168 Districts Ahmednagar, Nasik, Poona, and Satara— Sheets 4, 12, 16 and 35	. . . . .	1=2	1=1	28	28	...	28	7	...	...	...
Burma (*Lower*). Sheet 227 $\frac{\text{N.E.}}{1,3}$, $\frac{\text{N.W.}}{4}$, $\frac{\text{S.E.}}{1,2}$, and $\frac{\text{S.W.}}{4}$	. . . . .	1=4	1=4	6	20	...	20	6	...	...	...
Districts Bassein and Henzada— Sheets 140, 182, 184, 185 Districts Hanthawaddy and Pegu— Sheet 115 N.E., N.W., S.E., and S W. District Tharrawaddy— Sheets 77 $\frac{\text{N.E.}}{4}$, 93 $\frac{\text{N.E.}}{1,2,3,4}$, $\frac{\text{S.E.}}{1,2,3,4}$,, 94 $\frac{\text{N.E.}}{2,3}$, $\frac{\text{S.E.}}{2}$, N.E.. N.W. S.E. and S.W. Sheets 95 $\frac{\text{N.E.}}{4}$ and 110 $\frac{\text{N.W.}}{1,3}$, $\frac{\text{S.W.}}{1}$	. . . . .	...	...	...	...	...	...	...	30	3,700	3,700

OFFICE, CALCUTTA.

during the year 1886-1887—contd.

Silver and other Printing.			Heliogravure and Electrotyping.					Photo-collotype.		Value.	Remarks.
Silver prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electrotyped.	Plates Photo-etched.	Prints.	Photo Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	107 15 0	
...	...	...	...	2	2*	...	...	...	...	139 10 3	* 2 Pigment prints.
...	...	...	...	2	2	...	...	...	...	2,528 12 7	
...	...	...	...	...	...	...	...	...	...	449 3 7	
...	...	...	...	...	...	...	...	...	...	17 0 0	
...	...	...	...	...	...	...	...	...	...	110 10 5	
...	...	...	...	...	...	...	...	...	...	37 3 9	
...	...	...	...	...	...	...	...	...	...	168 2 6	Reprint
...	...	...	...	...	...	...	...	...	...	227 13 0	
...	...	...	...	...	...	...	...	...	...	1,010 1 3	
...	...	...	...	...	...	...	...	...	...	876 1 8	
...	...	...	...	...	...	...	...	...	...	159 7 2	
...	...	...	...	...	...	...	...	...	...	359 14 11	
...	...	...	...	...	...	...	...	...	...	191 13 7	
...	...	...	...	...	...	...	...	...	...	158 6 6	
...	...	...	...	...	...	...	...	...	...	81 13 9	
...	...	...	...	...	...	...	...	...	...	283 8 4	
...	...	...	...	...	...	...	...	...	...	621 14 9	
...	...	...	...	...	...	...	...	...	...	369 14 3	
...	...	...	...	...	...	...	...	...	...	297 9 6	
...	...	...	...	...	...	...	...	...	...	1,051 12 0	

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.
Standard Maps—*contd.*		M. I.	M. I.								
District Bassein— Sheets 141, 186 . . . . . . District Bassein and Henzada— Sheets 66, 78, 80 and 81 . . . District Henzada— Sheet 183 N.E., N. W., S.E. and S. W.	. . . .	1=2	1=2 1=1	28	28	...	28	7	...	...	...
District Prome— Sheets 74, 92, 93 and 179 . . . Districts Henzada and Prome— Sheet 77 . . . . Districts Pegu and Tharrawaddy— Sheet 180—	. . .	1=2	1=2 1=1	21	36	...	40	10	10	825	825
District Shwegyin— Sheets 124 and 126	. . .	1=2	1=2	8	32	...	32	8	8	400	400
,, *125 N.E., N.W., S. E., and S. W.	. . .	1=2	1=2	...	...	...	8	4	...	...	...
,, 123 S.E. and S.W.	. . .	...	...	...	...	...	...	...	2	150	150
,, 1 N.E., S.E., 2 N.E., S.E., 3 N.E. . . . . . . ,, 4 N.W., S.W., 5 N.W., S.W. . ,, 6 N.W. (S.E. Trans-frontier) . ,, 15 N.E., S.E.: 23 N.W. and S.W. (N.E. Trans-frontier) . .	. . .	4=1	4=1	12	48	...	48	12	35†	9,485	9,485
Central India and Rajputana.											
Sheets 219, 252, 384, 401, and 410 .	. . .	1=1	1=1	3	12	..	12	3	5	525	525
Cutch.											
Sheets 54, 55, 56 and 69 . . .	. . . .	...	...	...	...	...	...	...	4	600	600
,, 31, 32, 37, 38, 39 and 40 . .	. . . .	1 = 2	1 = 1	24	24	...	24	6	...	...	...
Gujarat.											
Sheets 41 $\frac{\text{N.E.}}{1,3}$, $\frac{\text{N.W.}}{3,4}$, $\frac{\text{S.W.}}{1,2,3,4}$ and 42 $\frac{\text{N.W.}}{3}$	. . . .	1 = 4	1 = 4	9	36	...	36	9	9	1,350	1,350
Sheets Joint Sections 1 and 2, 133 and 159 ,, 185 $\frac{\text{N.E}}{2,4}$, $\frac{\text{S.E.}}{2}$ and 190 section 9.	. . .	...	...	...	...	...	...	...	6	900	900
,, 88, 89, 214, N.E., N.W., S.E. and S.W. ,, 215 N.E., N. W., S.E., and S.W.	. . .	1 = 2	1 = 2 1 = 1	16	40	...	40	10	...	...	...
,, 41 $\frac{\text{S. W.}}{1,2,3,4}$	. . .	1 = 4	1 = 2	4	4	...	...	...	...	...	...
Hooghly River Survey—											
Sheet 3, Sections F. H. . . . ,, 4 ,, L. N. O. P. . . . ,, 5 ,, J. K. O. Q. . . . ,, I ,, J. L. M. N. O. P. . . ,, II ,, A. B. E. to K. . . ,, IV ,, I. J. K. M. . . . ,, V ,, E. L. P. . . .	. . . .	...	...	...	...	...	...	...	33	6,600	6,600
,, 1, 2, 3, 5, 6, 7, 8, 9. . . .	. . . . .	1 = 3 1 = 6	1 = 3 1 = 6	6	14	...	14	10	10	1,500	1,500
,, 6, 7, 8 and 9.	. . . . .	1 = 6	1 = 6	4	16	...	16	...	...	...	...
Hyderabad.											
Sheets 201, 210, 211, 218, 219, 221. . ,, 223, 225, (212, 213) . . . ,, (208, 209, 216, 217) . . . ,, (204, 205, 214, 215, 222) . . ,, (Kummumett Circar) . . .	. . . .	1 = 1	1 = 1	11	43	...	43	11	11	825	825
Kathiawar.											
Sheet 25	. . . . .	1 = 2	1 = 1	4	4	...	4	1	...	...	...
,, 79	. . . . .	...	...	...	...	...	...	1	1	150	150
Konkan.											
Sheets 161, 162 and 163	. . . . .	1 = 4	1 = 4	12	38	...	38	12	12	144	144
Mysore.											
Sheets 26, 49, 54, 58, 62, 67, 68 and 69 .	. . . . .	...	...	...	...	...	...	...	8	1,200	1,200
,, 1, 11, 18, to 25, 27 to 30, 43 to 48, 50, 55 to 57, 65, 66 and 70 . . .	. . . . .	1=1	1=1	27	108	...	108	29	27	3,850	3,850

OFFICE, CALCUTTA.

during the year 1886-1887—continued.

Silver and other Printing.			Heliogravure & Electrotyping.					Photo-collotype.		Value.	Remarks.
Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo-Blocks.	Electrotypes.	Plates.	Prints.	R a. p.	
...	...	...	...	...	...	...	...	...	...	371 1 6	
...	...	...	...	...	...	...	...	...	...	770 13 6	
...	...	...	...	...	...	...	...	...	...	555 1 8	*Negative of the 4 sections and photo-transfer of S.E. and S.W. were taken last year.
...	...	...	...	...	...	...	...	...	...	66 0 0	
...	...	...	...	...	...	...	...	...	...	44 6 1	
...	...	...	...	...	...	...	...	...	...	3,315 10 8	†Out of 35 plates 20 reprinted.
...	...	...	...	...	...	...	...	...	...	310 6 11	
...	...	...	...	...	...	...	...	...	...	165 12 3	
...	...	...	...	...	...	...	...	...	...	319 3 2	
...	...	...	...	...	...	...	...	...	...	851 14 0	
...	...	...	...	...	...	...	...	...	...	257 11 2	
...	...	...	...	...	...	...	...	...	...	528 0 0	
...	...	...	...	...	...	...	...	...	...	25 12 9	
...	...	...	...	...	...	...	...	...	...	908 6 9	
...	...	...	...	...	...	...	...	...	...	713 2 8	
...	...	...	...	...	...	...	...	...	...	180 0 0	
...	...	...	...	...	...	...	...	...	...	818 5 1	
...	...	...	...	...	...	...	...	...	...	52 12 9	
...	...	...	...	...	...	...	...	...	...	40 15 0	
...	...	...	...	...	...	...	...	...	...	667 10 2	
...	...	...	...	...	...	...	...	...	...	343 9 7	
...	...	...	...	...	...	...	...	...	...	2,570 12 0	

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Photozincographic Printing. Zinc Plates transferred.	Photozincographic Printing. Zinc Plates printed.	Photozincographic Printing. Pulls.	Photozincographic Printing. Copies.
Standard Maps—*contd.*		M. I.	M. I.								
North-West Provinces.											
Districts Agra and Aligarh, Sheet 37											
" Aligarh, " 23											
" Ballia and Sarun, " 218 and 220											
" Ballia, Ghazipur and Shahabad, Sheet 219.	. . . .	1=2	1=1	30	30	...	30	5	...	...	...
" Benares, Ghazipur and part of Shahabad, Sheet 211											
" Ballia, Sheet 208											
" Ballia and Sarun, " 217	. . . .	1=2	1=1	12	12	...	12	3	3	350	350
" Ghazipur " 194											
" Aligarh, Sheets, 36 N.E., N.W., S.E. and S.W.	. . . .	1=2	1=2	4	16	...	16	4	...	...	...
" Ballia and Ghazipur, Sheet 209	. . . .	...	...	...	...	...	...	...	1	150	150
" Ballia, Sarun and Shahabad, Sheet 221.	. . . .	1=2	1=1	4	4	...	4	1	...	...	...
North-West Provinces and Oudh.											
Sheet 56 A.	. . . .	1=1	1=1	1	4	...	4	1	...	...	...
" 56 B.	. . . .	...	...	...	...	...	...	...	1	150	150
North-West Trans-frontier.											
Two Sheets	. . . .	4=1	4=1	2	8	...	8	2	2	250	250
Three "	. . . .	4=1	4=1	3	12	...	12	3	...	...	...
Punjab.											
Districts Hissar and Patiala State, Sheets 243, 257, 258.	. . . .	1=2	1=1	16	16	...	16	4	4	600	600
" Hoshiarpur and Jullundur, Sheet 250.											
" Hissar and Patiala State, Sheet 242.											
" Bickaneer, Hissar, Loharu and Jind States, Sheet 261.											
" Hissar and Karnal, Sheet 256	. . . .	1=2	1=1	24	24	...	24	6	...	...	...
" Jullundur and Ludhiana, Sheet 252.											
" Ludhiana, Sheet 253											
" Jullundur, " 268											
" Delhi, Sheets 298, 299, 319 to 322	. . . .	1=1	1=1	6	24	...	24	6	...	...	...
Government Cattle Farm, Karnal, Sheets 1, 2, 3 and 4.	. . . .	1=8	1=8	4	16	...	16	4	4	400	400
Districts Hissar and Bickaneer State, Sheets 244, 259, 260.	. . . .	1=1 1=2	1=1	9	12	...	12	3	3	450	450
South Maratha Country.											
Sheets 275 and 276	. . . .	1=2	1=1	8	8	...	8	2	...	...	...
Total	. . . .	...	...	392	805	...	813	211	283	39,629	39,629
Index Maps.											
Andaman, Cutch, Damoh, Gujarat, Jubbulpore, Sambalpur, and South Maratha Survey.	. . . .	...	...	...	...	...	3	1	3	1,550	3,300
Burma Standard Sheets, Mirzapur, North-West Trans-frontier, and Raipur District.	. . . .	8=1 16=1	Reduced 12=1 16=1	4	4	...	4	1	3	1,550	2,200
Ajmere, Akyab, Basti, Bilaspur, Chhindwara, Darrang, Deccan, Gorakhpur, Kamrup, Mozufferpore, Narsinghpur, Saugor, and Seoni.	. . . .	...	...	...	...	...	...	...	8	4,050	5,800
Burma, Reconnaissance Sheets of,	. . . .	32=1	32=1	2	2	...	2	2	2	260	260
Burma, Standard Sheets of,	. . . .	31=1	Scale & Half	2	6	...	6	3	2	50	50
Hooghly River Survey	. . . .	4=1	6=1	1	1	...	1	1	1	100	100
Bombay Presidency (Original Index)	. . . .	...	Scale & Reduced	1	3	...	3	2	3*	125	125
Madras Survey, Sheet 1	. . . .	...	...	...	...	...	...	...	1	50	50
Bengal and Central Provinces Standard Sheets and North-Western Provinces and Oudh.	. . . .	32=1	52=1	3	3	...	3	2	4	1,200	1,550
Rajputana Survey	. . . .	...	...	...	...	...	1	1	3	1,050	550
Akyab, Cadastral Survey, Chhindwara, Narsinghpur, Saugor and Seoni Districts.	. . . .	8=1	12=1	3	3	...	3	1	...	...	...
Trans-frontier of India Sheets	. . . .	16=1	Reduced	1	1	...	1	1	1	450	450
Darrang, Kamrup, and Nowgong Districts, Cadastral Survey of,	. . . .	12=1	18=1	2	2	...	2	2	...	...	...

OFFICE, CALCUTTA.

during the year 1886-1887—continued.

Silver and other Printing.			Heliogravure and Electrotyping.					Photo-collotype.			
Silver prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.	Value.	Remarks.
										R a. p.	
...	...	...	...	...	...	...	...	...	...	381 14 2	
...	...	...	...	...	...	...	...	...	...	258 7 9	
...	...	...	...	...	...	...	...	...	...	211 3 2	
...	...	...	...	...	...	...	...	...	...	42 15 2	
...	...	...	...	...	...	...	...	...	...	53 1 7	
...	...	...	...	...	...	...	...	...	...	52 12 9	
...	...	...	...	...	...	...	...	...	...	40 15 0	
...	...	...	...	...	...	...	...	...	...	166 14 3	
...	...	...	...	...	...	...	...	...	...	158 6 6	
...	...	...	...	...	...	...	...	...	...	368 13 6	
...	...	...	...	...	...	...	...	...	...	316 12 6	
...	...	...	...	...	...	...	...	...	...	317 6 5	
...	...	...	...	...	...	...	...	...	...	329 13 11	
...	...	...	...	...	...	...	...	...	...	281 6 11	
...	...	...	...	...	...	...	...	...	...	105 9 6	
...	...	...	...	...	...	...	...	...	...	21,416 5 2	
...	...	...	...	...	...	...	...	...	...	190 8 5	
...	...	...	...	...	...	...	...	...	...	117 7 2	
...	...	...	...	...	...	...	...	...	...	386 2 10	
...	...	...	...	...	...	...	...	...	...	34 3 2	
...	...	...	...	...	...	...	...	...	...	86 13 8	
...	...	...	...	...	...	...	...	...	...	27 0 11	
...	...	...	...	...	...	...	...	...	...	69 14 7	*1 Plate reprinted.
...	...	...	...	...	...	...	...	...	...	10 2 3	Reprint.
...	...	...	...	...	...	...	...	...	...	132 5 0	
...	...	...	...	...	...	...	...	...	...	79 12 2	
...	...	...	...	...	...	...	...	...	...	37 3 2	
...	...	...	...	...	...	...	...	...	...	40 10 5	
...	...	...	...	...	...	...	...	...	...	27 9 8	

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Photozincographic Printing. Zinc plates transferred.	Photozincographic Printing. Zinc plates printed.	Photozincographic Printing. Pulls.	Photozincographic Printing. Copies.
		M. I.	M. I.								
Index Maps—*contd.*											
Angul State, Damoh, Jubbulpore, Bilaspur, Gorakhpur and Southern Maratha Survey.		4= 1 8= 1 16= 1	8= 1 12= 1 24= 1	5	5	...	5	1	...	...	...
Bassein and Tarai Districts		6= 1	8= 1	2	2	...	2	1	...	...	...
Ajmere* Basti and Sambalpur Districts, Cadastral Survey of,		4= 1	2= 1 8= 1	2	2	...	2	2*	...	...	...
Sankarpur State, Survey operations in,		4= 1	6= 1	1	1	...	1	1	...	...	...
Raipur District, Sheets 2 and 3 Nagpur and Wardha Districts		8= 1	12= 1	2	2	...	2	2	1	25	25
Gujarat		16=1	§	1	1	...	1	1	...	...	...
Total		...	...	32	38	...	42	25	32	10,460	14,460
Charts.											
Triangulation Charts of Central Provinces Topographical Survey.		4=1	4= 1	3	9	...	9	3	...	...	...
Triangulation Chart of Mysore Survey, Degree Sheet IX.		...	...	...	...	...	...	...	1	25	25
Total		...	...	3	9	...	9	3	1	25	25
Miscellaneous Maps and Plans.											
Arabia and Asia, Map of,		32=1	32=1	6	6	...	...	...	...	...	...
Basti District, Pargana Basti East		...	...	...	...	...	...	...	1	260	260
Do. Cadastral Map of (specimen map)		16=1	16=1	1	1	...	1	1	...	...	...
Beegah scale		...	scale	2	3	...	3	1	1	80	150
Bengal, Map of, (provincial) (original and duplicate)		...	..	2	...	...	...	...	...	...	...
Boundary between Garo hills and Mymensingh		1=2	1=2	1	5	...	5	2	2	100	100
Burma, Upper, Map of ,, ,, ,, (prelimimary) 1887		16=1	16=1	2	5	...	5	2	2	1,100	1,100
,, ,, Distribution Map of		...	...	...	...	...	...	...	1	50	50
,, ,, Map of (2nd edition)		...	...	...	...	...	...	...	2	250	250
,, Township Yaw Rough Map of,		1=4	1=4	1	4	...	4	1	1	60	60
Darjeeling District, Sheet 431		1=2	1=1	1	2	...	2	...	...	...	...
District Map of Simla		...	...	1	1	...	...	...	...	...	...
Extract from the Scientific American		...	Reduced	2	1	...	1	1	1	20	20
Headings of the Burma Survey (Cadastral)		...	...	...	...	...	...	...	...	400	1,170
India Sheet 2		32=1	...	1	...	...	...	...	...	...	...
,, Sheet 5 (original and duplicate)		32=1	...	2	...	...	...	...	...	...	...
,, Sheet 6 ,,		32=1	...	2	...	...	...	...	...	...	...
,, Map of, ,,		256=1	...	2	...	...	...	...	...	...	...
,, showing Railways open to traffic and under construction and under survey		...	...	...	...	...	...	...	1	125	125
,, showing Railways with Stations		...	...	...	...	...	...	...	...	200	200
Jacobabad to Chaman and adjoining country		16=1	16=1	1	1	...	1	1	1	100	100
Kheri District, main circuit Map, Sheets 6, 11, 12, and 13		...	...	9	9	...	9	9	9	54	54
Map showing Sind-Pishin Section of North-Western Railway and adjoining countries		4=1	4=1	...	...	...	...	...	...	90	90
Metric Table		...	...	...	...	...	...	...	1	20	20
Mysore Topographical Survey, compilation Map of		16=1	16=1	1	2	...	2	1	...	... 60	... 60
Naini Tal Municipality Map		...	...	...	...	...	...	...	...		
Ordnance Survey, Sheets 5 and 6		...	...	...	...	...	...	...	...	...	...
Panoramic Profile of Hills near Naini Tal		...	[illegible]	1	2	...	4	...	...	... 62	... 62
Plans of proposed Photo. and Litho. offices		1=8 feet	[illegible]	2	2	...	2	1	5		
Pishin-Dera Ghazi Khan road from Sakhi Sarwar, *viâ* Rokhinola		8=1	8=1	1	1	...	...	...	...	...	...
Portion of the Western Jumna Canals		12=1	14=1	2	1	...	...	...	...	...	...
Portion of Chart from Mud Point to South Bluff, Sheet 11		...	...	...	...	...	...	...	...	...	...
Quarter Atlas Sheet 6 S.E.		...	...	...	...	...	...	...	...	...	...
,, 9 S.E. and S. W.		...	...	2	...	...	...	...	...	...	...
,, 14 S.W.		4=1	4=1	2	1	2	...	...	...	...	...
,, 15 N.E., half of,		...	...	1	...	...	...	...	...	...	...
,, 28 S.E.		...	...	...	...	...	...	...	...	...	...
,, 38 S. W. and 39 S. W. (original and duplicate)		...	...	4	...	...	...	...	...	...	...
Quarter Atlas Sheet 76 S.W.		...	...	1	...	...	...	...	...	...	...
Quarter Atlas Sheet 79 S.W.		..	...	1	...	...	...	...	...	...	...
Relief Map of India		...	...	...	...	...	...	...	1	100	100
Scale of Contours		...	...	...	...	...	...	...		150	150
Shajahanpur District		...	...	...	...	...	...	...	...	30	30
Sholapur Municipality Map		...	...	...	...	...	...	...	...		
Skeleton Map of Afghanistan, Assam, Baluchistan, Burma, Punjab and Sind Frontier		...	...	...	...	...	...	...	2	200	300

during the year 1886-87—contd.

Silver and other Printing.			Heliogravure & Electrotyping.					Photo-collotype.			
Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electrotyped.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.	Value.	Remarks.
										R a. p.	
...	...	...	...	...	...	...	...	...	...	56 6 3	
...	...	...	...	...	...	...	...	...	...	27 4 9	
...	...	...	...	...	...	...	...	...	...	29 1 7	* 1 plate cancelled.
...	...	...	...	...	...	...	...	...	...	15 4 9	Reprint.
...	...	...	...	...	...	...	...	...	...	30 12 3	
...	...	...	...	...	...	...	...	...	...	13 3 3	
...	...	...	...	...	...	...	...	...	...	1,411 14 3	
...	...	...	...	...	...	...	...	...	...	119 6 6	
...	...	...	...	...	...	...	...	...	...	6 12 6	
...	...	...	...	...	...	...	...	...	...	126 3 0	
36	...	...	...	...	...	...	...	...	...	151 3 2	
...	...	...	...	...	...	...	...	...	...	50 11 0	
...	...	...	...	...	...	...	...	...	...	24 4 9	One proof taken only for experiment.
...	...	...	...	...	...	...	...	...	...	43 3 2	
...	...	...	...	...	...	...	2	...	...	90 0 0	
...	...	...	...	...	...	...	...	...	...	108 2 9	
...	...	...	...	...	...	...	...	...	...	285 14 0	
...	...	...	...	...	...	...	...	...	...	13 12 0	Reprint.
...	...	...	...	...	...	...	...	...	...	50 14 9	
...	...	...	...	...	...	...	...	...	...	62 4 2	
...	...	...	...	1	1	...	...	...	...	23 6 5	
...	...	...	...	...	...	...	...	...	...	42 0 0	
...	...	...	...	...	...	...	...	...	...	17 8 7	
...	...	...	...	...	...	...	...	...	...	30 0 0	
...	...	...	...	...	4	...	1	...	...	3?4 0 0	
...	...	...	...	...	...	...	2	...	...	729 0 0	
...	...	...	...	...	...	...	2	...	...	648 0 0	
...	...	...	...	...	...	...	2	...	...	121 6 2	
...	...	...	...	...	...	...	...	...	...	24 6 10	For record in S. G. O.
...	...	...	...	...	...	...	...	...	...	50 2 6	
...	...	...	...	...	...	...	...	...	...	32 7 5	For record in S. G. O.
...	...	...	...	...	...	...	...	...	...	240 0 0	
...	...	...	...	1	...	...	...	...	...	32 5 9	For record in S. G. O.
...	...	...	...	...	...	...	...	...	...	6 7 7	
...	...	...	...	...	...	...	...	...	...	29 6 5	
...	...	...	...	...	...	...	...	...	...	15 0 9	
...	...	...	1	...	1	...	...	...	...	528 0 0	
...	...	...	...	...	...	...	...	...	...	34 12 9	
...	...	...	...	...	...	...	...	...	...	60 3 0	
...	5	...	...	...	...	...	...	...	...	25 3 2	
...	2	...	...	...	...	...	...	...	...	14 1 7	
...	1	...	...	...	...	...	...	...	...	2 6 5	
...	...	...	...	...	6	...	1	...	...	594 9 7	
...	...	...	2	...	...	...	2*	...	...	291 9 7	*Matrix.
...	...	...	...	2	1	...	...	...	...	731 6 5	
...	...	...	2	...	3	...	...	...	...	564 9 7	
...	...	...	2	...	...	...	1	...	...	182 4 0	
...	...	...	...	...	...	...	4	...	...	583 3 2	
...	...	...	...	...	...	...	1†	...	...	145 12 9	†Duplicate.
...	...	...	...	...	...	...	1	...	...	182 4 0	Matrix.
3	...	...	...	...	...	...	...	...	...	13 8 0	
...	...	...	...	...	...	...	...	...	...	4 8 5	
...	...	...	...	...	...	...	...	...	...	38 9 8	
...	...	...	...	...	...	...	...	...	...	6 12 0	
...	...	...	...	...	...	...	...	...	...	28 9 0	

PHOTOGRAPHIC

Statement of Departmental Work done

Specification of Plate or Print.	Progress made.	Scale of Map. Original.	Scale of Map. Reproduced.	Sheets or Subjects.	Negatives. Direct Negatives.	Negatives. Reversed Negatives and Transparencies.	Photozincographic Printing. Photo-transfer Prints.	Photozincographic Printing. Zinc Plates transferred.	Photozincographic Printing. Zinc Plates printed.	Photozincographic Printing. Pulls.	Photozincographic Printing. Copies.
Miscellaneous Maps and Plans—*contd.*		M. I.	M. I.								
Skeleton Map of Naga Hills	. . .	...	..	...	...	...	...	...	10	5	5
Skeleton Map of India	. . .	...	¼	4	2	...	...	...	...	...	...
Specimen of Ordnance Survey Map	. . .	...	Enlarged	1	2	...	...	...	...	...	...
Specimen Map	. . .	...	½ and ¾	1	2	...	2	...	...	...	...
Specimen Chart	. . .	1=2	1=1	1	1	...	...	...	...	...	...
Specimen Plans and enlarged drawings	. . .	10=1 5=1	Enlarged 10=1	3	4	...	4	1	1	25	50
,, of Lines and Type	. . .	...	...	3	4	...	...	...	...	...	...
,, of hill shading, Ordnance Survey of Scotland	. . .	...	...	...	...	...	...	...	...	...	...
Standard Symbols for use on Maps	. . .	...	...	1	1	...	1	1	...	...	...
Stereographic Projection of the Northern Celestial Hemisphere	. . .	...	½	1	1	...	1	1	1	100	100
Theodolite subtense and compass subtense on stand	. . .	...	...	2	2	...	...	...	...	...	...
Vernacular titles for Cadastral Maps	. . .	...	...	3	...	...	...	...	...	...	...
Vertical Angle-book form	. . .	...	...	...	...	...	...	2	2	1,500	1,500
Viceroy's crest original and duplicate	. . .	...	...	2	...	...	...	...	...	...	...
Views in Holland (Specimen)	. . .	...	½	1	1	...	1	1	...	...	...
Reduction of standard sheets to Atlas scale	. . .	2=1	4=1	104	85	...	36	10	10	40	40
Experimental work—											
Heliogravure	. . .	...	...	2	3	4	...	...	...	...	...
Photo-collotype	. . .	...	...	3	4	...	...	...	...	...	...
Grained prints	. . .	...	...	1	1	...	...	...	...	...	...
Making tracing prints	. . .	...	...	...	...	...	...	...	...	...	...
Total	...	...	...	187	160	6	84	36	55	5,181	6,146
ABSTRACT OF DEPARTMENTAL MAPS.											
General Maps	. . . .	...	...	...	6	...	...	...	29	1,718	1,518
Provincial Maps	. . . .	...	...	...	...	...	...	...	1	150	150
Divisional Maps	. . . .	...	...	4	4	...	4	1	1	50	50
District Maps	. . . .	...	...	100	122	2	120	40	43	8,800	21,450
Plans of Cities and Cantonments	. . . .	...	...	1	2	...	2	1	50	4,875	4,875
Standard Sheets	. . . .	...	...	392	805	...	813	211	283	39,629	39,629
Index Maps	. . . .	...	...	32	38	...	42	25	32	10,460	14,460
Technical Charts	. . . .	...	...	3	9	...	9	3	1	25	25
Miscellaneous Maps and Plans	. . . .	...	...	187	160	6	84	36	55	5,181	6,146
Transfers and Proofs	. . . .	...	...	...	...	...	...	...	...	2,032	...
TOTAL	. . . .	...	...	719	1,146	8	1,074	317	495	72,920	88,303
Cadastral Maps.											
North-Western Provinces—											
Photo-zincographs	. . . .	...	...	1,768	1,769	...	1,783	1,733	1,733	36,956	36,956
Zincographs	. . . .	...	...	826	...	...	...	826	826	17,524	17,524
Total	. . . .	...	...	2,594	1,769	...	1,783	2,559	2,559	54,480	54,480
Burma—											
Photo-zincographs	. . . .	...	...	307	307	...	319	476	476	18,124	18,124
Zincographs	. . . .	...	...	71	...	...	...	71	71	2,414	2,414
Total	. . . .	...	...	378	307	...	319	547	547	20,538	20,538
Assam—											
Photo-zincographs	. . . .	...	...	425	425	...	421	418	418	22,154	22,154
Zincographs	. . . .	...	...	220	...	...	...	220	220	11,660	11,660
Total	. . . .	...	...	645	425	...	421	638	638	33,814	33,814
Bengal—											
Photo-zincographs	. . . .	...	...	1	1	...	1	...	...	...	...
Zincographs	. . . .	...	...	...	...	...	...	...	...	...	...
Total	. . . .	...	...	1	1	...	1	...	...	...	...
Transfers and Proofs	. . . .	...	...	...	...	...	...	...	...	7,249	...
TOTAL	. . . .	...	...	3,618	2,502	...	2,524	3,744	3,744	116,081	108,832

OFFICE, CALCUTTA.

during the year 1886-87—concluded.

Silver and other Printing.			Heliogravure & Electrotyping.					Pho o-collotype.		Value.	Remarks.
Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electro-typed.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.		
										R a. p.	
...	...	...	...	...	...	...	...	...	...	16 3 0	
...	...	...	...	...	...	...	...	...	...	10 12 9	
...	4	...	...	...	...	...	...	...	...	12 5 0	
...	...	...	...	...	...	...	...	...	...	16 12 9	
...	...	...	2	...	2	...	...	...	...	95 6 5	
...	...	...	...	...	...	...	...	...	...	67 9 11	
...	...	...	...	...	5	...	...	...	...	44 6 5	
...	2	...	...	...	...	...	...	...	...	2 11 2	
...	...	...	...	...	...	...	...	...	...	10 12 9	
...	...	...	...	...	...	...	...	...	...	21 10 2	
8	...	...	...	...	...	...	...	...	...	17 8 0	
...	...	...	...	...	...	3	...	...	...	31 8 0	
...	...	...	...	...	...	...	...	...	...	99 9 7	
...	...	...	1	...	...	...	2	...	...	78 0 0	
...	...	...	...	...	...	...	...	...	...	13 3 2	
148	94	...	...	...	...	...	...	...	...	1,168 14 7	
...	...	...	4	11	36	...	...	...	...	427 2 8	
...	...	...	...	...	...	...	...	8	16	...	
...	10	...	2	...	2	...	...	4	12	40 8 0	
...	...	...	...	...	...	...	...	...	...	9 11 0	
195	118	...	16	14	61	3	21	12	28	9,463 0 7	
...	...	...	...	...	...	...	...	...	...	596 13 8	
...	..	...	...	...	...	...	...	...	...	19 3 3	
...	..	...	...	...	...	...	...	...	...	68 3 2	
...	...	...	...	2	2	...	...	...	...	2,528 12 7	
...	...	...	...	...	...	...	...	...	...	1,010 1 3	
...	...	...	...	...	...	...	...	...	...	21,416 5 2	
...	...	...	...	...	...	...	...	...	...	1,411 14 3	
...	...	...	...	...	...	...	...	...	...	126 3 0	
195	118	...	16	13	61	3	21	12	28	9,463 0 7	
...	...	...	...	...	...	...	...	...	...	...	
195	118	...	16	15	63	3	21	12	28	36,640 8 11	
...	...	...	...	...	...	...	...	...	...	26,644 14 0	
...	...	...	...	...	...	...	...	...	...	8,403 6 0	
...	...	...	...	...	...	...	...	...	...	35,048 4 0	
...	...	...	...	...	...	...	...	...	...	6,962 15 0	
...	...	...	...	...	...	...	...	...	...	807 10 0	
...	...	...	...	...	...	...	...	...	...	7,770 9 0	
...	...	...	...	...	...	...	...	...	...	8,403 3 0	
	...	...	...	...	...	...	...	...	...	3,272 4 0	
...	...	...	...	...	...	...	...	...	...	11,675 7 0	
...	...	...	...	...	...	...	...	...	...	7 3 0	
...	...	..	...	...	...	...	...	...	...	..	
...	...	...	...	...	...	...	...	...	...	7 3 0	
...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	54,501 7 0	

PHOTOGRAPHIC OFFICE, CALCUTTA.

Statement showing the Amount and Value of Work done for other Departments during the year 1886-87.

Name of Department.	Sheets or Subjects.	Negatives.		Photozincographic Printing.					Silver and other Printing.			Heliogravure and Electrotyping.					Photo-collotype.		Value.	Remarks.
		Direct Negatives.	Reversed Negatives and Transparencies.	Photo-transfer Prints.	Zinc Plates transferred.	Zinc Plates printed.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Miscellaneous Prints.	Plates Photo-electrotyped.	Plates Photo-etched.	Prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.	R a. p.	
Asiatic Society of Bengal	13	7	4	6	6	3	1,750	3,500	2	2	...	...	...	...	...	...	7	1,799	488 0 0	
Accountant General, Bengal	...	...	...	...	...	1	160	160	...	...	...	...	...	...	...	...	...	...	39 10 0	
Archæological Survey, Madras	6	6	...	...	...	...	...	...	...	...	...	2	...	6	...	...	...	...	172 4 0	
Agent and Chief Engineer, Bengal Central Railway Company, Ld.	1	2	...	2	1	1	100	100	...	...	...	...	...	...	...	...	...	...	40 11 0	
Agent, Bombay, Baroda and Central India Railway	...	...	...	...	2	2	300	300	...	...	...	...	...	...	...	...	...	...	41 8 0	
Chief Commissioner, Burma	8	2	...	2	1	1	110	110	...	...	...	...	...	...	...	...	...	...	50 14 0	
Do., Assam	7	20	...	20	6	6	600	600	...	...	...	...	...	...	...	...	...	...	492 12 0	
Chief Engineer, Bengal Public Works Department	12	36	...	36	12	14	1,975	1,875	...	...	...	...	...	...	...	...	...	...	905 3 0	
Do., Baroda State Railway	...	...	...	29	16	16	4,800	4,800	...	...	...	...	...	...	...	...	...	...	935 10 0	From old negatives.
Chief Superintendent, Telegraph Stores	3	2	...	2	2	2	800	1,200	...	...	...	...	...	...	...	...	...	...	51 8 0	
Consulting Engineer for Railways, Lucknow	1	1	1	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	33 0 0	
Commissioner of Excise, Central Provinces	...	...	...	...	...	1	48	48	...	...	...	...	...	...	...	...	...	...	7 3 0	
Director General of Archæological Survey	7	8	2	...	...	1	675	675	...	...	...	4	...	11	...	...	7	4,431	685 7 0	
Do. of Telegraphs in India	2	2	...	2	1	1	100	100	...	...	...	...	...	...	...	...	...	...	32 12 0	
Do. of Railways	4	11	...	11	4	4	5,870	5,870	...	...	...	...	...	...	...	...	...	...	1,052 5 0	
Director of Geological Survey	23	10	...	10	3	3	2,100	2,800	74	...	...	...	...	...	...	...	...	...	243 6 0	
Executive Engineer, Quetta Division	1	7	...	7	4	...	...	...	...	...	...	...	...	...	...	...	...	...	131 2 0	
Do., Secunderabad Division	1	9	...	9	4	...	...	...	...	...	...	...	...	...	...	...	...	...	140 6 0	
Government of India, Revenue and Agricultural Department	...	...	...	...	...	1	230	230	...	...	...	...	...	200	...	...	...	...	74 13 0	
Do., Military Department	2	2	...	5	2	2	3,025	3,025	...	...	...	...	...	...	...	...	...	...	107 5 0	
Do., Foreign Department	11	18	...	13	6	6	386	386	485	...	...	...	...	...	...	...	...	...	1,481 12 0	
Do., Public Works Department	33	33	...	33	12	13	1,943	4,960	12	...	...	...	...	...	...	...	...	...	780 6 0	
Do., Legislative Department	2	2	...	...	...	...	...	...	24	...	...	...	...	...	...	...	...	...	21 10 0	
Government of Bengal, General Department	3	3	...	4	1	1	35	70	...	...	...	...	...	...	...	...	...	...	40 12 0	
Do., Public Works Department	6	1	...	1	2	3	513	503	...	2	...	...	...	...	...	...	...	...	60 0 0	
Government of Punjab, Public Works Department	11	22	...	26	11	23	1,810	970	...	...	...	...	...	...	...	...	...	...	810 12 0	
Do., Revenue Department	...	...	...	...	1	11	3,550	3,550	...	...	...	...	...	...	...	...	...	...	846 12 0	
Government of Bombay	8	8	...	8	2	...	...	...	...	...	...	...	...	...	...	...	...	...	105 10 0	
Government of North-Western Provinces and Oudh, P. W. D.	18	18	...	18	9	9	2,025	7,650	...	...	...	...	...	...	...	...	...	...	456 13 0	
Gorakhpur Municipality	20	15	...	15	4	...	...	...	...	...	...	...	...	...	...	...	...	...	194 2 0	
Health Officer to the Calcutta Municipal Corporation	4	4	...	1	...	...	...	...	...	3	...	...	...	...	...	...	...	...	30 12 0	
Inspector-General of Military Works	25	64	...	64	18	14	4,450	6,700	...	...	...	...	...	...	...	...	...	...	1,637 2 0	
Indian Museum	...	...	...	...	...	...	...	...	51	...	...	...	...	...	...	...	...	...	69 5 0	
Kashmir Railway Survey	4	36	...	36	11	11	240	240	...	...	...	...	...	...	...	...	...	...	500 0 0	
Lucknow Municipality	4	16	...	16	4	4	840	840	...	...	...	...	...	...	...	...	...	...	409 2 0	
Master of the Mint, Calcutta	...	...	...	...	...	...	...	...	5	...	...	...	...	...	...	...	...	...	7 8 0	
Manager, Rajputana-Malwa Railway	11	22	...	22	6	6	300	550	...	...	...	...	...	...	...	...	...	...	361 4 0	
Do., North-Western Railway	1	1	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	19 3 0	
Do., Dacca State Railway	1	1	...	1	1	1	60	60	...	...	...	...	...	...	...	...	...	...	36 12 0	
Do., Eastern Bengal State Railway	2	8	...	8	2	1	100	100	...	...	...	...	...	...	...	...	...	...	130 13 0	
Marine Survey of India	1	4	...	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	56 7 0	
Meteorological Reporter, Government of India	25	18	...	15	7	4	1,800	3,600	6	3	...	...	...	...	...	...	...	...	685 9 0	
Naini Tal Municipality	5	23	...	23	6	6	300	300	...	...	...	...	...	...	...	...	...	...	371 9 0	
Port Officer, Calcutta	3	9	...	9	4	4	420	420	...	...	...	...	...	...	...	...	...	...	227 11 0	
Port Commissioner	18	69	...	68	19	21	2,240	2,240	...	...	...	...	...	...	...	...	...	...	1,467 3 0	
Quarter Master General in India	61	75	...	96	38	48	7,742	9,452	...	...	...	...	...	...	...	...	...	...	2,522 6 0	
Secy. to the Commr., Reve. Sett., Land Records and Agri., Madras	2	...	2	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	115 3 0	
Secretary to Board of Revenue, North-Western Provinces and Oudh	2	4	...	4	2	2	400	400	...	...	...	...	...	...	...	...	...	...	174 15 0	
Do. to the United Service Institution, Simla	1	1	...	1	1	1	765	765	...	...	...	...	...	...	...	...	...	...	83 12 0	
Settlement Officer, Mozufferpore	...	...	...	...	...	4	1,000	800	...	...	...	...	...	...	...	...	...	...	193 7 0	
Sanitary Commissioner with the Government of India	2	...	5	...	...	...	...	...	...	...	...	...	2	6	...	...	...	...	138 0 0	
Do. do. Bengal	12	12	...	12	2	2	852	852	...	...	...	...	...	...	...	...	...	...	379 8 0	
Do. do. Central Provinces	1	1	...	1	1	1	280	280	...	...	...	...	...	...	...	...	...	...	42 9 0	
Do. do. Hyderabad Assigned Districts	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11 11 0	
Superintendent, Government Printing, India	16	22	...	22	12	12	975	945	...	...	...	...	...	...	...	...	...	...	420 13 0	
Superintendent, Carriage and Wagon Department, East Indian Railway	1	1	...	1	2	1	25	25	...	...	...	...	...	...	...	...	...	...	22 4 0	
Superintendent, Royal Botanical Garden	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	350	191 15 0	
Superintending Engineer, Mysore, Public Works Department	40	32	...	...	...	...	...	...	277	...	...	...	...	...	...	...	...	...	539 9 0	
Sholápur Municipality	4	12	...	12	3	3	300	300	...	...	...	...	...	...	...	...	...	...	230 7 0	
Special work done for trade and private individuals	15	15	2	24	8	8	642	1,127	177	...	...	...	2	3	...	...	...	...	479 6 0	
TOTAL	466	697	16	701	261	279	56,636	73,478	1,113	10	...	6	7	229*	...	...	18	6,580	22,080 5 0	* Including 29 pigment prints.
GENERAL ABSTRACT.																				
Departmental Maps and Plans	719	1,146	8	1,074	317	495	72,920	88,303	195	118	...	16	16	63	3	21	12	28	36,640 8 11	
Cadastral Maps	3,618	2,502	...	2,524	3,744	3,744	116,081	108,832	...	...	...	...	...	...	...	...	...	...	54,501 7 0	
Extra-Departmental Maps and Plans	466	697	16	701	261	279	56,636	73,478	1,113	10	...	6	7	229	...	...	18	6,580	22,080 5 0	
GRAND TOTAL	4,803	4,345	24	4,299	4,322	4,518	245,637	270,613	1,308	128	...	22	23	292	3	21	30	6,608	1,13,222 4 11	

PHOTOGRAPHIC OFFICE, CALCUTTA.

Statement showing Expenditure (Dr.) and Value of work done (Cr.) during the year 1886-87.

Dr.

	R a. p.	R a. p.
Normal Establishment.		
Superintendent's salary	4,887 3 11	
Assistant Superintendent's salary	2,772 0 0	7,659 3 11
Establishment	30,961 5 8	
Rent of office and taxes	4,525 4 0	
Contingencies	2,122 2 11	37,608 12 7
Cadastral Establishment.		
Superintendent's salary	4,887 3 11	
Assistant Superintendent's salary	2,772 0 0	7,659 3 11
Establishment	29,819 14 5	
Rent of office and taxes	3,426 6 0	
Contingencies	7,455 0 9	40,701 5 2
Chemicals and stores received from England	20,427 15 6	
Paper received from England	32,563 2 0	52,991 1 6
Stores and materials from the Stationery Office	130 0 0	
Printing paper and cloth from Stationery Office	150 8 4	280 8 4
Stores received from the Mathematical Instrument Office	114 2 0	
Articles repaired at Mathematical Instrument Office	187 3 0	301 5 0
Cost of work done by Lithographic Office	2,934 6 0	
Paper and stores received from the Lithographic and Engraving Offices	315 12 0	3,250 2 0
Work done by the Foundry and Shell Factory	25 0 11	25 0 11
Total		1,50,476 11 4

Cr.

	R a. p.	R a. p.
Departmental Maps and Plans	36,640 8 11	
Miscellaneous Maps and Plans, extra-departmental	22,080 5 0	58,720 13 11
Cadastral Maps, North-Western Provinces	35,048 4 0	
Cadastral Maps, Burma	7,770 9 0	
Cadastral Maps, Assam	11,675 7 0	
Cadastral Maps, Bengal	7 3 0	54,501 7 0
Old tin and packing cases sent to the Mathematical Instrument Office	175 7 0	
Articles and stores supplied to other Offices of the Survey of India Department	20 1 6	195 8 6
Stores and Materials supplied to other Departments	121 5 3	121 5 3
Sale of unserviceable articles	96 13 0	
Pure silver recovered from silver residues	2,260 0 0	2,356 13 0
Balance against the Department		34,580 11 8
Total		1,50,476 11 4

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement of Departmental Work done during the year 1886-87.

Specification of Stone or Print.	Lithographic Printing.							Type Printing.					
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Stones.	Coloured copies.	Uncoloured copies.	Pages or items.	Pulls to each item.	Total Pulls.	Total Copies.	Value.	Remarks.
		In. Mls.										R a. p.	
General Maps.													
Transferred from Copper-plate.													
Rajputana Agency, in 2 sheets.	Additions and corrections made.	1 = 16	Double royal	2	2	...	75	...	...	150	75	318 8 0	
India, in 6 sheets, sheets Nos. 2, 4 and 6.	Ditto	1 = 32	Dl. elephant	3	3	..	...	...	...	...	...	897 6 0	Not yet printed.
Drawn previously but printed during the present year.													
Canal Map of India, in 6 sheets.	Corrections made.	1 = 32	Ditto	6	11	50	...	...	...	550	50	157 4 0	
India showing Density of Population.	Ditto	1 = 80	Special	1	3	620	...	...	...	1,860	620	597 14 0	
Reprint.													
India, showing the Progress of Imperial Surveys to 1st October 1886, to accompany Annual Report.	Corrections &c., made and colour stones prepared.	1 = 128	Imperial	1	4	500	50	...	...	2,050	550	213 5 0	
Provincial Maps.													
Reprint.													
Skeleton Map of Punjab and Surrounding Countries.	...	1 = 32	Atlas	1	1	...	285	...	...	285	285	41 0 0	
District Maps.													
Drawn during the year.													
Ghazipur	Drawn on transfer paper.	1 = 4	Imperial	1	1	...	...	...	...	...	...	214 3 0	Not yet printed.
Transferred from Copper-plate.													
Assam—													
Nowgong	Additions and corrections made.	1 = 4	Double royal	1	1	...	...	...	...	...	...	205 12 0	Not yet printed.
Sibsagar	Ditto	1 = 4	Ditto	1	1	...	...	...	...	...	...	71 6 0	Ditto.
Bengal—													
Burdwan	Additions and corrections made.	1 = 4	Atlas	1	1	...	...	...	...	...	...	281 6 0	Not yet printed.
Chumparun	Ditto	1 = 4	Ditto	1	1	...	...	...	...	...	...	121 12 0	Ditto.
Moorshedabad	Ditto	1 = 4	Ditto	1	1	...	...	...	...	...	...	142 12 0	Ditto.
Sonthal Pergunnahs	Ditto	1 = 4	Dl. elephant	1	1	...	300	...	...	300	300	366 9 0	
Central Provinces—													
Jubbulpore	Additions and corrections made.	1 = 4	Dl. elephant	1	1	...	...	...	...	...	...	109 3 0	Not yet printed.
Transferred previously but printed during the present year.													
Khoolna	Further corrections made.	1 = 4	Atlas	1	1	...	100	...	...	100	100	63 13 0	
Jessore	Ditto	1 = 4	Ditto	1	1	...	150	...	...	150	150	83 5 0	
Hoshangabad	Ditto	1 = 4	Antiquarian	1	1	...	150	...	...	150	150	190 15 0	
24-Pergunnahs	Ditto	1 = 4	Atlas	1	1	...	150	...	...	150	150	98 9 0	
Nuddea	Ditto	1 = 4	Ditto	1	1	...	150	...	...	150	150	103 13 0	
Reprint.													
Cachar	Corrections, &c., made.	1 = 4	Double royal	1	1	...	150	...	...	150	150	106 10 0	
Carried over	...	...	...	28	38	1,170	1,560	...	...	6,045	2,730	4,385 5 0	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement of Departmental Work done during the year 1886-87—contd.

Specification of Stone or Print.	Lithographic Printing.							Type Printing.		Total Pulls.	Total Copies.	Value.	Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Stones.	Coloured Copies.	Uncoloured copies.	Pages or items.	Pulls to each item.				
		In. Mls.										R a. p.	
Brought forward	...	...	...	28	38	1,170	1,560	...	...	6,045	2,730	4,385 5 0	
Atlas Sheet.													
Transferred from Copper-plate.													
Quarter-Sheet No. 47 S. E.	Corrections, &c., made.	1 = 4	¼ Atlas	1	1	...	50	...	...	50	50	89 14 0	
Standard Maps.													
Drawn during the year.													
Oudh Revenue Survey, Sheets Nos. 131, 158, and 159.	Drawn on transfer paper.	1 = 1	Double royal	3	3	...	...	...	...	...	...	1,285 2 0	Not yet printed.
Oudh Revenue Survey, Sheet No. 152.	Re-drawn on transfer paper.	1 = 1	Ditto	1	1	...	...	...	...	...	...	592 3 0	Ditto.
District Mymensingh, Sheet No. 362.	Drawn on transfer paper.	1 = 1	Ditto	1	1	...	...	...	...	...	...	546 0 0	Ditto.
District Jalpaiguri, Sheet No. 293.	Re-transfer made, with corrections.	1 = 1	Ditto	1	1	...	...	...	...	...	...	25 3 0	Ditto.
Drawn previously but printed during the present year.													
District Jalpaiguri, Sheets Nos. 293, 294, 295, 315, 316, 338 and 339.	Corrections, &c., made.	1 = 1	Double royal	7	7	...	1,300	...	...	1,300	1,300	1,207 1 6	
Oudh Revenue Survey, Sheets No. 86, 87, 104, 118, 119, 122, 132, 133 and 134.	Ditto	1 = 1	Ditto	9	9	...	1,800	...	...	1,800	1,800	4,260 9 0	
Index Maps.													
Reprints.													
Index to the Sheet Map of North-Western Provinces.	...	1 = 32	Imperial	1	1	...	100	...	...	100	100	8 4 0	
Index map, No. 8 Party, on the scale of 1" = 1 mile, to accompany Annual Report.	Corrections made and colour stone prepared.	...	Foolscap	1	2	500	50	...	...	1,050	550	65 7 0	
Index to the Indian Atlas showing the state of the engraving and materials for engraving to 1st October 1886, to accompany Annual Report.	Ditto	1 = 256	Ditto	1	2	500	50	...	...	1,050	550	69 15 0	
Index to the Indian Atlas showing the Sheets that have been published to 1st October 1886, to accompany Annual Report.	Ditto	1 = 256	Ditto	1	2	500	50	...	...	1,050	550	66 10 0	
Miscellaneous maps.	...	...	...	30	32	220	8,251	...	...	8,352	8,471	595 6 0	
Departmental forms.	...	...	...	45	46	...	86,710	...	...	98,478	86,710	8,275 0 6	
Total	...	...	...	130	146	2,890	99,921	...	...	119,275	102,811	21,472 0 0	
Circular Orders	...	...	...	...	...	...	...	35	4,800	...	3,550	186 1 0	
Memoranda, &c.	...	...	...	...	...	...	...	485	146,777	...	135,243	2,498 15 0	
Forms, &c.	...	...	...	...	...	...	...	659	655,337	...	251,886	8,179 14 0	
Transfers for headings, foot-notes, references of published maps.	...	...	...	...	...	...	...	5,151	34,207	...	34,207	3,473 5 0	
Four Rubber Stamps	...	...	...	...	...	...	...	...	...	..	...	21 0 0	
Total	...	...	...	...	...	...	...	6,330	841,121	...	424,886	14,359 3 0	
Total Value	...	...	...	...	...	...	...	...	...	...	...	35 831 3 0	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement shewing the Amount and Value of Work done for other Departments during the year 1886-87.

Name of Department.	Lithographic Printing. Sheets or subjects.	Stones.	Coloured copies.	Uncoloured copies.	Total pulls.	Total copies.	Value. R a. p.	Remarks.
Archæological Survey of India	21	15	...	14,280	10,200	14,280	852 2 0	
Asiatic Society of Bengal	6	3	...	4,545	2,295	4,545	375 13 0	
Board of Revenue, Lower Provinces	1	1	...	600	600	600	53 2 0	
Calcutta Municipality	15	17	2,200	5,700	9,100	7,900	716 2 0	
Central Provinces Government	3	3	...	2,805	2,805	2,805	269 1 0	
Ditto, Settlement Department	3	3	...	2,000	2,000	2,000	474 3 0	
Consulting Engineer, Government of India, for Guaranteed Railways.	8	8	300	1,332	1,878	1,632	338 9 0	
Conservator of Forests, Punjab	1	1	...	12	12	12	3 3 0	
Chief Commissioner, Burma	1	2	...	...	...	...	62 6 0	Not yet printed.
Commissary General-in-Chief	10	7	...	3,205	2,102	3,205	286 1 0	
	2	1	...	...	...	...	3 0 0	Not yet printed.
Deputy Commissioner, Ningyan District	9	9	...	27	27	27	19 15 0	
Director of Land Records and Agriculture, Assam	1	1	...	200	200	200	36 11 0	
Director of Military Education in India	4	6	900	...	1,400	900	421 2 0	
Executive Engineer, Bhamo Division	3	3	...	300	300	300	79 2 0	
Ditto, Pishin Irrigation Division	1	1	...	24	24	24	4 13 0	
Ditto, Rangoon Division	1	1	...	110	110	110	341 7 0	
Ditto, West Berar Division	1	4	...	55	220	55	656 12 0	
Geological Survey of India	6	10	2,770	1,230	9,540	4,000	1,085 9 0	
Government of India, Financial Department	1	1	...	...	...	...	28 12 0	Not yet printed.
Ditto, Foreign Department	52	40	110	3,359	1,595	3,469	1,329 11 0	
	4	4	...	...	...	...	61 2 0	Not yet printed.
Ditto, Home Department	4	3	...	629	425	629	273 5 0	
Ditto, Military Department	14	7	...	910	470	910	142 13 0	
Ditto, Revenue and Agricultural Department.	20	29	...	1,118	2,099	1,118	599 5 0	
Government of Bengal	17	16	4,350	1,164	6,764	5,514	631 5 0	
Ditto, Public Works Department	14	9	205	1,309	1,659	1,514	461 9 0	
Government, North-Western Provinces and Oudh, Public Works Department.	1	2	715	...	1,430	715	156 2 0	
Government, Punjab	2	2	...	443	443	443	227 2 0	
Ditto, Public Works Department, Irrigation Branch.	3	3	...	4,400	4,400	4,400	401 9 0	
Ditto, Finance Department	3	6	565	...	1,130	565	189 9 0	
Ditto, Settlement Department	1	1	...	1,360	1,360	1,360	297 4 0	
General Superintendent, Horse and Mule-Breeding Operations in India.	1	3	105	...	315	105	55 15 0	
General Officer Commanding Upper Burma Field Force.	1	1	...	200	200	200	105 0 0	
Honorary Secretary, Lady Dufferin's Fund	1	5	2 000	...	10,000	2,000	182 2 0	
Inspector General of Civil Hospitals, Punjab	1	2	225	...	450	225	95 14 0	
Meteorological Reporter, Government of India	27	24	1,040	16,710	16,420	17,750	1,852 1 0	
	3	3	...	...	...	...	176 6 0	Not yet printed.
Ditto ditto, ditto Bengal	2	2	...	11,492	11,492	11,492	135 0 0	
Ditto ditto, ditto Bombay	1	1	...	500	500	500	25 10 0	
Marine Survey of India	2	1	...	110	55	110	58 12 0	
Medical College	1	1	...	50	50	50	6 0 0	
Miscellaneous maps, plans, &c.	5	5	...	3,025	3,025	3,025	248 0 0	
Military Secretary to Viceroy	1	1	...	20	40	20	25 12 0	
Magistrate of Beerbhoom	1	1	...	600	600	600	20 8 0	
Officer in charge Nicobar Islands	1	1	...	...	...	...	24 0 0	Not yet printed.
Ordnance Department, India	6	2	...	1,224	408	1,224	131 1 0	
Officer Commanding Presidency Volunteers	6	2	...	220	660	220	71 10 0	
Quarter Master General in India	89	55	...	5,962	4,177	5,962	3,048 6 0	
	9	17	...	...	...	...	3,315 6 0	Not yet printed
Secretary, Public Service Commission	7	4	...	...	...	...	117 6 0	Ditto.
Sanitary Commissioner, Government of India	8	7	500	3,800	3,700	4,300	444 14 0	
	3	4	...	...	...	...	262 8 0	Not yet printed.
Secretary for Berar to the Resident at Hyderabad.	9	7	...	1,415	1,015	1,415	364 8 0	
Surgeon-General, Her Majesty's Forces, Bengal	9	6	...	2,308	1,408	2,308	278 7 0	
Superintendent, Government Printing, India	2	3	2,030	1,325	5,385	3,355	164 14 0	
Ditto, Royal Botanical Gardens	26	26	...	9,500	9,500	9,500	970 10 0	
Stationery Office	9	8	...	4,033	3,933	4,033	348 8 0	
Store-keeper, Burma State Railway	1	1	...	1,255	1,255	1,255	144 8 0	
Telegraph Department, India	39	18	...	6,480	2,080	6,480	532 3 0	
	12	7	...	...	...	...	300 0 0	Not yet printed.
Traffic Superintendent, Rajputana-Malwa Railway.	1	1	...	2,605	2,605	2,605	31 15 0	
Total	517	438	18,015	123,951	143,861	141,966	24,416 5 0	

LITHOGRAPHIC AND PRINTING OFFICE, CALCUTTA.

Statement showing Expenditure (Dr.) and Value of Work done (Cr.) during the year 1886-87.

Dr. **Cr.**

Dr.	R a. p.	R a. p.	Cr.	R a. p.	R a. p.
Superintendent's salary	4,887 3 11		Standard and other maps and plans issued to the Survey of India Department	12,601 9 6	
Assistant Superintendent's salary	2,772 0 4		Miscellaneous maps issued to the Survey of India Department	595 6 0	
Establishment	33,924 11 4		Departmental Forms	8,275 0 6	21,472 0 0
Office rent and taxes	3,879 0 0				
Contingencies	1,140 15 7	46,603 15 2			
Lithographic drawing and printing materials received from England	839 8 2				
Type-printing materials received from England	122 8 7				
Miscellaneous type received from England	68 13 10		Miscellaneous maps and plans, extra-departmental	24,416 5 0	24,416 5 0
Paper received from England	2,515 9 10				
Hand lever perforating machine, &c., received from England	85 9 10	3,632 2 3	Work done in Type Department	14,359 3 0	14,359 3 0
Paper received from Stationery Office	9,148 9 3		Paper supplied to Photo. and other offices of the Survey of India Department	113 15 9	
Miscellaneous articles received from Stationery Office	96 2 11	9,244 12 2	Old tin and packing cases sent to Mathematical Instrument Office	25 15 0	139 14 9
Type received from the Engineer-in-Chief, Benares-Pooree Railway Survey	25 12 0	25 12 0			
Instruments received from Mathematical Instrument Office	13 2 0		Unserviceable type sent to Government Printing, India	58 10 0	
Cost of repair of articles at Mathematical Instrument Office	105 15 0	119 1 0	Sale of waste paper	52 2 0	110 12 0
		59,625 10 7			
Balance in favour of the Department		872 8 2			
		60,498 2 9			60,498 2 9

MATHEMATICAL INSTRUMENT OFFICE.

TABLE A.

Detail of issues to, and receipts from, Provinces and Departments during financial year 1886-87.

Provinces and Departments.	RECEIPTS.	ISSUES.	DEBITS.	CREDITS.
	Value.	Value.	Value.	Value.
	R	R	R	R
Archæological Survey	...	199	199	...
Assam	5,348	4,878	...	470
Bengal, Civil	12,332	12,615	283	...
„ Military	1,603	9,767	8,164	...
Bombay, Civil	...	358	358	...
„ Military	355	2,860	2,505	...
Burma	2,154	35,113	32,959	...
Central India	175	147	...	28
Central Provinces	18,546	1,858	...	16,691
Forests	211	2,197	1,986	...
Gazetteers and Statistical	...	2	2	...
General Administrations, Foreign States	...	58	58	...
Geological Survey and Museums	60	201	141	...
Guaranteed Railways	1,587	185	...	1,402
Hyderabad P. W. Department	...	273	273	...
Law and Justice (Port Blair and Nicobars)	...	55	55	...
Madras, Civil	2,860	5,494	2,634	...
„ Military	7,432	11,176	3,744	...
Marine	151	1,540	1,389	...
Meteorological Department	427	2,403	1,976	...
Mint	...	36	36	...
North-Western Provinces and Oudh	449	1,269	820	...
Political	4,945	4,966	21	...
Punjab	66	4,397	4,331	...
P. W. D. Military Works	246	2,374	2,128	...
„ N. W. State Railway	3,751	1,874	...	1,877
„ Coorg	...	7	7	...
Rajputana-Malwa Railway	...	2	2	...
Rajputana P. W. Department	2	142	140	...
Sindh-Pishin and Bolan State Railway	1,262	651	...	611
Survey Department	23,291	79,952	56,661	...
Telegraph	...	331	331	...
TOTAL	87,253	1,87,377	1,21,203	21,079
NET DEBIT	...	...	1,00,124	
Cash Sales	...	6,893	6,893	
GRAND TOTAL	87,253	1,94,270	1,07,017	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B.

Instruments, &c., purchased in the local market during the financial year 1886-87.

	No.	Value. R	a.
Instruments.			
Barometers, aneroid, small	4	257	12
Camera lucida	1	25	0
Clinometers, Watkin's	6	110	4
Compasses, drawing, common, brass, 5″	30	37	8
,, ,, ,, ,, 6″	70	105	0
,, ,, ,, electrum 5″	17	25	6
,, magnetic, pocket, in brass cases	11	137	8
,, prismatic, card, 2″	1	22	0
,, ,, Hunter's pattern	4	110	4
Clinometers, compasses, Watkin's	3	195	0
Hygrometers, Mason's	5	67	8
Instruments, drawing, mathematical, brass, 3rd sort	9	168	6
,, ,, ,, electrum, 3rd sort	6	129	0
Lamps, Bull's eye	23	101	0
Lenses, reading, 1″	12	9	3
,, ,, 1½″	3	4	8
Levels, spirit, in wooden cases, 12″	5	10	10
,, ,, ,, ,, 10″	1	2	0
Machines, map-printing, Ordnance pattern	6	255	0
Planimeters, electrum	3	155	0
Protractors, plain, semi-circular horn	2	2	11
,, rectangular, ivory, 6″	53	184	10
,, ,, wooden, 6″	20	21	8
Pins for chains, common pattern	6,000	468	12
,, ,, Revenue Survey pattern	1,000	187	8
Rules, carpenter's, boxwood, 2′ 2-fold, 2′ 4-fold, and 3′ 4-fold	138	93	4
,, parallel, bar, ivory	3	9	0
,, sight, for plane tables	275	825	0
Scales, horn	400	265	2
,, offsets, single, wooden	1	0	8
,, plotting ,, ,,	1	4	0
Squares, optical, German pattern	200	1,300	0
Stands for plane-tables	275	1,925	0
Stands for telescopes	1	7	12
Tapes, measuring, 25 feet	1	3	0
,, ,, 66 ,, metallic	1	3	0
,, ,, steel, pocket and others	5	90	0
Telemeters	1	47	8
Thermometers, chemical or traveller's	15	84	12
,, maximum and minimum on same board	3	33	0
,, spare, for Syke's hydrometers	13	40	0
,, grass	3	33	0
Watches, common	6	120	0
,, stop	4	260	0
TOTAL	8,641	7,936	12
Books.			
Griffin's Chemical Handicraft	1	2	7
,, Scientific ,,	1	2	2
Text Book of Steam Engine	1	4	10
Manual of Surveying	6	72	0
Nautical Almanacs	20	44	14
Tables, Logarithmic, Hutton's	6	43	6
Stanley's Drawing Instruments	1	3	1
Loome's Treatise on Meteorology	1	6	2
TOTAL	37	178	10

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B—*continued.*

Instruments, &c., purchased in the local market—continued.

Sundries.	No.	Value.	
		R	a.
Glasses for pluviometers	12	48	0
Numbers for chains	950	267	3
Pencil leads for instruments	3	6	0
Telescopes for range finders	6	44	10
Trunks, mule, leather	4	58	0
Cases, leather	24	84	0
Typing ink	2	5	8
Glass ink-bottles	36	5	7¼
Glass bottles for hydrometers	24	12	0
Horn sheets	100	50	14
Sponges	2	0	12
Numbers for chains, iron, single	500	15	10
Penknife, pocket	1	1	0
Eraser	1	0	3
TOTAL	1,665	599	3¼
BOOKS	37	178	10
INSTRUMENTS	8,641	7,936	12
GRAND TOTAL	10,343	8,714	9¼

TABLE C.

List of Instruments, &c., manufactured in Workshop during the financial year 1886-87.

Instruments.	Number.	Value.	
		R	a.
Bars, standard, steel	3	90	0
Boards, drawing, deal, large	24	301	0
„ „ „ small	5	50	0
„ „ mahogany, large	1	18	0
Chains, measuring, 30 and 33 feet	175	800	0
„ „ 66 „	635	5,397	8
„ „ 100 „	50	500	0
„ „ other sizes and sorts	145	1,107	0
Clinometers	3	105	0
Compasses, magnetic, for plane tables, 5″ needles	77	1,018	0
„ „ „ 6″ „	25	375	0
„ prismatic, silver ring 4″	7	280	0
„ surveying, Bengali	3	48	0
„ „ English	5	325	0
Curves, railway, zinc, single	4	8	0
Glasses, copying or tracing	7	266	8
Hold-alls	24	264	0
Lamps, referring	12	45	0
Pens, dotting	2	2	0
Plane tables, deal	364	3,582	0
„ „ military pattern	4	30	0
Pluviometers, Symon's pattern	97	1,258	0
Protractors, card board, 5″ and 12″	800	225	0
Pins for chains, common pattern	1,500	148	7
Rods, measuring, wooden	142	256	0
Rules, sight, for plane-tables	70	313	0
„ brass, for military plane tables	6	60	0
Carried over	4,100	16,881	0

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C—*continued.*

List of Instruments, &c., manufactured in Workshop—continued.

	Number.	Value.	
		R	a.
Brought forward	4,100	16,881	0
Scales, diagonal, cardboard	2,000	312	8
„ „ metal	200	250	0
„ engine divided cardboard, single	1,000	187	8
„ horn	100	75	0
„ offsets, single, ivory and slips	165	61	14
„ plotting, single, metal	7	16	0
Sectioner, dead beat Macginnes's	1	18	6
Squares, optical, German pattern	6	38	0
Staves, levelling, Roorkee pattern, double	6	144	0
„ „ telescopic and Sopwith's	51	780	0
Sundials	1	75	0
Stands for compasses, prismatic	7	105	0
„ „ surveying, Bengali	3	19	8
„ „ „ English	5	81	0
„ Heliotropes	3	30	0
„ plane-tables	50	350	0
„ thermometers	1	3	4
TOTAL	7,796	19,419	7

Sundries.

	Number.	R	a.
Boxes and cases, block tin and tin	21	33	0
„ of sorts	4	3	12
Cases, packing	723	2,748	11
Doolies	10	17	8
Gauges, writing	6	11	14
Numbers for chains, brass, single and sets	85	118	12
Tubes, tin and zinc	76	60	3
Ink rollers, small	22	66	0
Plummets	24	31	8
Washers, brass	540	11	4
Cases, leather	12	36	0
Padded boards for thermometers	6	18	0
Spare rods for raingauges, country pattern	3	10	8
Canvas bags, waterproof, lined	12	72	0
Needles for compasses	4	8	0
Gauges for testing raingauges	12	90	0
Rods for raingauges	80	240	0
Pads for grass thermometers	6	18	0
Bohenbergar eye-piece	1	30	0
Reservoir for raingauge	1	2	6
Handles for chains	40	22	0
Head piece for plane tables	1	2	4
Discs with iron clamp	12	14	8
Hammers	30	16	0
Type frames	2	60	0
Wheels as per sample	2	30	0
Sectional electrum	1	32	6
Reflecting telescope stand	1	200	0
Scales, electrum, for levels	12	26	5
TOTAL	1,749	4,030	13
Add—Total of Instruments	7,796	19,419	7
SUM TOTAL	9,545	23,450	4
Brass Castings, &c., for Material Stock	...	1,556	0
GRAND TOTAL	..	25,006	4

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D.

List of Principal Instruments repaired in Workshop during the financial year 1886-87.

Instruments.	Number.
Anemometers	30
Arithmometers	2
Balance, electrical	1
Barometers, of sorts	69
Boards, drawing, of sorts	25
Chains of sorts	51
Chronometers	4
Clinometers	3
Compasses, Azimuth	2
Compass cards, of sorts	1
Compasses, bow pen, of sorts	70
,, bow pencil	2
,, circular	3
,, drawing, of sorts	147
,, magnetic, for plane-tables	64
,, mining	9
,, magnetic pocket	20
Compass pillar	1
Compasses, prismatic, of sorts	61
,, proportional	9
,, ship	7
,, surveying of sorts	62
Declinometer	1
Fiducial edge	1
Gauges, of sorts	6
Glasses, binocular	6
,, magnifying	1
Hand press	1
Heliographs	13
Heliotropes	1
Hydroclinometers	2
Hydrometers	77
Hygrometers	39
Instruments, drawing, of sorts	39
Lamps Bull's-eye	1
,, referring	2
Lenses, of sorts	1
Levels, of sorts	68
Machines, hand-printing	2
Magnets	2
Microscopes, of sorts	4
Micrometers	3
Mirrors, of sorts	10
Meter, current	1
Opiesometer	1
Padded boards	3
Pens, double, of sorts	3
,, drawing, of sorts	145
Pentagraph, of sorts	1
Perambulator	1
Pins for chains	290
Plane-tables	21
Planimeters	15
Pluviometers	10
Pointers station	5
Protractors, of sorts	14
Quadrants, gunner's	7
Quintants	4
Range finders	31
Rules, of sorts	16
,, sight, for plane-tables	32
Scales, of sorts	22
Scales, letter-weighing	1

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D—*continued.*

List of Principal Instruments repaired in Workshop—continued.

Instruments.	Number.
Sextants, of sorts	7
Squares, optical	93
Stands for compasses of sorts	52
„ for heliographs	14
„ for heliotropes	...
„ for levels	35
„ for plane-tables	14
„ for range finder	1
„ for theodolites	22
Staves, of sorts	69
Subtense compass	1
Tapes, of sorts	50
Telescopes, of sorts	65
Theodolites, of sorts	59
Thermometers, of sorts	49
Typeholder	2
Type hand-press	2
Watches, of sorts	2
Wind vances	3
TOTAL OF PRINCIPAL INSTRUMENTS REPAIRED	2,086
MINOR INSTRUMENTS REPAIRED	405
TOTAL OF ALL INSTRUMENTS REPAIRED	2,491

Profit and Loss Account of the Workshop for the financial year 1886-87.

Debits.	R	a.	Credits.	R	a.
Workshop Establishment, less proportion debitable to the Store Branch for cleaning and adjusting serviceable instruments	34,668	4	By repairs for public officers	11,808	12
One-third of office establishment	2,408	15	„ „ „ Stock	29,472	8½
Workshop contingencies as distinguished from materials purchased	598	11	„ Manufactures for Stock—		
Value of Materials— For special work	12,946	10	"Instruments"	20,683	13
„ General Workshop use	437	13	"Packing Cases"	2,766	7
For Manufacture of packing cases	1,659	15			
Paid for repairs	1,040	8			
Wear and tear of plant	1,206	0	„ Manufactures for materials	1,556	0
Half of rent at R325 per mensem	1,950	0			
Printing and stationery	206	1	Work done for Workshop, Store and Correspondence Branches of Office	326	0
Four per cent. on value of tools and plant amounting to R60,913-3	2,436	8			
Workshop profit	7,845	6½	Work on prepayment	791	3
TOTAL	67,404	11½	TOTAL	67,404	11½

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Extract from the Narrative Report of MR. W. H. COLE, *M.A., in charge Computing Section.*

The following tabular statements exhibit the money value of the work performed by the Computing Section during the Survey year 1886-87.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Computing Section.

DR. CR.

	R	R		R	R
Deputy Superintendent's salary .	8,967		Work done for the Survey of India Department as shown in the following table.	48,371	
Assistant Superintendent's salary	5,380				
Establishment	33,048				
Contingencies and travelling allowance.	535	47,930			48,371
Stationery	50	50	Extra Departmental work done.	288	288
Library, books and periodicals, also for binding Syl. Vol. VIIA.	679	679			
TOTAL .	...	48,659	TOTAL .	...	48,659

Statement of Departmental work done by the Computing Section.

No.	Class.	Value.
		R
1	Records, Library (including cost of purchase of books, &c., and binding of syl. vols.) .	2,458
2	Computations	16,069
3	Accounts, returns, correspondence	3,104
4	Supply of data, &c.	1,101
5	Preparation of press copy	7,803
6	Examination of press proofs	3,421
7	Do. charts, &c.	362
8	Protection of stations	1,583
9	Miscellaneous	10,881
10	Meteorology and general science	1,877
	TOTAL .	48,659

Statement showing the value of work done for other Departments by the Computing Section.

Names of other Departments.	Value.
	R
Quartermaster-General's Department in India	37
Meteorological Department	251
TOTAL .	288

Some explanation of the various items will now be given.

CLASS 1, RECORDS, LIBRARY, &C.—The records of all the survey operations appertaining to the Trigonometrical Branch, from the time of Colonel Lambton to the present date, find a resting-place in this office, where they are carefully stored and periodically inspected. Further, as each instalment is received it is closely examined, indexed, registered, and a detail receipt furnished to the executive officer from whom it comes. The custody of the Library, which now contains over four thousand volumes and pamphlets of a scientific character, also comes under this head, as well as the cost of books and periodicals purchased during the year, both for the Library itself and also for the several survey parties of the Trigonometrical Branch. Further, the binding of three hundred and fifty copies of a Synoptical Volume has been charged to this account.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

CLASS 2, COMPUTATIONS.—The principal operations under this heading have been—

(1) The completion of the final reduction of the principal triangulation of the South-West Quadrilateral which was nearly finished last year. The whole of the principal triangulation of India between the meridians of 67° and 92° has now been finally reduced.

(2) The reduction of the secondary triangulation of the Assam Longitudinal Series and Assam Valley Series of the North-East Quadrilateral. This has been steadily proceeded with, and it is hoped will be completed during next year. One other series of this quadrilateral remains; but as the field work is not yet complete it cannot be taken in hand at present.

(3) In the Southern Trigon Colonel Lambton's triangulation has been under treatment, in order to reduce it to final terms; it forms a very extensive network, and though good progress has been made with it, a great deal yet remains to be done. All the secondary triangulation appertaining to the South Konkan Meridional Series has been finally reduced.

(4) The Latitude observations taken during 1886-87 by Lieutenant Burrard, R.E., have been reduced, the services of two computers having been lent to the Astronomical Party for this purpose.

(5) Two computers were also lent to the officer in charge of No. 14 Party (Mirzapur) for nearly three months to enable him to bring up the arrears of the Khándesh Topographical Survey.

(6) One computer has been placed at the disposal of Major Gore, R.E., for ten months, to aid in the computations of the Afghan Boundary Survey.

(7) Several tables for the new edition of Auxiliary Tables to facilitate the calculations of the Survey of India were computed and others were examined.

The remainder of the work performed by the Computing Section was of a miscellaneous character.

CLASS 3, ACCOUNTS, RETURNS AND CORRESPONDENCE.—Under this heading are included indents, estimates, monthly detailed and abstract progress reports, stock returns of Ordnance stores, the compilation of data for the Annual Report and various other items. The assistance rendered in the current work of the Deputy Surveyor General's office is also included in this class.

CLASS 4, SUPPLY.—Requisitions from seventeen officers for data of various kinds have been complied with. In this class is also included the cost of labour in the despatch of maps, charts, books and forms.

CLASS 5, PREPARATION OF PRESS COPY.—This consists in the writing of the letter-press for the several publications; and also in abstracting and compiling the results of the several calculations in a suitable form for publication. All tabular data when so compiled are carefully compared twice before handing to the printer. The details of the work are as follows:—

Southern Trigon.—The Introductions to three series were revised and completed; the synopses of latitude, longitude, and azimuth of seven series were recompared; the final examination of a portion of the Appendix on Lambton's triangulation, written by Lieutenant Burrard, was completed. The above are for the Professional Volumes. For the Synoptical Volumes of this section of the triangulation, only the data of the South Konkan Meridional Series were sufficiently advanced for a compilation to be made. The whole of the secondary triangulation of the Trigon has been divided up, and a suitable share assigned to each series; and the data for a second Synoptical Volume has been put in hand.

South-Wst Quadrilateral.—The compilation of the details of the principal triangulation of this Quadrilateral, with the exception of the heights, is complete, and the data have undergone comparison. The compilation of the abstracts of the heights is partly finished.

North-West Quadrilateral.—The compilation of the Synoptical Volume of the Jodhpore and Eastern Sind Series was completed and the volume has been printed and published. The whole of the triangulation, both principal and secondary, of the North-West Quadrilateral has now been finally disposed of and published.

Observed Latitudes.—The compilation of the details of the Latitude Volume have been completed and the introductory chapters have been written. Good progress in the printing of both has been made.

Longitude Operations.—After the manuscript for the new Volume of Longitude operations (Vol. X) was made over to this office, it was found in course of examination of the press proof that the manuscript could not be relied on as altogether errorless, and a good deal of examination of details had to be made while the pages were passing through the press. Moreover, 38 pages of appendix were also examined.

Spirit-levelling Operations.—The Pamphlet of Heights, No. 2 Madras Presidency, was examined and passed for the press, and the printing all but completed before the expiration of the Survey year. It will shortly be issued.

Charts.—Letter-press data for the East Coast Series charts, Nos. 7, 8 and 9, were partly compiled and corrected.

Auxiliary Tables.—These tables have been finished and are now in course of issue.

CLASS 6, PRESS PROOFS.—The work done under this heading relates entirely to the Printing Section. It consists of the examination and comparison of proofs. As most of the matter printed is numerical or depends on numerical data, this examination can only be performed by men thoroughly acquainted with all the details of the subject in hand. Ordinary press readers could not be expected to render the critical examination which such matter requires. The charge for this class, though shown against the Computing Section, in order to balance the cost is debited against the Printing Section. Should the cost of the two sections be combined, this sum (R3,421) should be deducted from the total.

CLASS 7, CHARTS.—The careful examination of all charts of triangulation and of spirit-levelled heights before publication, is a matter of very great importance, and this work is also performed by the Computing Section, where the familiarity with the original records renders the detection of mistakes much easier and more certain than if the examination was made by the draftsmen themselves. All the charts, diagrams, &c., prepared during the year by the Drawing Section for the publications of the office were so examined; among them may be especially noted the East Coast Series charts Nos. 4, 5, 8 and 9, the final chart of the Eastern Sind Series, the Assam Longitudinal Series Degree Sheets 25 to 28 for the Synoptical Volume, besides which several other charts and diagrams were examined.

CLASS 9, MISCELLANEOUS.—In this class are included several duties of the Computing Section which cannot fairly be assigned to any of the other classes, such as the following:—The current observatory work at Dehra, the rating of chronometers; the cleaning and keeping in order of instruments of the larger class, &c.; the taking and reducing of time observations at Mussooree in order to give the time for the 12-o'clock gun; the reduction of the experimental base-line measured at Dehra last year; the adjustment of heights observed by Captain Jennings in Persia; the reduction of heights observed by Colonel Woodthorpe in Gilgit and beyond; the comparison against standard 4246, and determination of errors of the thermometers in use and in store in the office; and many other duties including the examination of two candidates for the Junior Division.

CLASS 10, METEOROLOGY AND GENERAL SCIENCE.—Deep sunk earth thermometers have been in use for some years; they were placed in holes sunk in a rather primitive fashion. One, the deepest, had caved in during a rainy season and the next to it had suffered in consequence. The other holes had also become large cavities in course of time. Four thermometers were re-set in holes lined with earthenware pipes 4 inches in diameter, *viz.*, at depths of 25·6, 12·8, 6·4 and 3·2 feet. Thermometers have also been retained in two of the old holes, *viz.*, the 12·8 feet, and 6·4 feet, for the sake of comparison; and though at first differences showed themselves, the temperatures of the corresponding thermometers settled down in September to very near identity, but they have begun to separate again since, the temperatures in the old holes being irregular, as was to be expected; especially as the new holes are provided with pads at intervals to stop convection currents, while the old ones being large and irregular cavities, nothing can be done to prevent these currents. An explorer and his assistant were instructed in the use of certain instruments and Mr. Dalgleish's latitude observations in Eastern Turkestan and Mongolia were reduced.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

MEAN MONTHLY READINGS OF EARTH THERMOMETERS.

Depth in feet of thermometer bulbs below surface of ground.	YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
		°	°	°	°	°	°	°	°	°	°	°	°
25·6	1881	...	...	...	...	...	73·55	73·90	75·02	76·07	76·69	76·98	76·71*
	1882	75·91	75·13	74·52	74·11	73·97	74·05	74·31	74·95	75·69	76·14	76·39	76·37
	1883	75·85	75·02	74·28	73·89	73·97	73·96	74·32	74·90	75·66	76·16	76·28	76·12
	1884	75·20	74·39	73·90	73·64	73·65	73·95	74·34	76·00	76·87	77·33	†77·27	76·72
	1885	75·83	74·95	74·34	74·00	73·92	74·02	74·25	‡	‡	‡	‡	‡
	1886	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
	1887	(a) 74·58	74·67	74·30	73·80	73·50	73·55	73·95	75·05	76·01	...	...	...
12·8	1881	...	...	...	...	...	74·87	76·47	77·88	78·98	79·26	77·71	74·89
	1882	72·33	70·79	70·47	71·70	73·37	75·23	76·87	78·20	78·98	79·02	77·64	74·89
	1883	72·46	70·36	69·83	70·94	73·00	75·17	76·82	78·20	78·97	78·93	76·93	73·50
	1884	70·95	69·75	70·01	71·47	73·39	75·75	77·42	79·24	79·82	79·34	§77·08	74·52
	1885	72·18	70·37	70·03	71·14	72·66	73·99	76·09	78·98	79·42	79·25	77·93	75·36
	1886	72·49	b70·56	70·26	70·95	72·46	74·12	76·18	78·63	79·54	79·41	77·82	75·16
(Old)	1887	(c) 72·56 (d) 69·22	68·80	69·67	71·12	73·38	76·09	77·65	79·23	79·77	...	...	...
(New)	1887	72·16	70·87	70·18	70·97	72·87	75·37	77·20	78·94	79·58	...	...	...
6·4	1881	...	...	...	...	...	80·66	81·01	80·75	81·24	80·33	75·80	70·58
	1882	67·17	66·06	67·75	,2·29	76·47	80·01	80·78	81·30	81·32	80·16	75·75	71·03
	1883	67·64	65·10	66·48	71·00	76·72	79·29	80·70	81·42	81·12	79·50	74·50	68·71
	1884	66·03	65·61	67·95	72·36	76·99	80·76	81·46	81·64	81·10	78·85	73·81	69·57
	1885	66·64	64·83	66·73	71·10	74·29	77·59	80·32	80·77	80·85	79·90	76·19	70·97
	1886	66·53	64·72	66·61	69·99	74·87	77·87	80·34	81·54	81·70	79·92	75·50	70·69
(Old) ¶	1887	65·79	64·16	67·63	71·40	76·96	80·23	80·57	81·08	80·89	...	...	...
(New)	1887	(e) 64·65	64·54	67·58	71·72	77·91	80·94	80·86	81·11	80·88	...	...	...
3·2	1881	...	...	...	...	...	85·93	83·29	82·03	82·40	79·67	72·20	65·59
	1882	62·57	62·31	67·61	75·49	80·86	84·77	82·71	83·04	82·20	79·21	71·73	66·14
	1883	62·27	60·70	64·83	74·13	81·57	83·44	83·00	83·43	81·74	78·23	69·72	62·50
	1884	61·23	61·90	67·69	75·75	82·32	85·11	84·20	81·94	81·38	76·50	69·32	64·18
	1885	61·38	60·28	65·97	73·52	76·30	82·30	82·68	80·94	81·35	78·73	72·55	65·37
	1886	60·79	60·22	65·33	72·39	78·89	82·14	82·55	82·48	82·37	78·44	71·74	65·56
(New)	1887	(f) 61·70 58·57	59·99	68·80	76·55	85·47	84·93	82·56	81·63	81·31	...	...	...
1·1	1881	...	...	...	...	...	89·16	84·14	82·55	83·19	77·81	67·81	60·72
	1882	58·91	59·41	69·50	78·88	84·99	88·24	83·48	84·08	82·89	77·85	67·96	62·17
	1883	57·98	58·45	65·87	79·53	86·65	87·94	84·55	84·89	82·19	76·70	65·41	57·83
	1884	58·28	59·89	69·56	80·14	88·27	88·57	85·59	82·03	81·64	74·14	65·38	60·10
	1885	57·35	57·75	68·28	77·20	78·63	87·22	84·35	81·16	82·09	77·45	69·03	60·91
	1886	57·13	57·76	66·25	77·19	83·02	86·44	83·78	82·99	83·16	76·78	68·36	61·20
	1887	55·80	58·16	69·27	79·12	89·25	85·94	82·73	81·34	81·01	...	...	...
Thermometer in Shade.	1881	...	...	...	...	...	87·68	82·54	81·00	82·86	82·72	75·22	71·19
	1882	66·77	66·51	81·36	88·72	91·04	89·11	81·61	82·40	84·62	83·47	75·04	72·36
	1883	64·80	68·72	75·89	91·83	95·54	90·60	83·54	83·85	82·86	82·00	70·95	66·12
	1884	67·36	68·52	81·32	89·51	97·33	89·69	83·86	79·73	80·30	77·30	71·77	67·37
	1885	62·50	65·44	79·35	85·63	84·47	91·97	82·74	79·08	82·41	81·98	75·09	66·31
	1886	63·04	67·49	73·74	88·55	87·82	90·60	82·35	81·75	85·05	80·90	74·56	68·93
	1887	59·79	70·64	80·37	89·88	98·66	89·09	81·28	78·60	83·34	...	...	...

* The hole which had gradually filled up about 2½ feet, was dug down to the original depth between the 20th and 24th December 1881.

† The hole which had gradually filled up 2 feet since December 1881, was dug down to the original depth between the 9th and 18th November 1884.

‡ Earth fell in from the sides of the hole on the 2nd and 3rd August 1885; and covered the thermometer to the depth of 11 feet. It was found impossible to sink another thermometer to this depth till 20th January 1887, when a new hole was dug down to the depth of 25·6 feet and lined with 4-inch stoneware pipes.

(a) This is the mean of the readings of the last 11 days of the month.

§ The hole which had gradually filled up 11 inches since June 1881, was dug down to the original depth on the 17th and 18th November 1884.

(b) When the 25-foot hole filled up in August 1885, the 12-foot hole, which was close by, deepened about a foot, and the length of chain being greater than necessary, the thermometer remained suspended at a depth of 14 feet till 23rd January 1887, when the hole was filled up till it was only 12·8 feet deep. At the same time a new hole was dug to this depth and lined with 4-inch stoneware pipes. Readings from both have been regularly taken for the sake of comparison.

(c) This is the mean of the readings of a 14-feet deep thermometer for the first 23 days of the month.

(d) This is the mean of the readings of a 12·8 feet deep thermometer on the last 7 days of the month.

¶ A new hole was dug in January 1887 and lined with stoneware pipes, but the old hole was left undisturbed for the sake of comparing the readings.

(e) This is the mean of the readings of the last 7 days of the month.

(f) This is the mean of the readings of the first 13 days of the month, after which a new hole was sunk lined with 4-inch stoneware piping, and the reading below is for the last 14 days of the month.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Mean Velocity in Miles of the Winds which blew at Dehra Dún during the Twelve Months of 1886-87 for each Hour of the Day.

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	3·21	2·41	2·26	1·16	2·00	2·52	2·63	1·58	1·57	0·68	0·54	1·17
1 " 2	2·48	2·10	2·06	0·97	1·96	2·35	2·50	1·61	1·43	0·52	0·50	1·10
2 " 3	2·27	1·79	1·71	0·87	2·04	2·45	2·13	2·19	1·30	0·23	0·61	1·07
3 " 4	1·93	1·76	1·90	1·00	1·38	1·71	1·67	1·61	1·33	0·23	0·50	1·41
4 " 5	1·83	1·34	1·35	1·03	1·96	1·48	1·77	1·42	1·10	0·60	0·21	0·69
5 " 6	1·86	1·52	1·52	0·77	1·80	1·45	1·53	1·55	1·13	0·77	0·11	0·69
6 " 7	1·59	1·07	1·55	0·74	1·80	1·00	1·17	0·87	0·97	0·80	0·14	0·62
7 " 8	1·24	0·71	1·61	0·84	1·76	0·94	1·10	1·03	1·57	0·53	0·21	0·76
8 " 9	1·38	0·79	1·26	0·97	1·20	1·00	1·50	1·74	1·43	0·67	0·57	0·55
9 " 10	2·17	1·11	1·29	1·23	1·60	1·94	2·37	3·00	1·90	1·40	1·00	1·45
10 " 11	1·93	2·10	1·84	1·58	1·88	3·00	3·13	3·35	2·00	1·40	1·21	1·47
11 " 12	2·69	2·31	2·29	1·68	2·52	4·26	4·27	4·19	1·97	1·30	1·21	1·57
12 " 13	2·39	2·48	2·61	2·10	3·08	4·42	4·43	3·94	2·57	1·52	1·26	1·90
13 " 14	2·75	2·72	2·52	2·52	3·24	4·52	4·30	5·06	2·70	1·94	1·85	2·14
14 " 15	2·71	2·07	2·26	2·10	3·32	4·55	4·97	4·90	3·27	2·10	1·78	2·31
15 " 16	2·39	2·21	2·06	2·03	3·08	4·61	4·53	4·77	3·13	1·81	1·74	2·28
16 " 17	1·10	1·10	1·29	1·68	2·65	3·71	4·10	5·03	2·57	1·32	1·30	1·97
17 " 18	0·69	0·41	0·61	0·87	1·77	2·81	3·13	3·32	2·23	1·10	0·78	0·55
18 " 19	1·31	1·14	1·26	0·71	0·50	1·61	2·00	2·42	1·47	0·65	0·70	0·48
19 " 20	2·48	1·97	2·03	0·61	1·00	1·55	2·07	1·48	1·27	0·26	0·30	0·79
20 " 21	2·76	2·59	2·00	0·81	1·50	2·13	2·23	1·35	1·50	0·29	0·67	1·07
21 " 22	2·83	2·90	2·52	1·06	2·62	2·45	2·67	1·97	1·90	0·35	0·63	0·90
22 " 23	3·24	3·00	2·35	1·06	2·38	2·52	2·27	1·77	1·50	0·68	0·44	0·79
23 " 24	2·86	2·55	2·42	1·06	1·96	2·81	2·47	1·90	1·80	0·48	0·85	1·03
Sums	52·09	44·15	44·57	29·45	49·00	61·79	64·94	62·05	43·61	21·63	19·11	28·76
Average	2·17	1·84	1·86	1·23	2·04	2·57	2·71	2·59	1·82	0·90	0·80	1·20

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Monthly Meteorological Results taken from the

Year and Month.	Barometer reduced to 32° Fahrenheit.						Hygrometer.			
	At 9-30 A.M.			At 3-30 P.M.			At 9-30 A.M.		At 3-30 P.M.	
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean temperature of dew point.	Monthly mean humidity.	Monthly mean temperature of dew point.	Monthly mean humidity.
1886.										
October	27·787	27·591	27·698	27·711	27·505	27·604	61·0	·668	62·1	·568
November	·926	·705	·810	·838	·621	·716	52·1	·677	53·2	·512
December	·938	·752	·829	·867	·681	·748	44·7	·651	46·8	·489
1887.										
January	27·833	27·521	27·700	27·747	27·458	27·622	45·6	·807	46·0	·626
February	·943	·572	·740	·863	·465	·661	42·2	·593	42·2	·379
March	·742	·467	·638	·636	·366	·550	46·0	·470	44·4	·312
April	·700	·476	·607	·630	·351	·518	49·5	·357	46·9	·266
May	·711	·362	·488	·571	·258	·382	56·3	·342	53·1	·243
June	·492	·312	·423	·466	·223	·332	66·8	·593	65·9	·492
July	·524	·270	·400	·450	·193	·328	73·9	·857	75·1	·819
August	·540	·337	·449	·480	·290	·389	73·4	·874	74·6	·879
September	·672	·404	·534	·574	·312	·456	69·2	·786	70·3	·700

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Register at the Trigonometrical Branch Office, Dehra Dún.

THERMOMETER.								RAIN.		WIND.	CLOUD.	
DRY BULB.					WET BULB.							
Maximum in sun's rays.	Minimum on grass.	Maximum in air.	Minimum in air.	Monthly mean in air.	Maximum in wet.	Minimum in wet.	Monthly mean wet.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 9-30 A.M.	At 3-30 P.M.
148·0	44·7	85·5	53·7	71·6	74·5	47·6	63·3	5	3·76	N. E.	1	2
135·4	36·9	77·5	44·5	63·6	64·7	40·6	55·3	1	0·03	S. W.	1	2
127·4	35·3	72·7	41·0	57·6	59·5	38·9	49·9	2	0·99	W. S. W.	3	3
126·4	30·7	68·5	36·2	52·6	57·3	35·3	47·5	10	2·93	W.	6	7
135·1	27·4	78·3	35·7	59·0	64·2	33·7	49·4	1	0·34	W. S. W.	2	3
144·8	46·0	85·3	49·2	68·0	66·4	43·0	54·9	3	0·08	W.	4	4
156·9	44·9	99·5	54·1	77·0	68·9	47·2	60·0	2	0·17	N. W.	2	2
158·1	55·6	102·8	64·4	86·5	77·3	55·0	66·2	1	0·37	S. W.	...	1
154·0	61·8	99·7	60·8	82·2	82·1	61·2	71·4	13	10·19	Calm.	3	4
156·4	66·8	90·7	70·1	79·1	83·1	69·5	76·3	26	32·97	Calm.	8	8
158·5	66·9	86·9	69·8	77·5	81·6	69·3	75·7	28	30·27	Calm.	9	9
158·1	57·7	87·8	63·7	75·9	80·5	60·9	71·7	10	4·88	Calm.	3	5

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

TYPE PRINTING SECTION.—With the exception of a little work done for the Forest Department, the energies of this office have been almost entirely devoted to the printing of volumes of the Account of the operations of the G. T. Survey, of Synoptical Volumes of the Levelling operations and of the new edition of the Auxiliary Tables. Very satisfactory progress has been made during the year with the volumes of the Department.

Statement of Expenditure (Dr.) and Amounts credited (Cr.) on account of the Type Printing Section during the year 1886-87.

DR. CR.

	R	R		R	R
Superintendence	960		Letter-press, forms, diagrams, &c., for the Survey of India Department	13,784	13,784
Establishment	7,769				
Aid rendered by Computing Section	3,421				
Wear and tear of plant	612				
Contingencies	96	12,858			
Stores received from England	127	127			
Stores purchased in India	59		Miscellaneous letter-press, &c., extra departmental	95	95
Stationery from Stationery Office	835	894			
TOTAL	...	13,879	TOTAL	...	13,879

Statement of departmental work done by the Type Printing Section during the year 1886-87.

Specification of print.	No. of pages.	Total No. of pulls.	No. of copies.*	Value.
				R
Professional Volumes	593	113,154	510	8,698
Synoptical ,,	111	21,306	360	1,489
Pamphlets of spirit-levelled heights	70	5,287	510	582
Letter-press for charts, map headings and foot-notes	134	5,085	30	476
Auxiliary Tables	95	30,970	1,012	1,504
Forms	43	9,815	150	349
Explorations	19	1,144	110	161
Miscellaneous work done for the Trigonometrical Branch	107	25,561	80	525
TOTAL	1,172†	212,322	...	13,784

* Approximate number. † Equal to 1,464 pages of standard (foolscap) size.

Statement showing the amount and value of work done for other Departments by the Type Printing Section during the year 1886-87.

Name of other Departments.	No. of pages.	Total No. of pulls.	No. of copies.	Value.
				R
Forest Department	36	2,945	...	95
TOTAL	36*	2,945	...	95

* Equal to 31 pages of standard (foolscap) size.

The usual table showing the work annually performed by this section during the past five years is given below, the unit (a page of foolscap) being the same throughout. It will be observed that the out-turn of the past year is largely in excess of any previous one :

	1882-83.	1883-84.	1884-85.	1885-86.	1886-87.
Pages composed	1,381	1,489	1,505	1,340	1,516
Pages printed	475,586	362,386	470,970	638,593	805,076

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

An analysis of the pages composed is as follows :—

		PAGES
Professional	Longitude operations	500
	Latitude operations	291
	Great Arc Series, section 8° to 18°	90
	South-East Coast and Ceylon Series	6
	Madras Meridional and Coast Series	6
	Mangalore Meridional Series	12
	Appendix to Southern Trigon Volumes	24
	Bombay Longitudinal	21
	TOTAL	950
Synoptical	Jodhpur and Eastern Sind Meridional Series	121
	Madras Meridional and Coast Series	15
	Madras Longitudinal Series	9
	Bombay Longitudinal Series	6
	TOTAL	151
Miscellaneous	Spirit-levelled Heights, No. 2, Madras Presidency	67
	Letter-press for chart headings and foot-notes	92
	Auxiliary Tables	140
	Orders, Memoranda, Forms, &c.	57
	For Forest Department	31
	Explorations (M—H's)	28
	TOTAL	415

DRAWING SECTION.—The time of the office has been largely taken up in affording aid to Major Gore in the execution of trans-frontier maps required by the Government of India, and the regular work has therefore been a good deal in abeyance. Four charts of levels in the Punjab were in hand during the year ; three were published, but large additions by the canal authorities necessitate a new edition of two of them, which is in hand. These level charts, which exhibit the operations of this Department, the Department of Public Works, and Railway Companies, all reduced to mean sea-level, are of great value, and it is a matter of regret that more progress cannot be made with them. Some final charts of triangulation have been prepared to illustrate Synoptical Volumes and also some charts of the work executed by the Coast Triangulation Party. The data on these charts are in final terms. A sketch map of explorer M—H's route has been published, and a set of charts of Himalayan snow peaks was constructed for the Australian Geographical Society. Mr. Carey's route from Khotan *viâ* Kurla to Hami, &c., from a survey by Mr. Dalgleish (about 3,000 miles in length) was plotted and adjusted and a tracing supplied to Mr. Carey for the use of the Royal Geographical Society, London. Also a good deal of work of minor importance was done.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Drawing Section during the year 1886-87.

DR. | CR.

	R	R		R	R
Superintendence	4,800		Maps, Charts, &c., for the Survey of India Department	40,577	40,577
Establishment	37,602				
Contingencies	213	42,615	Maps, &c., Extra-departmental	2,213	2,213
Stationery from Stationery Office	175	175			
TOTAL	...	42,790	TOTAL	...	42,790

Statement showing the value of work done for other Departments by the Drawing Section during the year 1886-87.

Name of other Departments.	Value. R	a.	REMARKS.
For Bengal Government	35	15	
„ Foreign Office	840	11	
„ Quartermaster-General	1,270	7	
„ Forest Department	48	2	
„ Marine „	18	2	
TOTAL	2,213	5	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Departmental work done in Drawing Section during the year 1886-87.

Title of Maps, &c.	Scale 1 inch=.	Remarks and Progress.
Final Charts of Triangulation.	Miles.	
Assam Longitudinal Series Degree Sheets Nos. 1 to 28 .	4	Suspended for preparation of additional data to be incorporated therein.
Jodhpore Meridional Series	4	For reduction to half scale published.
Eastern Sind Meridional Series	4	Ditto ditto.
Preliminary Charts.		
East Coast Series, Secondary Triangulation Charts, Nos. 4, 5, 6, 7, 8 and 9.	2	Nos 4, 8 and 9 published. Nos. 5, 6 and 7 in press.
Compilation.		
Sketch Map to illustrate the route of Explorer M—H from Dagmara Thana, *viá* the Dudhkosi to Dingri and thence *viá* Jonkha Jong and Kirong to Tirbenighât.	8	For reduction to half scale. Published.
Level Sheet No. 6, Second Edition	2	Published.
Ditto „ 81, ditto	2	In press.
Ditto „ 83, ditto	2	In course of preparation.
Ditto „ 88, ditto	2	Ditto ditto.
Chart to accompany Pamphlet of spirit-levelled Heights No. 1, Madras Presidency.	12	For reduction to half scale. Published.
Miscellaneous.		
Charts showing snowy peaks on the Himalayas from Assam to the Kunar river, comprising sheets Nos. 19-20-27-28 of North-West Trans-Frontier, Nos. 5-6-12-13, 7-14-15, 20-21-28-29 and 22-23-30-31 of North-East Trans-Frontier, and Nos. 1-2-5-6, 3-4-7-8, 9, 14-15-21-22 and 16-23 of Northern Trans-Frontier.	16	For Australian Geographical Society.
Prepared Zenith distance observation forms . . .	...	For Photozincography and Departmental use.
Prepared Forms P 43, P 44 A, P 44 B and P 25 . .	...	Ditto ditto.
Prepared Forms for computation of distance apart . .	...	Ditto ditto.
Prepared Diagram of personal equation between Major Strahan, Major Heaviside and Lieutenant Burrard for arcs of Longitude.	...	For General Report, 1885-86.
Prepared Monthly diagrams of conspicuous sun spots from October 1886 to September 1887.	...	Published in Survey Notes.
Prepared two plates of figures of the Madras Meridional and Coast Series.	6	Reduced to half scale for publication in Professional Volumes.
Corrected the Index to sheets of Kangra and Simla Hill States.	16	Published in Annual Report, 1885-86.
Coloured up to date Map of India showing progress of Imperial Surveys.	...	Ditto ditto.
Extracted notes from Prejevalsky's Travels in High Asia .	...	For record in office.
Copied a Report on Sikhim received from Quartermaster-General, 47 pages of quarto size Memo. Book.	...	Ditto.
Examined 442 proofs of Maps and Charts . . .	...	
Finished drawing of Degree Sheet VIII, comprising Nos. 38-39-53-54, 40-41-55-56 of Rajputana.	2	Published.
Finished Sheet No. 76 of Rajputana Survey . . .	1	Ditto.
Corrected Sheets Nos. 6 and 7 of Ajmere City Survey .	$\frac{1}{12}$	Ditto.
Examined Sheets Nos. 200 S.E., 200 N.W., 200 N.E., and 201 S.E., of Mirzapur Survey.	$\frac{1}{2}$	
Examined and corrected Chart to accompany Pamphlet of spirit-levelled Heights No. 2 of Madras Presidency.	8	For reduction to half scale. Published.
Examined and corrected 4 maps and 1 chart of Triangulation of Nicobar Islands Survey.	2 & 5	In press.
Examined Indian Atlas Sheets Nos. 38 S.W. and 39 S.W.	...	
Maps coloured, No. of copies=5,057	...	
22 Maps for Surveyor General's Office	Various .	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Statement of extra-departmental work done by the Drawing Section during the year 1886-87.

Title of Map.	Scale 1 Inch=	Remarks and Progress.
Compilation, Mapping, &c.	Miles.	
Copied boundary-line between Nepal and Darjeeling in Sheets Nos. 1, 2, 3 and 4 (Mechi river) of Nepal Boundary Survey	¼	For Deputy Commissioner, Darjeeling.
Prepared Triangulation Chart of India showing triangulation in the vicinity of the coast.	96	For the Superintendent, Marine Survey, Bombay.
Prepared a tracing of the map showing area affected by the Deoban-Chakrata Sledge Road.	½	For the Conservator of Forests, School Circle, Dehra.
Completed with respect to heading and foot-notes, Forest maps, before sending to press.	Various .	For Forest Department.
Made an extract from standard sheet No. 76 of Rajputana Topographical Survey.	1	For Officer on special duty, Sirohee Boundaries, Rajputana.
13 Maps for Foreign Office and Quartermaster-General's Office.	Various .	

PHOTOZINCOGRAPHIC SECTION.—This office has been employed in printing maps, charts, forms, diagrams, &c., both to illustrate the volumes published by the office and for general use; it has also executed a good deal of work for the Forest Department and a certain amount for the Foreign Office and Quartermaster-General's Department.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Photozincographic Section during the year 1886-87.

DR. CR.

	R	R		R	R
Superintendence	2,400		Maps, Forms, Diagrams, &c., for the Survey of India Department.	14,129	14,129
Establishment	8,603				
Contingencies	176	11,179			
Chemicals and Stores from England	2,925				
Paper received from England .	1,703	4,628			
Chemicals and Stores purchased in India	418		Miscellaneous Maps, Plans, &c., Extra-departmental . . .	6,188	6,188
Stationery (paper) from Stationery Office	170	588			
Shipping and Landing charges .	50	50			
Balance to credit of Department .	...	3,872			
TOTAL .	...	20,317	TOTAL .	...	20,317

NOTE.—In addition to the credits above shown, the section has realized (by sale on payment of maps, &c.) and paid into the treasury the sum of R943-7-8.

Statement showing the amount and value of work done for the other Departments by the Photozincographic Section during the year 1886-87.

Names of other Departments.	Photozincographic Printing.						Type-printing.		No. of Pulls.	No. of Copies.	Value.		Remarks.
	No. of sheets or Sections or subjects.	No. of Negatives.	No. of Photo-transfer Prints.	No. of Zinc Plates.	No. of Silver Prints.	No. of Blue Prints.	No. of pages or Items.	No. of copies.			R	a.	
Forest Department .	80	284	207	55	...	315	...	...	3,614	4,632	3,554	11	
Foreign Do. .	10	36	56	10	...	...	...	...	405	405	736	2	
War Office . . .	25	8	161	...	...	161	...	...	...	52	138	0	
Quartermaster-General	34	112	68	13	69	...	...	...	2,586	2,901	1,638	13	
Chief Engineer, Khwaja-Amran State Railway . . .	3	12	8	...	12	20	...	...	1	3	90	0	
Superintending Engineer . . .	2	...	...	...	...	16	...	...	...	2	30	0	
TOTAL .	154	452	500	78	81	512	...	...	6,606	7,995	6,187	10	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Statement of Departmental work done by the Photozincographic Section during the year 1886-87.

Specification of Plate or Print.	Photozincographic Printing.									Type-printing.		Total No. of pulls.	No. of copies.	Value		Remarks.
	Progress made.	Scale of maps.	Size of each sheet.	No. of sheets, sections or subjects.	No. of negatives.	No. of photo. transfer prints.	No. of zinc plates.	No. of silver prints.	No. of blue prints.	No. of pages or items.	No. of copies.			R	a.	
Plates IV, V, and VI	F.	1 inch= Various	1/8 D.E.	3	6	12	2	...	...	...	...	650	1,300	175	0	For Professional Vol. X of Electro-telegraph Longitudes.
Plate 7 of the Great Arc Series	,,	2 and 12 miles.	1/8 ,,	3	4	7	3	...	...	...	...	1,018	1,518	140	1	For Professional Volume of Southern Trigon.
Rajputana Topographical Survey Sheets Nos. 73, 74, 75 and 76	,,	1 mile	D.E.	4	6	6	4	...	...	...	...	303	303	145	15	
Do. Survey Degree Sheet No. VIII	,,	2 ,,	,,	2	12	12	2	...	...	...	...	306	306	239	14	
Abstract account of conspicuous Sun-spots for 9 months	,,	...	1/2 F.P.	9	9	18	9	...	...	...	...	941	1,882	233	12	For Survey of India Notes.
Index Map to the Nicobar Island Survey	,,	16 ,,	1/3 D.E.	1	2	2	1	...	...	...	...	36	36	37	5	
Nicobar Island Survey Sheet No. 1	,,	2 ,,	D.E.	1	8	8	1	...	...	...	...	50	50	121	2	
Do. do. Nos. 2 and 3	In Press.	2 ,,	,,	2	16	16	2	...	...	...	...	...	...	220	12	
Do. Map	,,	5 ,,	,,	1	8	...	1	...	...	...	...	...	...	45	9	
Do. Triangulation Chart	,,	2 ,,	,,	1	6	6	1	...	...	...	...	...	...	82	13	
Bhopal and Malwa Survey Triangulation Chart, Degree Sheet No. IX	F.	4 ,,	,,	1	6	12	2	...	...	...	...	33	33	143	13	
North-East Trans-Frontier Sheet No 5	,,	8 ,,	,,	1	6	6	1	...	...	...	...	60	60	99	5	
Northern do. do. Nos. 20 and 21	,,	8 ,,	,,	2	12	12	2	...	...	...	...	120	120	198	10	
Graticule Sheet, North Trans-Frontier; 24° to 28°	,,	16 ,,	,,	1	...	...	1	...	...	...	...	6	6	3	0	
Do. do. do. 34° to 36°	,,	8 ,,	,,	1	..	...	1	...	...	...	...	24	24	7	8	
Do. North-East do. 32° to 36°	,,	16 ,,	,,	1	...	...	1	...	...	...	...	12	12	6	0	
Do. North-West do. 38° to 40°	,,	8 ,,	,,	1	...	...	1	...	...	...	...	24	24	7	8	
Southern Waziristan; Preliminary issue	* ,,	2 ,,	,,	1	...	...	1	...	...	...	...	25	25	7	10	
Index to South-West Asia Sheets	* ,,	320 ,,	1/4 ,,	1	...	2	1	...	...	...	...	32	64	19	0	
Maps of the City of Jeypore, Nos. 1 to 8	* ,,	1/8 ,,	D.E.	8	...	...	16	...	...	...	...	800	400	122	0	
Table of Distances	,,	...	1/2 S.R.	6	3	12	1	...	...	...	...	50	50	96	13	
Gujarát Survey Sheet No. 50	,,	1/4 ,,	1/4 D.E.	1	2	...	...	2 pcs.	...	...	...	...	1	15	14	
Do. do. No. 49, Section 14	* ,,	1/4 ,,	D.E.	1	...	6	1	...	...	...	...	12	12	54	10	Specimen copies.
Himalaya Peaks from Assam to the Kunar River	,,	16 ,,	...	10	16	76	10	...	...	...	...	100	100	714	10	For Australian Gregraphical Society.
Index to the Sheets of the Punjab Survey	,,	16 ,,	1/2 ,,	1	8	16	3	...	...	...	...	542	542	196	11	For General Report, 1885-86.
Charts of Spirit-levelling operations Nos. 1 and 2	,,	24 and 16 miles.	D.E. and 1/4 D.E.	2	6	10	3	...	...	...	...	1,030	1,030	218	11	For Pamphlets of Spirit-levelled Heights, Nos. 1 and 2, Madras Presidency.
Level Chart Sheet No. 6 (2nd Edition)	,,	2 ,,	D.E.	1	6	6	1	...	...	...	...	110	100	107	12	
Do. do. No. 81 (do.)	In Press.	2 ,,	,,	1	6	...	1	...	...	...	...	...	...	34	3	
Do. Bench-marks (do.)	F.	...	1/8 ,,	1	1	2	1	...	...	...	...	52	104	23	14	
Hyderabad Survey, Nos. 220 and 224	,,	1 mile	D.E.	2	...	12	2	...	...	...	...	155	155	134	10	
Diagram of North-West Quadrilateral	,,	64 ,,	1/8 ,,	1	...	2	1	...	...	...	...	175	350	28	15	For Vol. VII A (Synoptical).
Do. Personal Equation	,,	...	1/16 ,,	1	2	6	2	...	...	...	...	240	480	48	6	For General Report, 1885-86.
Skeleton Chart of principal chains of triangles, &c.	,,	280 miles	1/8 ,,	1	1	4	1	...	...	...	...	120	480	46	0	Ditto.
Final Charts of Jodhpore Meridional Series, Nos. 1 and 2	,,	8 ,,	D.E and 1/2 D.E.	2	16	16	2	...	...	...	...	910	910	325	15	For V. VII Alo (Synoptical).
Do. Eastern Sind Meridional Series	,,	8 ,,	D.E.	1	9	9	1	...	...	...	...	375	375	169	12	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Secondary Triangulation Charts of East Coast Series, Nos. 4, 8 and 9	,,	2 ,,	,,	3	18	18	3	...	...	...	...	90	90	257	5	
Secondary Triangulation Charts of East Coast Series, Nos. 5, 6 and 7	In Press.	2 ,,	,,	3	24	...	3	...	...	...	...	...	...	136	11	
Madras Meridional and Coast Series, Plates 1 and 2	,,	12 ,,	1/8 ,,	2	2	8	2	...	...	...	...	...	...	61	12	For Professional Vol. of Southern Trigon.
Star Chart in four plates	F.	...	1/8 D.E.	4	4	12	3	...	4	...	...	1,020	1,020	176	2	For new edition of Auxiliary Tables.
Surat City, Cantonment and Environs, eastern half	* ,,	1/8 mile.	D.E.	1	...	...	...	...	...	...	...	54	54	25	10	
Mirzapur Survey Sheets, Nos. 200 N. W., 201 N. E., and 201 S.E.	,,	1/2 & 1 ,,	D.E. and 1/4 D.E.	3	.14	14	3	...	7	...	...	317	317	272	0	
Sketch map illustrating the route of explorer M—H	,,	16 mile.	1/2 D.E.	1	4	4	1	...	...	...	...	123	123	60	0	For Exploration Report.
Bangalore Cantonment and City in 13 Sheets	,,	1/12 ,,	D.E.	11	66	66	11	...	...	...	...	1,133	1,133	1,176	5	
Khándesh Survey Triangulation Chart Degree Sheets, Nos. III and VI	,,	4 ,,	,,	1	6	6	1	...	...	...	...	22	22	89	3	
Country between Umballa and Delhi	* ,,	4 ,,	,,	1	...	8	1	...	...	...	...	25	25	72	7	
Ajmere City, Nos. 6 and 7	,,	1/12 ,,	,,	2	15	15	2	...	...	...	...	150	150	236	5	
Kumaun and Garhwál Survey, Contour Sheet No. 14	* ,,	1 ,,	,,	1	...	10	...	...	...	...	...	...	2	45	0	
Index to Sheets of Punjab Survey, Simla Hill States	,,	...	1/8 ,,	...	1	3	...	...	3	...	...	...	3	11	3	
Miscellaneous Forms, &c., &c., for departmental use	,,	...	Various.	50	36	105	36	...	10	...	...	13,525	8,709	1,893	15	
Other maps for office use and for Surveyor-General's Office	,,	various.	,,	177	340	552	76	36	370	...	...	1,155	1,261	4,845	0	
			Copies of Maps of other Departments taken for Departmental use.													
Forest Map of Chota-Nagpore Sheets Nos. $157\frac{S.W.}{2}$, $157\frac{S.W.}{4}$ and $157\frac{S.W.}{2}$R.	F.	1/4 and 1 mile.	D.E. and 1/4 D.E.	3	14	21	3	...	...	...	...	40	55	13	0	Copies retained, *for office record*, of maps, &c., requisitioned for by other departments; the cost of press pulls and stationery being all that is here charged to the Survey Department.
Forest Map, Kapurthala	,,	2 ,,	1/8 D.E.	1	1	4	1	...	...	...	...	5	20	2	10	
Chakráta-Deoban Sledge Road Map	,,	1/2 ,,	D.E.	1	6	6	1	...	...	...	...	15	15	6	6	
Berar Forest Survey, parts of Sheets Nos. 20 and 20A	,,	1/4 ,,	D.E. and 1/2 D.E.	4	16	20	4	...	90	...	...	66	66	23	13	
Kalesar Reserved Forest Sheet No. 336	,,	1/4 ,,	D.E.	1	9	9	1	...	30	...	...	20	20	6	10	
Kumaun and Garhwál Forest Survey Sheets Nos. XIV, XLIII and LXXVIII	,,	1/4 ,,	,,	3	18	19	2	...	90	...	...	47	46	19	4	
Kumaun and Garhwál Forest Survey Sheets Nos. I, III A, III B, IV, V, XV, XVII to XXIII, XXV to XXVIII, XXXI, XXXII, XXXIV to XXXVIII	,,	1/2 ,,	1/4 ,,	24	60	60	16	...	60	...	...	211	390	49	15	
Kumaun and Garhwál Triangulation Chart No. II	,,	1 ,,	D.E.	1	8	8	1	...	5	...	...	17	17	6	5	
Changa Manga Plantation Map	,,	1/4 ,,	,,	1	7	7	1	...	...	...	...	16	16	6	8	
Puranpur Reserved Forest	,,	1 ,,	,,	1	6	6	1	...	...	...	...	16	16	6	8	
Chir Forest on the Tons river	,,	1 ,,	1/2 ,,	1	4	4	1	...	...	...	...	15	15	3	6	
Tiri-Garhwál Leased Forests, Jaunsár Division	,,	1/2 ,,	1/2 ,,	1	4	8	1	...	...	...	...	8	16	2	9	
Map of Jaunsár Forest Division	,,	4 ,,	1/2 ,,	1	4	4	1	...	...	...	...	16	16	3	5	
Dehra Dún and Sahéranpur Forest Division	,,	4 ,,	1/2 ,,	1	...	4	1	...	...	...	...	20	20	3	7	
Map of Nindhaur Hills, Working Circle	,,	1 ,,	D.E.	1	8	8	1	...	...	...	...	15	15	6	6	
Do. Singhbhoom	,,	4 ,,	,,	1	4	4	1	...	...	...	...	20	20	3	14	
Appendix B, illustrating the system of working on a confidential route	,,	6 ,,	1/2 F.P.	1	...	2	1	...	...	...	...	10	20	1	7	
Ránikhet Cantonment and Environs	,,	1/8 ,,	D.E.	1	7	7	1	...	...	...	...	15	15	6	6	
Diagram, Indexes 2 and References 2	,,	...	1/16 ,,	5	2	4	2	...	40	...	...	10	50	1	12	
35 Other Maps	,,	Various	D.E. and 1/2 D.E.	35	63	28	13	114	12	...	...	120	173	322	8	
TOTAL	...	...	...	425	948	1,350	279	152	721	...	...	26,627	24,792	14,129	2	

* Additional prints of previous publications.—D.E. represents Double Elephant; F. P. represents Foolscap; F. represents Finished; S.R. represents Super-royal.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

SOLAR PHOTOGRAPHIC SECTION.—This section comprises a photographer and four *khalásis;* the photographer has two photohelios in his charge, one giving 8-inch pictures and the other 12-inch. With the former he has to take two negatives each day that the sun is visible except on Sundays, when he takes only one negative: with the latter he takes negatives when the sun shows any remarkable phenomena. During the year the sun was invisible on 61 days, and two other days were lost from illness of the photographer. Of the 302 days on which negatives were taken, the sun showed either spots or faculæ on 298, and only four days showed no features.

Statement of expenditure (Dr.) and amounts credited (Cr.) on account of the Solar Photographic Section during the year 1886-87.

DR. CR.

	R	R		R	R
Superintendence	600		Value of Negatives and silver prints taken for the Solar Physics Committee, under authority from the Secretary of State for India (debitable to the Industry, Science and Art Departments).	4,494	4,494
Solar Photographer . . .	1,347				
Establishment	234				
Contingencies	814				
		2,995			
Chemicals and Stores received from England.	1,261				
		1,261			
Chemicals and Stores purchased in India.	213				
		213			
Shipping and Landing charges .	25				
		25			
TOTAL .	...	4,494	TOTAL .	...	4,494

Table of Working Facts for the year 1886-87.

1886-87.	NUMBER OF DAYS.				NUMBER OF NEGATIVES.										NUMBER OF WORKING DAYS WHEN SOLAR PHENOMENA WERE	
	When Negatives were taken.	Failures.			Solar Phenomena.								TOTAL.			
		From bad weather.	From various causes.	TOTAL.	Spots and Faculæ.		Spots only.		Faculæ only.		None.				Visible.	Absent.
					8″	12″	8″	12″	8″	12″	8″	12″	8″	12″		
October .	31	...	...	31	44	8	...	...	14	...	...	...	58	8	31	...
November .	30	...	...	30	6	...	...	...	52	...	...	...	58	...	30	...
December .	22	9	...	31	28	...	...	...	14	...	...	...	42	...	22	...
January .	18	13	...	31	25	...	...	...	5	...	...	...	30	...	18	...
February .	25	3	...	28	31	...	...	...	14	...	...	...	45	...	25	...
March . .	29	2	...	31	32	...	...	...	19	...	...	...	51	...	29	...
April . .	26	2	2	30	30	...	...	...	18	...	...	...	48	...	26	...
May . .	30	1	...	31	46	...	3	...	8	...	...	...	57	...	30	...
June . .	27	3	...	30	39	...	4	...	1	...	...	...	44	...	27	...
July . .	17	14	...	31	24	...	...	...	...	...	2	...	26	...	16	1
August . .	20	11	...	31	19	...	...	...	10	...	...	...	29	...	20	...
September .	27	3	...	30	19	10	2	...	21	...	5	...	47	10	24	3
TOTAL .	302	61	2	365	343	18	9	...	176	...	7	...	535	18	298	4

Total number of silver prints prepared during the year is 1,110.

Table of Percentages of daily visibility of the Sun and the presence of features.

Year.	In 100 days the sun was invisible on	In 100 days features were present on
1877-78	9 days (obtained from 273 days) . .	30 days (obtained from 248 working days).
1878-79	11 ,, ,, 89 ,, . .	28 ,, ,, 79 ,,
1879-80	14 ,, ,, 289 ,, . .	82 ,, ,, 232 ,,
1880-81	15 ,, ,, 365 ,, . .	96 ,, ,, 307 ,,
1881-82	10 ,, ,, 365 ,, . .	100 ,, ,, 328 ,,
1882-83	13 ,, ,, 365 ,, . .	100 ,, ,, 318 ,,
1883-84	21 ,, ,, 366 ,, . .	100 ,, ,, 285 ,,
1884-85	22 ,, ,, 365 ,, . .	100 ,, ,, 284 ,,
1885-86	21 ,, ,, 365 ,, . .	100 ,, ,, 290 ,,
1886-87	17 ,, ,, 365 ,, . .	98 ,, ,, 298 ,,

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Contrasting the percentages of days of invisibility above given with those for Greenwich, as furnished by the Astronomer Royal's Report, we have—

Year.	At Dehra, year ending 30th September.	At Greenwich.
1880-81	15	60
1881-82	10	45 Year ending 20th May.
1882-83	13	45
1883-84	21	41 Year ending 31st December.
1884-85	22	58
1885-86	21	
1886-87	17	

Circular No. $\frac{61 S.}{81-2}$

Extract from the Proceedings of the Government of India, in the Revenue and Agricultural Department (Surveys), dated Simla, the 26th June 1888.

READ—

The General Report on the Operations of the Survey of India Department for the year 1886-87.

RESOLUTION.

Personnel.

THE administration of the Department remained in the hands of Colonel H. R. Thuillier, R.E., who was confirmed in the appointment of Surveyor-General on the death of Colonel G. C. DePree in February 1887. The Revenue and Trigonometrical Branches continued to be under the superintendence, respectively, of Colonel J. Sconce, S.C., and Colonel C. T. Haig, R.E.

Number of parties.

2. The various operations were carried on by 25 different parties.

Secondary coast triangulation.

3. One party continued the secondary triangulation on the Coromandel Coast, carrying the chain of triangles from Madras to a distance of 170 miles, a little beyond Nellore. Owing to bad weather and sickness, the party did not succeed in continuing the triangulation northwards so as to unite with the operations of the previous year. A gap of 80 miles was thus left over for the following season.

Topographical surveys.

4. The number of topographical survey parties was reduced from ten in 1885-86 to eight in the year under report, the Cutch and Deccan parties having been transferred to the Central Provinces to take up the traverse surveys of districts coming under revision of settlement. Two out of the eight parties were employed partly on topographical and partly on Forest surveys in Bombay. A topographical section was, however, added to the cadastral party in Burma with the view of completing the topography of hill ranges in the Akyab District; and the Punjab traverse party also made some original surveys of portions of Native States. The two parties in Bombay, one party in Baluchistan, one in the Mirzapur District, North-Western Provinces, and one in the Himalayas, were employed in continuation of the operations of the preceding year. A second party was sent (from Rajputana) to Baluchistan to aid in the general survey of that country and for special survey work on the frontier required by the Military authorities. Another party was transferred to Madras from Mysore, and it took up the survey of the Madura and Tinnevelly districts. The area remaining to be topographically surveyed in that Presidency was, on the suggestion of the Government of India, made over to the Imperial Survey Department, with the view of accelerating the completion of revenue surveys in Madras by the Local Survey Department. The eighth topographical party made a survey of the Nicobar Islands, mainly with the object of meeting the requirements of navigation. A portion of the coast of the Little Andaman Island was also surveyed at the request of the Chief Commissioner of Port Blair.

The aggregate area topographically surveyed on various scales by all the parties amounted to 17,510 square miles, as compared with an outturn of 19,162 square miles surveyed in 1885-86 by ten parties.

Native soldiers were attached to the two Baluchistan, the Mirzapur and the Himalaya parties for training in survey work.

It may be explained that the reduction in the number of topographical survey parties to meet demands for revenue surveys is due to the fact that the latter class of work cannot be postponed without entailing loss of State revenues, whereas topographical surveys, however useful, may be postponed without serious detriment to the administration.

5. The Forest surveys in Bombay were, as already mentioned, carried on by sections of two topographical survey parties. The areas surveyed lie partly in the Belgaum District, Southern Circle, and partly in the Thánà District, Northern Circle. In the Southern Circle, the work comprises the preparation of a skeleton map showing the survey of Forest boundaries, any details that are considered necessary being filled in afterwards by the Forest Department, whereas in the Northern Circle the Forest reserves have to be surveyed in full detail.

Forest surveys.

Two small forests in the Gorakhpur District, North-Western Provinces, were surveyed by the cadastral survey party employed there.

The Forest survey party in Burma was unable to continue its work in the Prome District on account of the unsettled state of that part of the country. Two European Surveyors and a few sub-surveyors were sent to Upper Burma, and the remainder of the party was transferred to the Zamayi Forests, Pegu District, where preliminary triangulation and traversing constituted the chief work. The outturn of final survey was very small.

6. Five out of six cadastral survey parties continued with little change the operations of previous years. They were employed in (1) the Bilaspur and Raipur districts, Central Provinces; (2) in the Basti; and (3) the Gorakhpur and Tarai districts, of the North-Western Provinces; (4) in the Darrang and Nowgong districts, Assam; and (5) in the Akyab, Bassein and Thongwa districts, Burma. The sixth party was divided into three Sections, two of which were engaged in Bengal, on the cadastral survey respectively, of the Sankarpur Wards' State, Dinagepore District, and the Government Estate of Angul, Orissa District. The third section took up the survey of the town of Calcutta, which comprises the survey of boundaries of separate properties paying revenue to Government in addition to the ordinary particulars concerning streets and houses, and the collection of information regarding owners of properties required for the Calcutta Collectorate.

Cadastral surveys.

There was a slight interruption in the progress of cadastral survey operations in the Bilaspur District owing to the partial scarcity caused by the failure of autumn crops in 1886. Two detachments from Bilaspur party were therefore sent to Raipur. The total outturn of survey work was, notwithstanding, 259 square miles more, and the average cost Rs. 36-13 per square mile less, as compared with the previous year. The average cost of operations in the Basti District increased during the year under report by Rs. 40-8-10 per square mile. This is accounted for by the unprecedented and extremely minute sub-division of property met with, the average size of fields being 0·27 of an acre. With the view of affecting a speedy completion of the cadastral survey of Gorakhpur, the party employed therein was enlarged, resulting in a larger outturn of work and a diminution of the cost per square mile. The experiment of employing Patwaris as surveyors in place of amins was tried during the year for the first time in the Tarai District. The Patwaris showed dissatisfaction at first, and it was difficult to train the men; but the plan proved successful in the end, and it is reported that some excellent work was turned out.

7. Traverse surveys were continued by one party in the Gurdaspur, Gujranwala and Shahpur districts of the Punjab, and by five parties in the Raipur Jubbulpore-Damoh, Seoni-Chhindwara, Saugor-Narsingpur and Sambalpur districts of the Central Provinces. The total areas traversed are 6,085 square miles in the Punjab and 10,576 square miles in the Central Provinces. Some outlying portions of Sikh States were surveyed by the Punjab party with the view of completing the topographical maps of that part of the country. A special survey was also made in the Gurdaspur District bordering on Kashmir territory, for the purpose of settling a dispute between British and Kashmir cultivators

Traverse surveys.

as regards the rights to water from irrigation channels. It is satisfactory to notice that the cost of traverse surveys in the Raipur District, Central Provinces, was reduced so low as Rs. 19-7 per square mile.

8. As only one officer was available for the superintendence of Astronomical work, the telegraphic longitude operations were suspended. The latitude observations were extended to the south of Jubbulpore and observations completed at five stations.

Geodetic.

9. Observations for registration of Tides were taken at 17 ports in India, Burma, the Andamans, Ceylon and Aden. A new Tidal Observatory was established at Akyab, while that at Dublat, near the mouth of the Hooghly, was swept away by a cyclone in September 1886. The spirit-levelling operations consisted of six sections; (1) from Tuticorin to Madura; (2) from Madura to Trichinopoly and Tanjore; (3) from Trichinopoly to Erode; (4) from Shoranur to Cochin Tidal Station; (5) from Kárwár Tidal Station to Marmagao and (6) from Agoada Fort Jetty to Agoada. The heights of 418 permanent bench marks and of 6 stations of the Great Trigonometrical Survey were finally determined.

Tidal and levelling operations.

10. Two detachments, one of which was supplemented by a section of the Forest survey party on the suspension of work in the Prome District, were employed on geographical surveys in Upper Burma. One of these detachments under Major Hobday completed the reconnaissance surveys of an aggregate area of 11,000 square miles lying partly in the Shan States and the Ruby Mines District, partly in the Yaw country and partly in the Yemethin, Mehtilla, Mandalay and Kyaukse districts. The survey of the town of Mandalay was also continued. The second detachment, under Colonel Woodthorpe, accompanied the Military expedition that proceeded from Manipur to the Chindwin District. Colonel Woodthorpe, with his assistant Mr. Ogle, succeeded in carrying the triangulation connected with the main series of India from Manipur to the Chindwin District.

Geographical surveys in Upper Burma.

11. An account of the explorations in Nepal and Thibet by explorer M. H. has been separately published, illustrated by a map of the routes; and appended to the report under review are Notes by Colonel H. C. Tanner with sketch maps of explorations in Bhutan and on the Sangpo river, made respectively by explorers R. N. and K. P. The latter went into Thibet in the year 1880 in company with a Chinese láma. Explorer K. P. was sold as a slave in the Pemakoi country, and managing to escape has returned with information, which, combined with an account given by a Mongolian láma, has enabled Colonel Tanner to construct an amended chart of the Sangpo river.

Trans-Himalayan Explorations.

12. The progress of work in the Head-Quarters offices at Calcutta was satisfactory. The number of maps published amounted to 4,158, of which 3,843 were cadastral maps. 178,398 maps, valued at Rs. 1,36,344, were issued; and the income from map sales amounted to Rs. 0,254. Owing to the contraction of cadastral and topographical surveys, and the employment of a larger number of field parties on traverse surveys, the number of original maps received for reproduction by photography was much below the average.

Head-Quarters offices, Calcutta.

The work of the Drawing office has greatly increased in connection with the mapping of surveys and reconnaissances of the Afghan Boundary Commission and by urgent demands for maps of Burma and Baluchistan. A new edition of the map of India on the large scale of 32 miles to the inch has been taken in hand, and it is also proposed to prepare an outline map on the same scale, which will be useful for representing lines of railway, canals, &c.

Experiments were continued with the view of introducing the aid of photography for reproducing the Indian Atlas sheets in lieu of hand-engraving. Reproduction by photozincography has proved a failure, but the experiment of first photographing the map from a manuscript drawing and then transferring it to copper by the photo-electrotype process, shows that this method is well adapted to take the place of hand-engraving for maps required for temporary use and which are likely to be superseded by later editions.

The heliogravure processes have been utilized largely for the reproduction of drawings for the Archæological survey and for a technical art series. In the appendix are specimens of collotype printing.

36,969 mathematical instruments valued at Rs. 1,91,183 were added to the serviceable stock, and 37,391 serviceable instruments valued at Rs. 1,83,519 were issued on indent.

Debra office.

13. The work of the computing branch of the office at Dehra made satisfactory progress, and several publications containing results of the final reduction of operations of the Great Trigonometrical Survey were made.

Madras.
Bombay.
Bengal.
N.-W. P. and Oudh.
Punjab.
Central Provinces.
Burma.
Assam.
Coorg.

ORDER.—Ordered, that the above Resolution be forwarded to the Local Governments and Administrations noted on the margin, to the Surveyor-General of India, and to the Foreign and Military Departments, for information. Ordered also, that the Resolution be published in the *Gazette of India*.

(True extract.)

E. C. BUCK,

Secretary to the Government of India.

FILE No. 81.
SERIAL No. 2.

No.

1888.

GOVERNMENT OF INDIA.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEY.

RESOLUTION.

Circular No. $\frac{61S.}{81-2}$

Dated Simla, the 26th June 1888.

SUBJECT:

Remarks on the General Report on the operations of the Survey of India Department for the year 1886-87.

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