GENERAL REPORT

ON THE

Operations of the Survey of India,

COMPRISING

THE GREAT TRIGONOMETRICAL, THE TOPOGRAPHICAL, AND THE REVENUE SURVEYS UNDER THE GOVERNMENT OF INDIA,

DURING

1881-82.

PREPARED UNDER THE SUPERINTENDENCE
OF
LIEUTENANT-GENERAL J. T. WALKER, C.B., R.E., F.R.S., &c.,
Surveyor-General of India.

Calcutta:
PRINTED AT THE BENGAL SECRETARIAT PRESS.
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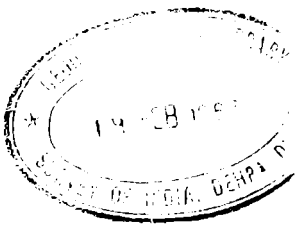

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VIEW OF KANCHINJUNGA FROM DARJEELING, FROM A SKETCH BY Lt COLONEL C. J. CRAMER ROBERTS.
Reproduced in heliogravure, at the Surveyor General's Office, Calcutta.
March 1883.

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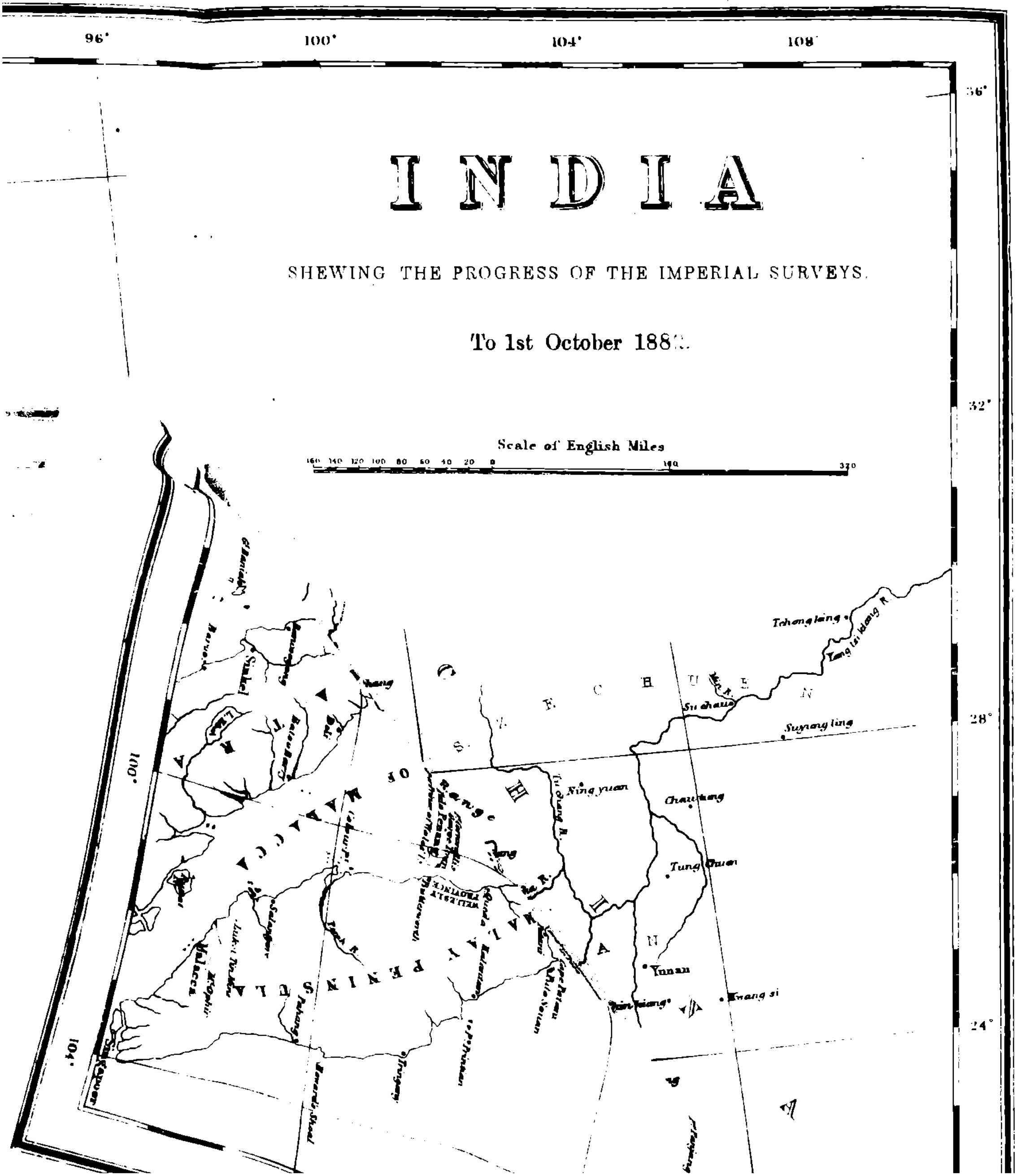
EIGHTH EDITION



GENERAL REPORT

OF THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1881-82.

INTRODUCTORY.

THE general direction of the Survey Department, and the immediate supervision of the Trigonometrical and Topographical Branches, have been performed by Lieutenant-General J. T. Walker, C.B., R.E., Surveyor-General. The immediate supervision of the Revenue Branch has been performed by Lieutenant-Colonel J. Sconce, S.C., Deputy Surveyor-General.

2. The principal operations which have been carried out during the survey year under review, viz. from 1st October 1881 to 30th September 1882, are as follows :—

Statement of Survey Operations and Parties.

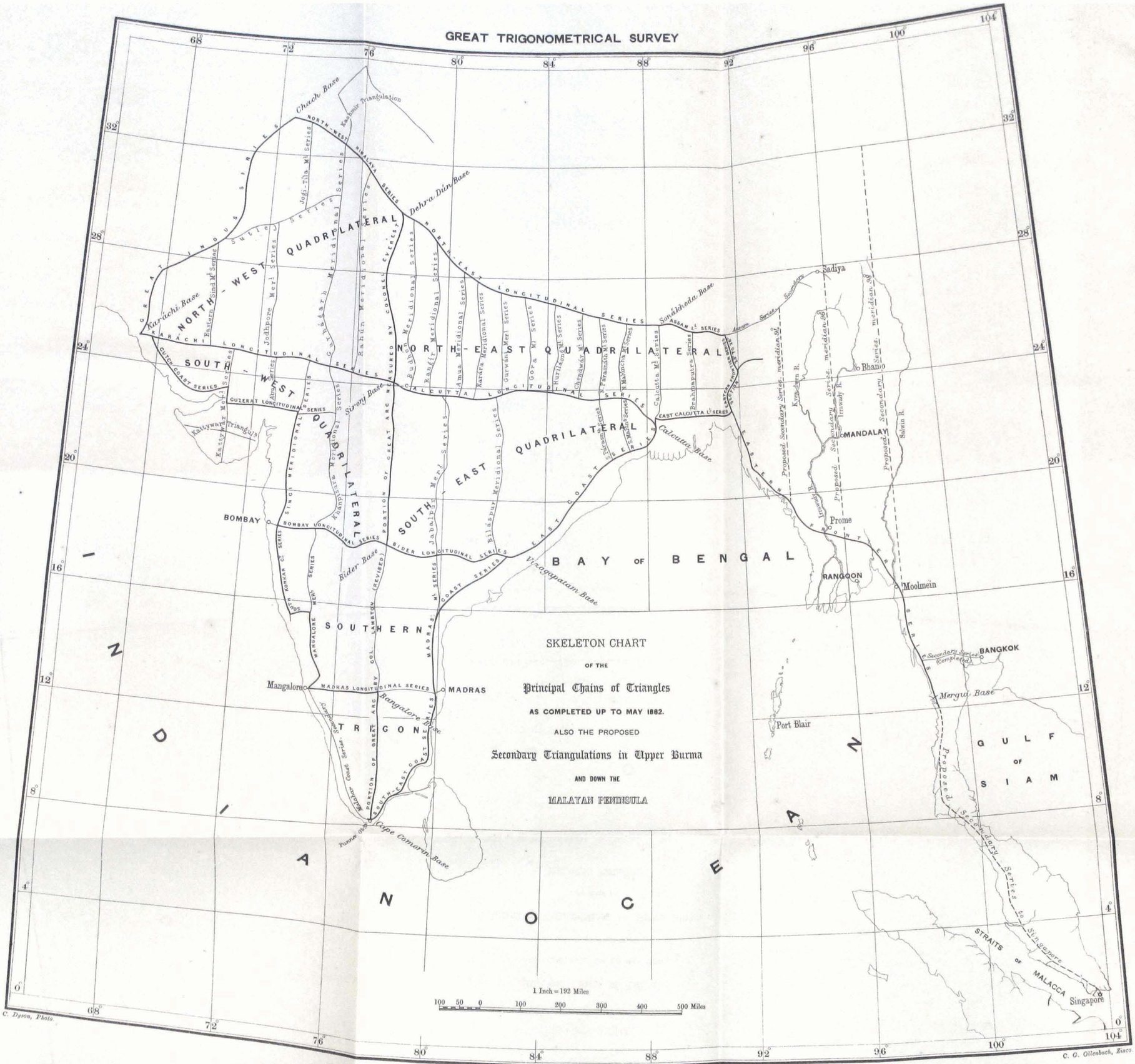
Number in this Report.	Nature and Locale of Operations.	Names of Executive Officers.	Designations of Survey Parties.	REMARKS.
	Base Line and Triangulation.			
I	Mergui and Eastern frontier.	Lieut.-Colonel B. R. Branfill. Major M. W. Rogers ...	Bombay party ... Eastern frontier party.	Base-line—principal triangulation—collateral astronomical operations.
	Topography.			
II	Central India	Major C. Strahan, R E. ...	No. 1 Topographical Survey	1-inch scale for reproduction.
III	Khandesh	„ T. T. Carter, R.E. ...	No. 2 Topographical Survey.	2-inch scale for reproduction.
IV	Malwa	„ J. R. Wilmer, S.C. ...	No 5 Topographical Survey.	1-inch scale for reproduction.
V	Sylhet	Lieut.-Colonel R. G. Woodthorpe, R E.	No. 6 Topographical Survey.	2-inch and ½-inch scales for reproduction.
VI	Rajputana	Mr. G. A. McGill	No. 7 Topographical Survey.	½-inch scale for reproduction.
VII	Mysore	Major H. R. Thuillier, R.E.	No. 8 Topographical Survey.	1-inch scale for reproduction.
VIII	Kohat	„ T. H Holdich, R.E....	Kohat Topographical Survey	
IX	Guzerat	Colonel C. T. Haig, R.E. ...	Guzerat Survey ...	2-inch scale for reproduction on same scale and reduction to 1-inch scale.
X	Cutch	Lieut.-Col. A Pullan, S.C ...	Cutch Survey ...	2-inch scale for reduction to 1-inch scale and ½-inch scale for reproduction
XI	Meerut Division, N.-W. P	Mr. E. T. S. Johnson ...	No. 3 Revenue Survey.	2-inch scale for reproduction to same scale, and for reduction to 1-inch scale.
XII	South Deccan	Major D. C. Andrew, S.C....	No. 11 Revenue Survey.	2-inch scale for reduction to 1-inch scale.
XIII	Hooghly River Survey ...	Bt. Lieut.-Col. E. P. Leach, V.C., R.E. Major S. H. Cowan, S.C. ...	No. 6 Revenue Survey.	On Hooghly river; partly on 16-inch, and partly on 6-inch scale, for reproduction to same scales.
XIV	Beluchistan	Major R. Beavan, S.C. ...	Beluchistan Survey ...	½-inch and ¼-inch scales for reproduction.

Number in this Report.	Nature and Locale of Operations.	Names of Executive Officers.	Designations of Survey Parties.	Remarks.
	Mouzawar or Village Survey.			
XV	Rawalpindi, Dera Ismail Khan, and Muzaffargarh, Punjab.	Lieutenant-Colonel D. Macdonald, S.C.	No. 1 Revenue Survey.	4-inch scale. In Rawalpindi for reproduction to same scale, and in all districts for reduction to 1-inch scale.
XVI	Konkan	Major H. Lees Smith, S.C. „ J. Hill, R.E. ...	No 10 Revenue Survey.	4-inch scale for reproduction to same scale and for reduction to 1-inch scale.
	Cadastral or Field Survey.			
XVII	Mirzapur and portions of Tarai district, N.-W. P.	Colonel F. C Anderson, S.C.	No. 5 Revenue Survey.	16-inch scale for reproduction to same scale and for reduction to 1-inch scale.
XVIII	Gazipur, Ballia, and Banares districts. Ganges River Survey, district Shahabad.	Major W. Barron, S.C.	No. 4 Revenue Survey.	In district Shahabad 4-inch survey, *not for publication.*
XIX	Hanthawaddy district and Arakan waste land grants.	Major J. R. McCullagh, R.E.	No. 2 Revenue Survey.	16-inch scale for reproduction to same scale, also for reduction to 2-inch and 1-inch scales.
XX	Bassein district	„ W. H. Wilkins, S.C.	No. 8 Revenue Survey.	In Arakan, skeleton boundary survey on 16-inch scale, *not for publication.*
XXI	Tharawaddy district ...	Mr. H. B. Talbot ...	No. 7 Revenue Survey.	
XXII	Sylhet Test Survey ...	.....	No. 6 Revenue Survey.	16-inch scale to test settlement survey.
	Miscellaneous.			
XXIII	Darjeeling	Captain H. J. Harman, R.E.	Darjeeling Survey ...	Various scales in Darjeeling, ½-inch in Sikkim.
	Geographical.			
XXIV	Manipur boundary.			
XXV	Northern Afghanistan.			
XXVI	Dardistan and Kishanganga.			
XXVII	Trans-Himalayan explorations. 1. Badakshan. 2. Frontiers of Sikkim. 3. Great Tibet.			
	Tidal and Leveling Operations.			
XXVIII	Tidal operations.	Major M. W. Rogers, R.E., and Major J. Hill, R.E.	Tidal and Leveling Party.	
XXIX	Tidal disturbances by earthquake.			
XXX	Spirit-leveling operations.			
	Geodetic.			
XXXI	Electro-telegraphic determination of longitudes.	Major G. Strahan, R E., and Major W. J. Heaviside, R.E	Nos. 1 and 2 Astronomical Parties.	

TRIANGULATION.

3. The chain of principal triangles, known as the Eastern Frontier Series, which in previous years had been carried from Assam through Arakan and British Burma into Tenasserim, has this year been brought to a close on a baseline of verification in Mergui, thus finishing the principal triangulation of all India on the lines originally marked out by Colonel Everest and sanctioned by the Hon'ble Court of Directors of the East India Company.

4. The completion of this great undertaking necessitates a brief review of the operations in the present report. It originated in a so-called "mathematical and geographical survey" which was commenced in Southern India in the year 1800 by Major Lambton, of Her Majesty's 33rd Regiment of foot, on the recommendation of the Hon'ble Colonel Wellesley, afterwards the first Duke of Wellington. Its object was, in Major Lambton's words, to "determine the exact positions of all the great objects that appeared best calculated to become permanent geographical marks, to be hereafter guides for facilitating a general survey of the peninsula;" and as at that time the elements of the figure of the earth were not known with sufficient approximation



Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, September 1882.

to enable the latitudes and longitudes of the "great objects" to be computed with accuracy from the data of the triangulation, Major Lambton pointed out that his intended survey would, in the interests "of general science * * * involve many more objects than what immediately appertain to geography," and that portions of the triangulation would have to be executed with the utmost possible precision, and be supplemented by astronomical determinations of position, with a view to the requirements of geodesy.

5. The operations between the years 1800 and 1825 may be briefly described as constituting a network of triangulation over Southern India, which was grounded on, and verified by, several chain-measured base-lines, and through the middle of which a principal chain of triangles was carried in a meridional direction, from Cape Comorin up to Sironj in Central India. This chain formed the southern portion of what is now known as Lambton and Everest's Great Arc. Its angles were measured with greater care than those of the collateral network, and at certain of its stations astronomical observations were taken for the determination of the minor arcs of amplitude. Colonel Lambton died in 1823, and was succeeded by Colonel Everest, who two years afterwards proceeded to Europe, where he spent four years in supervising the construction of new instruments—great theodolites, astronomical circles, standard of length, and compensation bars for base-line measurements—for employment in extending and revising the Great Arc, the importance of which for geodetic requirements had now become so thoroughly recognised by men of science in Europe, that Colonel Everest found no difficulty in obtaining *carte blanche* from the Government of India and the Court of Directors for all the instrumental equipment which he wanted. During his absence from India a small party of surveyors was employed in carrying a longitudinal chain of triangles eastwards from the point reached by the Great Arc in Central India to Calcutta.

6. On his return from Europe, in 1830, Colonel Everest recommended the abandonment of the network system of triangulation, and the substitution instead of what he called the "gridiron" system, consisting of meridional chains of triangles tied together at their upper and lower extremities by longitudinal chains. The meridional chains were intended to be constructed at intervals of about one degree apart, while the longitudinal chains would follow the parallels of Calcutta, Bombay, and Madras, and thus run at intervals of from five to six degrees apart. The external chains of the gridiron would of course follow the British frontier lines and the coast lines. The entire triangulation was to be grounded on base-lines measured with the Colby apparatus of compensation bars and microscopes—in terms of a fixed standard of length—which were to supersede the old base-lines that had been measured with chains of comparatively rude construction and of uncertain length. This programme of operation was approved by the Government of India and the Court of Directors, and it has furnished the guiding lines on which the principal triangulation has been executed during the period of almost exactly half a century which has elapsed since it was laid down.

7. The central lines of the several chains of principal triangles are shown in the skeleton chart facing this page. For convenience of treatment in the final reduction, the whole of the chains situated within the limits of India proper have been grouped into five sections. Four of these are roughly four-sided in outline, and are respectively called the North-East, North-West, South-East, and South-West Quadrilaterals—names in which the cardinal points have reference to the Kalianpur Observatory in Central India, which Colonel Everest adopted as the origin of the operations subsequent to 1832. The fifth is three-sided, and is called the Southern Trigon. The North-East Quadrilateral was completed first of all; and here it will be seen that the meridional chains of triangles lie at intervals of about one degree apart, as originally designed by Colonel Everest. But in the sections subsequently executed the intervals between the meridional chains have been materially increased, as the minor triangulations which in course of time came to be executed by the topographical surveys were of such accuracy that a smaller amount of principal triangulation was found to suffice for all geographical requirements, and more was not wanted for geodetical requirements. An additional meridional chain might have been constructed on the meridian of 84° within the South-East

Quadrilateral, and it doubtless would have been constructed but that before it could be commenced a network of excellent topographical triangulation had been thrown over the entire area which is included between the collateral principal chains, and nothing more was wanted. Similarly, in the Southern Trigon the execution of a chain of principal triangles along the west coast, from Cape Comorin to Mangalore, was desirable for symmetry, co-ordinately with the chain on the east coast from Cape Comorin to Madras; but it was not wanted for geodesy. For geographical purposes, the Malabar Coast Series of secondary triangles was amply sufficient. It had been mostly executed by Major Lambton, and it stood connected with the modern operations. Major Lambton had not, however, attempted to throw his triangulation over the broad belt of plains on the east coast, which is covered with trees and other obstacles that he had no means of surmounting. Thus a chain of principal triangles has been carried in modern times over these plains, as it was wanted for geographical purposes. It has, moreover, furnished a base from which a branch chain of triangles has been carried across the Paumben Straits to the island of Ceylon, in order to connect the surveys of India and Ceylon.

8. For geodetic purposes, the amount of principal triangulation which has been executed is ample. The first measurement of the sections of the Great Arc between Cape Comorin and Sironj was accomplished with instruments far inferior in accuracy to those with which the liberality of the Court of Directors furnished Colonel Everest in subsequent years; and being deemed of insufficient accuracy for geodetic requirements, its revision was directed to be undertaken as soon as might be consistent with the need of triangulation for geographical purposes in other parts of India. The northern section, from Sironj down to Bider, was indeed revised under Colonel Everest's superintendence in 1838-39; but the revision of the southern sections—Bider, Bangalore, Cape Comorin—was postponed for several years, and was eventually accomplished during 1869–74. The Longitudinal Series from Sironj to Calcutta has also been revised, as it was originally executed with very inferior instrumental means; and it happens to be the most important of all the great chains of triangles, because it furnishes bases for no less than fourteen meridional chains lying to its north and south. Partial revisions have been made in other quarters of work executed with inferior instruments which it was deemed necessary to raise to a higher standard of accuracy. Outside the limits of India proper the recently completed chain of principal triangles called the Eastern Frontier Series is a valuable contribution to geodesy as well as geography.

9. The whole of the triangulation rests on ten base-lines, which have been measured with the Colby apparatus of compensation bars and microscopes, which was constructed in England under Colonel Everest's superintendence. The relations of the length of the Indian Standard to the principal European Standards of Length have been very exactly determined. Considerations of symmetry would suggest the introduction of an additional base-line near Bombay, on the same parallel as the Bider and Vizagapatam base-lines, and measured with the same apparatus. But it so happened that a chain base-line had been measured on the Karleh plain, near Bombay, in the year 1828 by Captain Shortrede, the calculated value of which through the longitudinal series from the Bider base-line agrees very closely with the measured value. It was commended by Colonel Everest, who however some years afterwards, in 1848, made preliminary arrangements for the measurement of another line in the neighbourhood with the Colby apparatus; but he did not carry out this project. Eventually the idea was abandoned, as the distance from the Bider base is comparatively small, and no material advantage, at all commensurate with the labour and expense, would be derived from the measurement of a new base; for to measure a base-line with the Colby apparatus occupies two full-strength trigonometrical parties for an entire field season, unless there happens to be other employment for the survey officers in the neighbourhood of the base. There is some uncertainty as regards the unit of length adopted by Captain Shortrede in measuring the Karleh base; consequently this base has not been employed in the final reductions, though no new base has been measured.

10. Thus the great work of the principal triangulation of India is now an accomplished fact. Commenced in 1800 under the auspices of the Madras Government, it was carried on by Major Lambton, almost single-handed, until

the year 1818, when the Marquis of Hastings, who was then Governor-General, placed it under the direct and immediate control of the Supreme Government. Captain Everest was shortly afterwards appointed assistant to Major Lambton. In 1832 additional officers were appointed, and by the year 1840, when the geodetic operations on the northern sections of the Great Arc were completed, the *personnel* sufficed for the equipment of six trigonometrical survey parties; and this number of parties was uniformly maintained from that time onwards, until it could be gradually diminished on the completion of the successive chains of triangles. The operations have been uniformly and consistently supported by the Supreme Government, with the sanction and approval, first of the Hon'ble Court of Directors of the East India Company, and afterwards of the Secretary of State for India. In times of war and financial embarrassment the scope of the operations has been curtailed, the establishments have been reduced, and some of the military officers sent to join the armies in the field; occasionally the civilians also have been sent to the seat of war, to be employed on survey duties. But whatever the crisis, the operations have never been wholly suspended. Even during the troubles of 1857-58 they were carried on in some districts though arrested in others. They have been uninfluenced by changes of *personnel* in the administration of the British Indian empire; each succeeding Governor-General or Viceroy has honoured them with his support. At the close of the mutinies Lord Canning wrote of the principal triangulation and collateral topography in Kashmir to Colonel Waugh, then Surveyor-General of India, as follows:—

"I cannot resist telling you at once with how much satisfaction I have seen these papers. It is a pleasure to turn from the troubles and anxieties with which India is still beset, and to find that a gigantic work, of permanent peaceful usefulness, and one which will assuredly take the highest rank as a work of scientific labour and skill, has been steadily and rapidly progressing, through all the turmoil of the last two years."

And up to the last moment the successive Governments have accorded their support to the operations with equal liberality and constancy. It may well be doubted whether any similar undertaking, executed in any other part of the world, has been equally favoured and supported.

11. The field operations—viz. the measurements of the base-lines and angles of the principal triangulation—being completed, the next step is the final reduction and harmonizing of the results, giving to each measurement and observation its proper weight, and nothing more or less. Strictly speaking, this undertaking should be postponed until the completion of the whole of the operations, and then all the observations should be reduced simultaneously, because every fact of observation is more or less dependent on, and connected with, every other fact. But the simultaneous reduction of the vast number of such facts acquired over all India, by many individuals and during a period of many years, was obviously impossible. Thus it became necessary to divide the triangulation of India proper into the five sections which have already been mentioned in paragraph 7 and are indicated in the accompanying skeleton chart; and even then the simultaneous reduction of the numerous facts of observation collected together in each group was a work of enormous labour, necessitating—as remarked by Colonel Clarke, C.B., of the Ordnance Survey, one of the most eminent of living geodesists, in his recent treatise on geodesy—"the most elaborate calculations that have ever been undertaken for the reduction of triangulation." The division of the work into sections necessitated the maintenance of the results determined for the sections first reduced, in the contiguous sections, when they in turn came to be reduced; and this necessitated commencement with the section which in all its parts was of the highest accuracy. The section of which the field work was first completed was the North-East Quadrilateral; but as many of its angles had been measured with instruments of inferior accuracy to those employed in the sections which were subsequently completed, the reductions were performed in the following order:—1st, the North-West Quadrilateral; 2ndly, the South-East Quadrilateral; and 3rdly, the North-East Quadrilateral. The reductions were commenced in the year 1869: the final results of the first section are given in Volumes * II, III and IV of the Account of the Operations of the Great Trigonometrical Survey, published in 1879; those of the second in Volume

* Volume I is devoted to the Base-lines, and Volume V to the Pendulum Operations.

VI, published in 1880; and those of the third, in Volumes VII and VIII, which are now in the hands of the book-binders and will shortly be published. The fourth section selected for treatment was the Southern Trigon; its simultaneous reduction is now completed, but the final results will probably not be printed and ready for publication for another year or two. The last section to be taken in hand is the South-West Quadrilateral; but the final reduction of this section has not yet been commenced, nor has that of the recently completed Eastern Frontier Series.

12. The stations of the principal triangulation are 3,472 in number. They have been constructed with a view to being as lasting and permanent as possible. On the plains they are fashioned in the form of towers rising from 20 to 40, and even 60, feet above the ground level, and usually about 16 feet square at base, with an isolated central pillar for the instruments to rest on. On hills and mounds or other eminences the central pillar—always of masonry—is raised 2 to 4 feet above the ground level, and is surrounded with a platform of earth and stones. Mark-stones, engraved with a dot and surrounding circle to define with precision the point to which the observations are referred, are inserted on the surface and at the base of each pillar. The stations are invariably placed under the protection of the local officials: they are scattered over 338 British districts and Native states, in each of which some officer is required to submit annual reports of the condition of the whole of the stations within its circle; repairs are effected whenever necessary. If the present system of protection and repairs is maintained by future generations of officials, the duration of the stations should be co-eval with that of the hills and plains on which they stand, and the great work now completed will be of lasting utility.

13. A considerable amount of secondary triangulation has been executed *pari passu* with the principal triangulation, partly by observations from the principal stations to all the most prominent objects visible from them—as the snow peaks of the Himalayan ranges—partly by the construction of chains of secondary triangles resting on the primary chains, such as have been carried to a number of important towns and cities within the limits of the empire, and of late years beyond those limits to Kandahar and Kelat on the one side, and to Bangkok on the other. Much secondary triangulation, however, still remains to be executed. It is wanted on the coast lines, to furnish fixed points for the marine surveys, and in localities in the interior at a distance from the nearest principal chains, where data may be required for topographical surveys. But it is chiefly wanted outside the limits of India proper, as for the extension of the Eastern Frontier Series through the Malayan peninsula down to Singapore, and to furnish a basis for the geography of Upper Burma. For the latter purpose three chains on the meridians of 94°, 96°, and 98° respectively are desirable, the two first of which would close on the chain of secondary triangulation already completed in the Assam Valley, while the third might be carried still further to the north. Bangkok, the capital of Siam, having already been connected with the Indian triangulation by a chain of triangles, which was recently executed with the support of the Siamese Government, it is to be hoped that the ruler of Upper Burma may soon be moved to follow the good example set by his neighbour potentate, not only in assenting to the triangulation, but in rendering all desirable assistance towards its execution. The proposed chains of triangles for Burma and the Malayan peninsula are shown in the accompanying skeleton chart. The latter has already been sanctioned by the Government of India and the King of Siam, and it would have been commenced ere this had officers and funds been available for the purpose.

14. The requirements of geodesy necessitate astronomical observations for the determination of the latitude and the azimuth, and electro-telegraphic observations for the determination of differential longitudes, at several of the stations of the principal triangulation. These have already been completed to a considerable extent. Further operations of this nature are in progress at the present time; they are carried out by the two small astronomical parties which are attached to the trigonometrical or geodetic branch of the department, and by which all the operations that are required to render the principal triangulation fully subservient to geodetic science should be completed in the course of a

few years. An extensive series of pendulum observations for investigations of variations of gravity and the figure of the earth, taken chiefly at stations of the principal triangulation, has been completed and connected with the groups of corresponding observations in other parts of the globe. Long lines of spirit-levels have been, and are still being, carried on in connection with the principal triangulation, from the sea to the base-lines in the interior, and from sea to sea across the peninsula; they rest on determinations of the mean-sea level which have been, and are being, made at the tidal stations on the coasts.

15. The Index Chart to the Great Trigonometrical Survey of India which faces this page shows the whole of the principal triangulation, distinguishing between the early operations with inferior instruments and the operations since 1830 with superior instruments; the former being indicated by fine lines, the latter by thick lines. It also shows the more important secondary triangulations which have been executed outside the limits of the principal triangulation—as to the Himalayan snow peaks, to Kandahar, and to Bangkok; but it does not give any of the large amount of internal secondary triangulation, as it could not have done so without crowding the chart greatly and causing confusion with the early principal triangulation. For this reason the modern chain of secondary triangles which connects the old principal chains on the west coast of the southern peninsula, between Cape Comorin and Ponany, and between Cananore and Mangalore, is not shown. The Index Chart also indicates the positions of the base-lines which were measured with the Colby apparatus, the stations at which astronomical observations for either latitude or azimuth, or both, have been made, the longitudinal arcs, the stations at which pendulum observations for investigations of variations of gravity have been taken, the main lines of the spirit-leveling and the tidal stations. The chart was originally engraved in 1870, but it has now been brought up to the 1st October 1882, in order to be complete up to date.

TOPOGRAPHY.

16. The regular topographical operations have been carried on in continuation of those of last year, mostly in the same provinces and by the same parties. But the completion of the Jaunpur cadastral survey last year happily set free a party for employment in making a survey of the banks of the river Hooghly, for some distance above and below Calcutta. This has now been commenced, and is being carried on *pari passu* with a survey of the bed of the river, now in progress under the orders of the Port Commissioners. Many years have elapsed since the last survey of this important portion of the river Hooghly was made; the maps are out of date and otherwise inadequate to the requirements of the present time, for their scale—4 inches to the mile—is much too small to show the valuable properties situated along the banks of the river. In fact, it may be said that up to the present time this densely-populated riverain tract, which is studded with valuable estates and factories—the property of a wealthy mercantile community of Europeans and Natives—and is of vastly greater importance than any equal stretch of river in all India, has fared little or no better in the way of maps than the poorest and least significant village lands away from the river. Thus a large scale survey of the tract had become a necessity; and the fortunate circumstance that a new survey of the bed of the river was also about to be made has enabled two important collateral surveys to be carried on simultaneously, to the mutual advantage of both.

17. A constantly growing demand has arisen of late years for new surveys, on a large scale, of districts under the administration of the British Government, in supersession of the small scale surveys which were executed a generation or more ago. The first surveys were undertaken mainly with the object of furnishing sufficiently accurate materials for the series of maps known as the sheets of the Atlas of India; and as these maps were, and still are, produced on the scale of $\frac{1}{4}$ of an inch to the mile, a close survey of local details was not required for them. The operations were always regarded as sketchy and preliminary to exact survey. The survey establishments were not sufficiently large to undertake much survey work on an adequate scale for general administrative purposes, in one province, without putting a stop to the preliminary survey work in all other provinces. Thus the so-called

topographical surveys of those days were in reality geographical reconnaissances, sufficient for all the requirements of the Indian Atlas and for general reproduction on small scales, but not for purposes which demand accurate delineation of minute detail. Necessarily, therefore, calls are now being made from various quarters for new maps and new surveys; and not unfrequently complaints are made of the old surveys, that they are inaccurate and inadequate for present requirements. As a matter of fact, however, they are as good as they were intended to be, or could have been made without being far more costly. Their cost rates per square mile do not generally exceed a tenth of the average cost rates of surveys showing the topographical details with all the fulness and accuracy that are now required for local administrative purposes. They have had their day, and have been of much utility hitherto; but the time has arrived when they must be superseded by more elaborate survey operations.

18. The general out-turn of topography executed during the year in the course of the operations described in sections II to XIII, XIX, XXI, and XXIII of this report, excluding Forest Survey, has been as follows:—

6,431	square miles surveyed on the		1/3-inch	scale.
9,081	,,	,,	1	,,
8,627	,,	,,	2	,,
14	,,	,,	6	,,
33	,,	,,	16	,,

Four towns and one cantonment, embracing an area of 46 square miles, have been surveyed, on scales varying from 6 to 80 inches to the mile.

MOUZAWAR, RIVERAIN, AND FOREST SURVEYS.

19. The Mouzawar or Village Survey on the 4-inch scale of the Dera Ismail Khan district has been completed, and a similar survey has been extended into the Thal portion of the adjoining district of Muzaffargarh, where there had only been a Topographical Survey when the other parts of the district were surveyed village by village in 1856-57.

20. The Riverain Survey, on the 4-inch scale, on the Jumna river, which has been carried on for some years in connection with topographical operations in the Meerut Division, has been continued, and a similar Riverain Survey has been commenced on the Ganges river in connection with the same operations. A new Riverain Survey has been commenced by the Cadastral Survey Party employed in districts Ghazipur and Ballia of the North-West Provinces, which party has extended its operations across the Ganges to survey, on the 4-inch scale, the village lands of district Shahabad of Bengal, lying opposite to district Ghazipur.

21. The Punjab Revenue Survey Party has continued, for forest purposes, the 4-inch survey of the Kala Chitta Range in the Rawalpindi District, which work has been completed. The survey party in the Konkan, which has hitherto been employed in surveying on the 2-inch scale solely for topographical purposes, has been engaged in surveying the Thana District on the increased scale of 4 inches to a mile, to meet the requirements of the Forest Department. The area usually accomplished by the party has consequently been diminished, there being a difference in out-turn between the past and present seasons of 670 square miles. In British Burma a small area of very difficult country, forming part of one of the forest reserves in the Tharawaddy District, has been surveyed on the 4-inch scale.

22. The survey of the Dang Forests of the Khandesh District on the 4-inch scale, undertaken for the Forest Department, has been continued by the Guzerat Topographical Survey Party. The areas of all these operations are—

Mouzawar	...	...	1,687	square	miles.
Riverain	...	...	199	,,	,,
Forest	...	...	1,311	,,	,,

CADASTRAL SURVEYS.

23. In the North-West Provinces the Cadastral Survey of district Ghazipur has been completed, and cadastral operations have been continued in districts Ballia and Mirzapur, also in certain villages of the Tarai

District. An experimental measure has been introduced at the request of the Board of Revenue, North-West Provinces, in connection with the Cadastral Survey of Mirzapur, of having the *khasras* (giving particulars of the occupancy and ownership of village lands) written by the surveyors at the time of the survey of the fields. The experiment, which is expected to bring about a large reduction in the usual expense of the preparation of the "Record of Rights," cannot be considered to be complete until the duties of the Settlement Officer in connection with the Record of Rights have been carried out during next season.

24. In British Burma, districts Hanthawaddy, Bassein, and Tharawaddy have continued to occupy the three cadastral parties at work in the province, and the Hanthawaddy party has also carried on the survey of the Rangoon Town District.

The Hanthawaddy party has again sent a detachment to Arakan to continue the skeleton survey of boundaries of waste land grants.

In Assam a small party, specially organized, has been engaged on the Cadastral Survey of selected villages in three parts of district Sylhet, as a test on the accuracy of the *mahalwar* maps of the district, which were constructed by a civil establishment in 1862. The areas surveyed cadastrally are—

North-West Provinces	...	...	...	1,385 square miles.
British Burma	...	...	...	3,513 „ „
Assam (Sylhet)	...	...	...	26 „ „

25. In British Burma the officers of the Cadastral Survey Parties have continued to hold in view the wishes of the local administration regarding the training of Burmans as field surveyors; but the reports concerning the value of the work of these men are not so favourable as last year. Though doing work generally good in quality, the Burmans are said to be very inferior to the Hindustani surveyors in rapidity of execution, most of them working only in a half-hearted way, and serving with the survey parties solely with the object of qualifying for better civil appointments. The dislike of the Burmans to remain long with the survey parties arises partly from the circumstance that the employment offered to them as field surveyors extends only over six months, without, as a rule, any leave allowances being granted to them during the other half of the year. There is also the disadvantage in the employment that service as a "field surveyor" is only temporary service, non-qualifying for pension.

26. The field surveyors of the Indian Cadastral Surveys labour under the same disadvantage of having their service regarded as only "temporary," having in this respect succeeded to the status of the settlement "amins," whose duties they have assumed, and being quite distinct, as regards the conditions of service, from the sub-surveyors (trained as topographers and theodolite surveyors) of the permanent establishments, whose service qualifies for pension. The present "field surveyors" are much more highly trained than the old "amins," and many of them have served continuously, and in several districts, since the commencement of cadastral operations in the North-West Provinces. The men are deserving of having their status improved; and in the interests of Government it is desirable that they should be permanently attached to Cadastral Survey Parties, and their service made "permanent," if cadastral operations are in future, as now, to form a considerable part of the regular duties of the Survey Department.

27. Towards the close of the year an important Resolution—No. 45S, dated 4th September 1882—was issued by the Government of India in the Revenue and Agricultural Department, drawing the attention of the Local Governments marginally specified to the unequal cost of revenue surveys undertaken in different provinces or districts, as well as to the inconvenience and expenditure caused by the absence of a definite understanding between the survey and the revenue officers as to the extent and character of the work which one department requires from the other. A question was raised as to the comparative cost of cadastral surveys executed by the Survey Department and those executed by the Revenue Settlement Department. It was stated that

North-Western Provinces.
British Burma.
Bengal.
Punjab.
Central Provinces.
Assam.

whereas the accuracy of the professional maps never fell below a certain fixed standard, on the contrary under non-professional management the work turned out was very unequal, and many of the maps had proved comparatively useless. Enquiries have led the Government to suppose that the cost of the latter is not at the present time much below that of the former, more particularly in the North-West Provinces, where a considerable decrease in the rate of expenditure has been effected by modifications of procedure, the officers of both the Survey and Settlement Departments having co-operated in reducing the system of cadastral survey to a more efficient and economical standard than that which had formerly prevailed. A further question was raised as to the extent to which the work of the survey parties employed upon topographical surveys can be utilized for cadastral purposes, or whether, on the other hand, maps which have been supplied by non-professional cadastral parties can be utilized for topographical purposes. The system which should be adopted in future cadastral surveys is considered; it is remarked that there is a general consensus of opinion that a skeleton survey, conducted under professional agency, should precede all field plotting, by whatever agency performed; the skeleton is expected to contain all the tri-junction pillars in the boundaries of villages, and a series of intermediate pillars at distances of somewhat less than half a mile apart; the field plotting, when not filled in professionally, to be undertaken by the village *patwaris* or accountants. Local Governments are at liberty to employ other than professional agency when they please, provided the agency employed is thoroughly trained for the purpose. Suggestions are made regarding the training of *patwaris*, the formation of survey schools, and the system of mensuration to be taught. The inconvenience of irregular demands on the Survey Department, which involve sometimes the formation of untrained survey parties, at other times the breaking up of well-trained parties, is prominently noticed; and Local Governments are requested to cause forecasts to be made of the areas which will have to be surveyed during the next ten years, and so to arrange their programmes that work may be found without interruption during that term for the entire staff which is placed in charge of the initial operations. As regards locally organized surveys, the cost must be kept within certain limits, a system of survey must be adopted which will ensure the quality being kept up to a certain standard, and the cost and quality must be tested by recognized experts.

GEOGRAPHICAL RECONNAISSANCE.

28. The geographical surveys and reconnaissances described in sections VIII, XIV, XXIII, XXIV, XXVI, and XXVII have resulted in an addition to the country already mapped as follows:—

Burma and Manipur boundary	1,600	square miles,	1/2-inch	scale.
Ditto	1,150	,,	1/4	,,
Kohat frontier	450	,,	1/2	,,
Beluchistan	3,240	,,	1/8	,,
Ditto	2,420	,,	1/4	,,
East Sikkim	180	,,	1/2	,,
Nepal	720	,,	1/2	,,
Tibet	690	,,	1/2	,,
Dardistan	200	,,	1/4	,,
Kishanganga	600	,,	1/4	,,

TRANS-HIMALAYAN GEOGRAPHICAL EXPLORATIONS.

29. The celebrated explorer Pundit Nain Singh, C.I.E., who was originally trained by the late Col. T. G. Montgomerie, R.E., for Trans-Himalayan survey operations, and whose services are well known not only to the Government of India, but to all who take an interest in the geography of Central Asia, died on the 24th January 1882. He had received honorary distinctions from the Royal and other Geographical Societies in Europe, had been made a Companion of the Indian Empire and been given a grant of land in perpetuity for himself and his heirs by the Government of India in acknowledgment of his services. And these services were not restricted to the several years when he was actually making explorations; but after he retired from active duties he was occasionally employed in training other natives of India for similar explorations, and in imparting to them something of the knowledge and skill which he had himself acquired in the course of his long and varied experiences. Very

intelligent and most trustworthy, his name will always hold an honourable place in the annals of the Indian Survey Department.

30. The present report contains a map and brief accounts of route surveys in the regions to the west and north of the frontiers of Sikkim, which were made in 1879 by an employé of the Educational Department of Bengal, and during 1880-81 by an employé of this department, which have recently been worked out and mapped by Captain Harman.

Also a map and a short account of route surveys in and beyond Badakshán, in Roshán, Shignán, and other districts bordering the Panjah river and the collateral affluents of the river Oxus, which were made during the years 1878 to 1881 by M— S—, an employé of this department, and which contribute much matter towards the filling in of the numerous lacunæ in the existing maps of this region.

Also a preliminary account of explorations over an extensive area in Great Tibet, to the north and east of the regions reached by Pundit Nain Singh, which were made by his pupil and once companion, A—k, who has returned to India, after an absence of four years, so recently that as yet there has not been time to reduce his observations, translate his journals, and construct a map in illustration.

31. At the International Geographical Congress and Exhibition which was held at Venice in the autumn of 1881, two medals were placed at the disposal of the Surveyor-General for award to the two native explorers whom he considered most meritorious. One of these has been presented to M—S—; the other is reserved for presentation to A—k, in the expectation that when his route surveys are worked out he will be found to be fully deserving of the honour.

PART I.

THE OPERATIONS OF THE SEVERAL SURVEY PARTIES APPERTAINING TO THE THREE BRANCHES OF THE SURVEY DEPARTMENT.

TRIANGULATION AND COLLATERAL OPERATIONS.

I.—THE EASTERN FRONTIER SERIES.

32. The programme of operations for the field season embraced the following projects:—

(A) The connection of the principal triangulation with the base-line of verification in Mergui, which had been selected and marked out during the previous field season, as intimated in the report for last year.

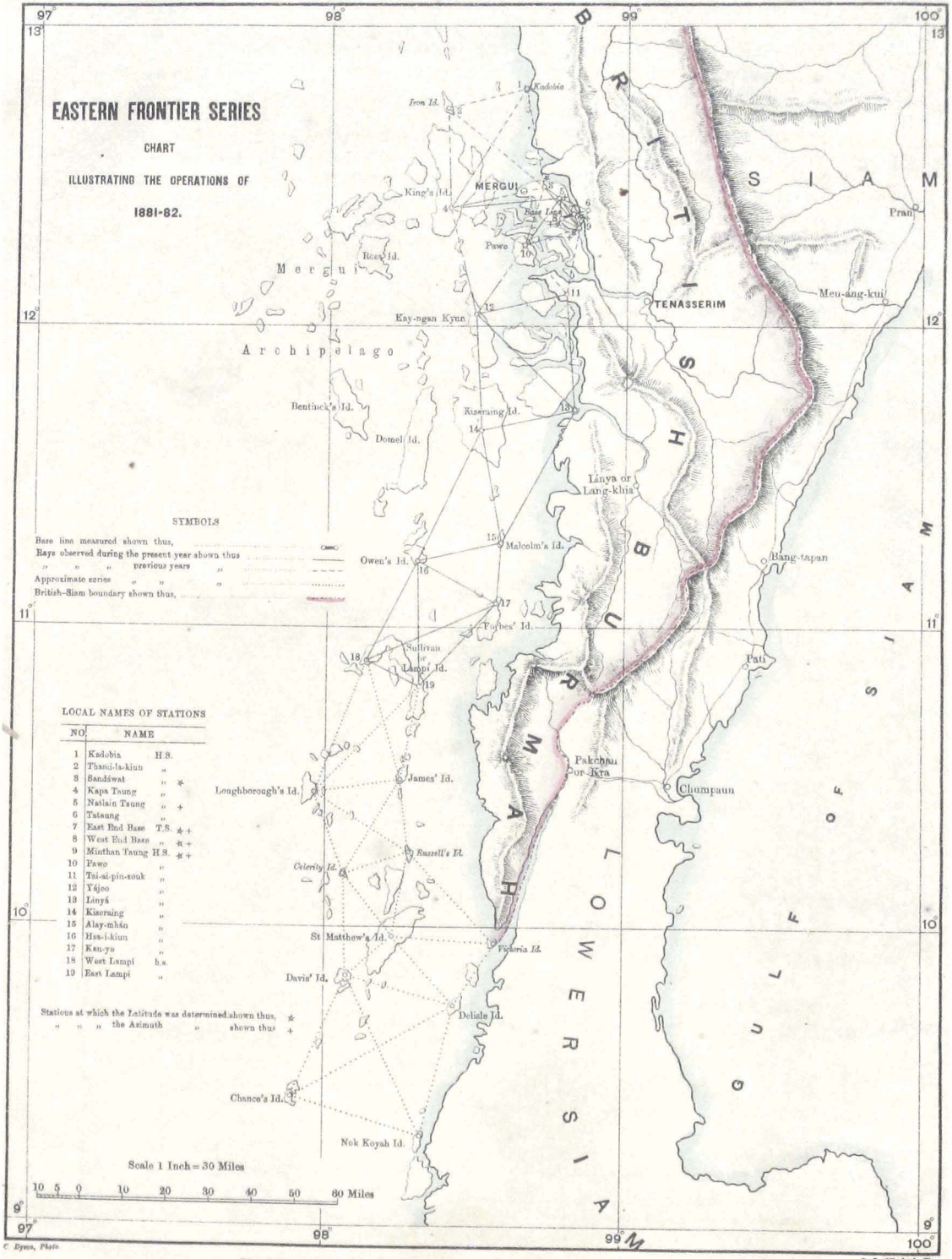
(B) The extension of the principal triangulation down the coast line and the islands of the Mergui Archipelago, as far as might be practicable during the time available.

(C) The preparation and measurement of the base-line in Mergui, and its connection with the mean-sea level.

(D) Astronomical determinations of latitude and azimuth at the stations of the principal triangulation in the neighbourhood of the base-line.

33. The experience gained in previous years had shown that suitable atmospheric conditions for the observation of distant objects were only to be expected during the first half of the field season. By the middle of the month of January dense haze usually sets in, which shuts all distant objects out of view, and this of course necessitates the suspension of the measurement of the angles of triangles of which the sides usually range from 10 to 40 miles in length. It was therefore determined to devote the first half of the field season to the principal triangulation, and the remainder to the measurement of the base-line, the astronomical observations being taken whenever convenient. With a view to expedite the progress of the triangulation and make the most of the limited period of favourable atmosphere, the Government steamer *Celerity* was placed for a few months at the disposal of this department, in order that the survey officers might no longer be dependent—as they had been in previous years—on the sailing vessels ordinarily used by the native sea-faring population in their coasting voyages, and the employment of which had been a constant source of delay and inconvenience. The steam-launch *Moulmein* was also lent for a short time by the Chief Commissioner in British Burma, and was found most serviceable.

34. Two triangulation parties were available for the operations, viz. the Eastern Frontier Party, recently under Captain Hill, but now under Major Rogers; and the party under Colonel Branfill, which in the previous year had been employed in completing the Eastern Sind Series. During the first half of the season these parties worked independently of each other,—Colonel Branfill's in connecting the principal triangulation with the base-line and executing the necessary preliminaries for the linear measurement; Major Rogers', in extending the principal triangulation southwards. They then assembled at the base and measured it with the Colby apparatus of compensation bars and microscopes—used in conjunction with the standard of length of this survey—which has been employed since the year 1830 in measuring all base-lines for the principal triangulation, and is mentioned in paragraph 6 of this report. Colonel Branfill supervised and took a share in both the measurement of the base-line and the collateral triangulation and astronomical observations.



C. Dyson, Photo.

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, January 1883

C. G. Gillman, Toxo.

35. The principal triangulations were completed by the middle of January; the work executed by both parties fixes 15 new stations, and gives as many new triangles; it extends over a direct distance of 109 miles between the parallels of 10° and 12°, and includes an area of 1,688 square miles. Eight new stations were fixed in connecting with the base-line, and seven on the extension. But whereas the former are comprised within a distance of 15 and an area of 21 square miles, the latter extend over a distance of 94 miles and embrace an area of 1,667 square miles. Major Rogers made a reconnaissance of the islands of the Mergui Archipelago with a view to the future secondary triangulation to Singapore, down to the parallel of 9° 20′, a distance of about 60 miles beyond the southernmost side of the principal triangulation. Forty-eight prominent points on the Malayan Peninsula and the islands of the Archipelago were fixed by both parties, by observations taken at the principal stations; they lie in an area of 3,344 square miles exterior to that of the principal triangulation. Thus the entire area operated in was about 5,000 square miles.

36. Great advantage was derived from the employment of steamers instead of sailing vessels, in enabling the survey officers and the parties of signallers to be moved about with rapidity; for the observing season proved to be a very short one—barely two months—between the cessation of the rains in November and the setting in of the haze in January. The steam-launch *Moulmein* proved to be an invaluable auxiliary to the steamer *Celerity*, in affording access to points on the coasts and islands which the larger vessel could not have reached because of the shallowness of the water. By means of heliographic signals on the Morse system—between himself, the officers of the steamer, and his assistants—Major Rogers directed the general movements, and was thus able to make the most of the steam power at his disposal. Captain Hotham, of the Indian Marine Department, commanded the *Celerity*, with the crew of which the steam-launch was also worked. His services, and those of his subordinate officers, are warmly acknowledged by Major Rogers; for they all took a keen interest in the operations, and Captain Hotham has expressed a wish to be again employed in co-operation with our officers whenever the triangulation is extended to the south.

37. By the end of January all hands were engaged on the measurement of the Mergui base-line under Colonel Branfill. This base is about 3·4 miles in length, or somewhat less than half the average length of all the base-lines previously measured in India with the Colby apparatus, with the exception of the Cape Comorin base, which is only 1·7 miles in length; but the Cape Comorin base was measured four times, with a view to the investigation of the probable error of base-lines measured with the Colby apparatus, whereas the longer bases were only measured once. The shorter a base the greater the number of triangles that are required to connect it with the principal triangulation, and *vice versâ*. In the operations of this Survey the length has generally been regulated with a view to employing the measuring parties during the whole of the field season, in order to avoid the loss of time which would be entailed by transferring them to other operations in other, and probably distant, localities during the most favourable season of the year for field work. But suitably level ground for the measurement of a longer base could not be found anywhere on the coasts or the islands of the Mergui Archipelago, whereas there was ample employment for the survey parties in the neighbourhood, in addition to the measurement of the base. Thus a base of short length was not only obligatory, but the most convenient in the present instance.

38. The actual measurement of the base and the comparisons of the compensation bars with the standard of length occupied only 24 days. This, of course, is exclusive of the time spent in various preparations on the spot, which were all more or less tedious. The apparatus had been put into thorough working order, under the supervision of Mr. Hennessey, before it was despatched from the head-quarters of the Trigonometrical Survey in Dehra Dún, and it reached Mergui in good order, having met with no mishap on its long journeys by land and sea; thus the measurement of the base was performed with rapidity, and without let or hindrance of any kind. At several, but not all, previous base-lines it has been customary to divide the line into sections connected by triangulation, in order to test the

operations by comparing the ratios of the measured lengths of the sections with the values of ratio afforded by the triangulation, and also to guard against accidental gross error in the record of the number of sets measured from day to day; but the measured length was found to agree so closely with the value brought down through the principal triangulation, that it was certain that no material errors could have been made; and the evidence afforded by the tests applied on previous occasions—and more particularly by the four-times measured base at Cape Comorin—have sufficed to establish the great accuracy and precision of the apparatus, and to show that further triangulation tests are unnecessary. Consequently, though in the present instance the base-line was divided into two sections, with a view to enabling comparisons of the measuring bars with the standards of length to be made at the centre as well as at the two extremities, the sections were not connected by triangulation, as no advantage, commensurate with the labour of measuring three additional principal triangles, would have been gained; the time this would have occupied was more profitably spent in astronomical observations for latitude and azimuth. With a view to determining the height of the base-line above the sea, a line of spirit levels was carried between one end of the base and a point on the coast, at which a tidal station will hereafter be established.

39. The value of the length of the base-line, as determined by calculation through the triangulation from the side of origin of the Eastern Frontier Series, is in excess of the measured value by about 3·4 inches, or 1 inch per mile; the triangulation consists of a chain of polygonal figures—mostly hexagons and quadrilaterals—of which the length is nearly 1,000 miles, while the number of triangles on the shortest line between the side of origin and the base-line is 108. Thus the closing error on the base is, for so long a chain, a small one; it is less than the theoretical probable error of the triangulation calculated on the assumption that the probable errors of the angles do not exceed 0·5″: it indicates that the error generated in the measurement of the angles of the principal triangles may be safely considered to have been very minute.

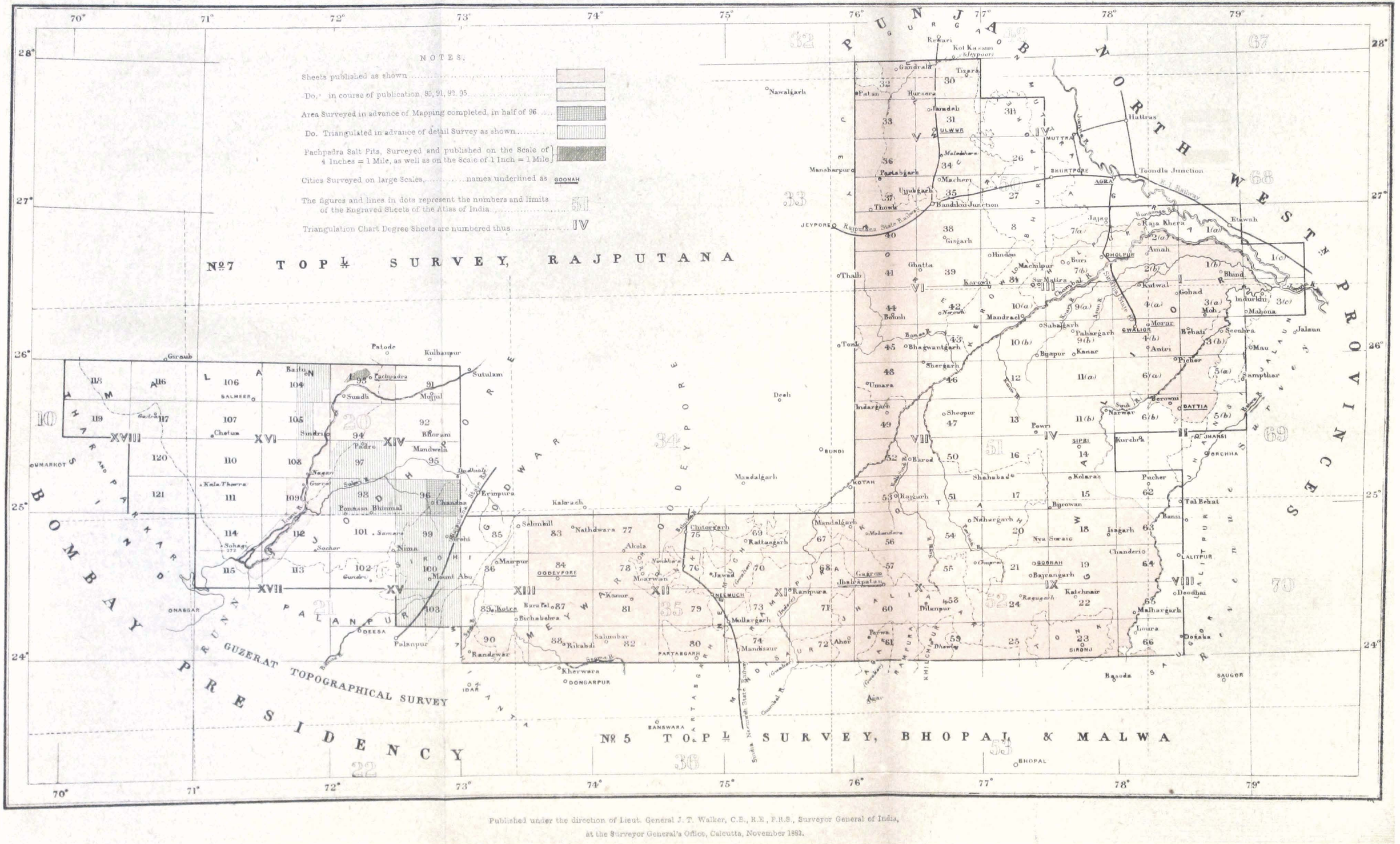
40. Astronomical observations for the determination of the latitude and the azimuth were taken at four of the stations of the principal triangulation in the vicinity of the Mergui base-line. It is well known that all such determinations are liable to be influenced by local deflections of the plumb-line; consequently it is always preferable to obtain fairly accurate results at several points than seemingly very accurate results at a single point, for the magnitude of the latent error due to the local deflections frequently exceeds the probable errors arising from all other causes put together. In the present instance all the astronomical stations lie within an area of about 20 square miles; and the differences between the observed and the geodetically computed latitude and azimuth at each station show that there can be no material variations of local attraction within this area. The mean geodetic latitude has been found to be 8·2″ in defect of the mean astronomical latitude, while the mean geodetic azimuth is 11·2″ in excess of the mean astronomical azimuth. The geodetic calculations have been brought up from Kalianpur—Colonel Everest's station of astronomical origin, referred to in paragraph 7—through the triangulation of the two Longitudinal Series west and east of Calcutta, and through that of the Eastern Frontier Series; and they are based on Colonel Everest's elements of the figure of the earth, which have invariably been used in all the calculations of this Survey up to the present time. Later and more accurate elements were calculated by Colonel Clarke, C.B., of the Ordnance Survey, in 1866; if they were employed, the difference in latitude would be reduced to about 6″, and that in azimuth to 8″. These quantities may therefore be taken to represent the magnitudes of the discrepancies arising from the combined action of the errors of the triangulation connecting the astronomical origin at Kalianpur with the astronomical terminus at Mergui, and the errors due to the local attractions at the two localities; the heoretical probable errors of the triangulation are less than ±1″ in latitude and ±3″ in azimuth; thus, the discrepancies are probably mainly due to the influence of local attractions in deflecting the plumb-line at the initial and terminal astronomical stations.

No. 1 PARTY.

INDEX TO THE SHEETS OF THE GWALIOR & CENTRAL INDIA TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile.

To accompany Surveyor General's Report for 1881-82.



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, November 1882.

41. Latitude determinations were also made at Moulmein by Major Rogers and his assistants at the end of the field season. The observations were taken at three stations, situated within an area of seven square miles. Here, in latitude 16° 29′, the mean geodetic value was found to be 6·5″ in defect of the mean astronomical value, as compared with 8·2″ at Mergui, in latitude 12° 23′. The zenith distances of the stars under observation were measured on the 18-inch vertical circle of an old two-foot theodolite, of inferior accuracy to the one employed by Colonel Branfill; but the difference between the results is probably mainly due to differences in the local attractions at Moulmein and Mergui.*

42. At the end of the field season Major Rogers made inspections of the working of the tide-gauges at Moulmein, Amherst, Rangoon, Elephant Point, and Port Blair, and then proceeded to Poona to relieve Major Hill of the charge of the Tidal and Leveling Party. The latter officer resumed charge of the Eastern Frontier Party, but a few weeks subsequently was transferred to the charge of the Deccan Topographical Party, on the death of Major Lees Smith. Thus the supervision of the recess duties generally—and more particularly the calculations for the reductions of the principal triangulation and the astronomical observations—mainly devolved on Colonel Branfill, who, having brought all the work to a satisfactory completion and handed it over to Mr. Hennessey for final disposal in the Computing Office at the head-quarters of the Trigonometrical Survey in Dehra Dún, proceeded to Europe on furlough for two years. The parties employed in the operations which have now been described have been broken up; most of the officers have been transferred to Topographical Surveys; the Native establishments have been reduced and transferred to the new Secondary Triangulation Party and the Nepal Boundary Survey.

II.—GWALIOR AND CENTRAL INDIA SURVEY (No. 1 TOPOGRAPHICAL PARTY).

43. The triangulation carried on by this party during this season lay mainly in the Native State of Sirohee, but also included small portions of Pálanpur and Dántá, the well-known hill station of Mount Ábu, falling about the centre of the triangulated part. The area thus prepared for future survey was about 1,620 square miles, all of which was more or less bad and difficult country.

Personnel.

Major C. Strahan, R.E., Officiating Deputy Superintendent, 2nd grade, in charge.
Mr. W. J. Cornelius, Assistant Surveyor, 1st grade.
„ P. J. W. Doran „ „ 1st „
„ C. T. Templeton „ „ 2nd „
„ A. Kitchen „ „ 2nd „
„ G. P. Tate „ „ 3rd „
Sub-Surveyor Abdul Gufar.
„ Abdul Aziz.
„ Ahmad Sayid.
„ Jafir Ali.
„ Abdul Rahman.
„ Mr. J. R. Harris.

44. The country surveyed in detail on the scale of 1 inch = 1 mile lay in the three Rajput States of Marwar (Jodhpore), Mewar (Oodeypore), and Sirohee, embracing an area of 2,440 square miles, of which Major Strahan reports that 460 square miles were about as difficult and intricate as could well be found, whilst the remainder was singularly easy to delineate. The portions completed during the season are represented on the index map as part of sheet 85 (the difficult ground mentioned above) and sheets 91, 92, 95, and part of 96.

45. The programme of operations for the field season was somewhat interfered with, as Major Strahan had to pass a military examination, which necessitated his withdrawal for several weeks from the field operations to a military cantonment. He might have claimed to be relieved of all survey duty during this period, but being aware that no officer was readily available to take his place he did not take the leave to which he was entitled, but continued to

* Colonel Branfill reports of Lieutenant the Hon'ble M. G. Talbot, R.E., who was attached to his party with a view to being instructed in the geodetic operations of this Survey, that he took an equal share with him in the principal triangulation and astronomical observations, and has shown himself to be "an excellent observer, with very keen eye-sight and delicacy of manipulation:" he was also of much assistance at the base-line. Mr. D. Atkinson executed the spirit-levels, connecting the base-line with the sea, conjointly with Mr. Senior. Mr. Pocock built three of the principal stations, one being 1,500 and another 2,000 feet above the level of the sea, and cleared the hill-tops of forest. Mr. Potter built and cleared three stations, one, Kisseraing, on a large island surrounded by mangrove swamps, to reach which it was necessary to open out a road more than five miles in length for the passage of the large theodolite. Mr. Torrens was employed on similar operations, and on secondary triangulation in Mergui. Each officer shared in the measurement of the base-line. Subsequently Messrs. Pocock and Potter took most of the star observations for the latitude determinations at Moulmein. Including Moung Shony Gyoke, the Burmese sub-surveyor, all are reported by either Colonel Branfill or Major Rogers to have worked remarkably well and given entire satisfaction.

exercise general superintendence over the survey operations while preparing himself for the military examinations.

46. As the No. 7 Topographical Party has recently been transferred from Rajputana to Burma, the uncompleted portion of the ground which had originally been allotted to it for survey has been handed over to No. 1 Party to complete, which will in future be designated the "Central India and Rajputana Survey Party." The extent of area which it has to complete is about 22,500 square miles; of this area the greater part, being desert country, will be surveyed on the half-inch to the mile scale.

47. During the ensuing season this party will extend the triangulation over sheets Nos. 101 and 102, and will complete the detail survey of sheet 99 and the remaining part of sheet 96 in addition to part of the country to the north, which has been previously triangulated by No. 7 Party.*

III.—KHANDESH AND BOMBAY NATIVE STATES SURVEY (No. 2 TOPOGRAPHICAL PARTY).

48. This party continued the survey of the Khandesh district as in previous seasons, the field survey being made on the scale of 2 inches = 1 mile, and the maps published on the scale of 1 inch = 1 mile. An area of 490 square miles of country was triangulated during the season; and in addition 1,025 linear miles of traverse were completed, fixing 1,034 village boundary tri-junction pillars. This completes the preparation for detail survey of the country remaining to this party.

Personnel.

Major T. T. Carter, R.E, Deputy Superintendent, 2nd grade, in charge.
Mr. A. G. Wyatt, Surveyor, 4th grade.
„ J. A. Barker, Assistant „ 1st „
„ F. E. Warde „ „ 1st „
„ G. G. Vander-Beck „ „ 2nd „
„ E. Graham „ „ 2nd „
„ C. George „ „ 3rd „
Sub-Surveyor Sheikh Omer.
„ „ Mr. F. Rozario.
„ „ Hyder Ali,
and five others.

49. The topography completed during the season covered an area of 1,554 square miles. Of this, upwards of 1,060 square miles was cultivated country. This area is represented on the index map as sheets 21, 23, 24, and part of sheet 34, and is situated in the undermentioned talukas:—

	Square mile.
Amalner	260
Erandol	258
Páchora	450
Chálisgaon	228
Nandurbár	260
Nasirabad	5
Dhulia	9
Pimpalner	3
Nizam's territory ...	81

The country in sheet 34, Major Carter reports as being very unhealthy; it being impossible to send surveyors into it before the beginning of April. It is chiefly forest land inhabited by Bhils. They attribute the unhealthiness of their district to the water absorbing poisonous qualities from the roots of certain shrubs. Even in April and May the parties have to be numerically stronger than usual to fill the places of men suffering from fever.

50. It is expected that during the ensuing field season the remainder of the country allotted to this party will be finally surveyed. Arrangements have therefore been made for this party to take over the portions of Malwa that have not as yet been surveyed by No. 5 Topographical Party, which is about to be transferred to Mirzapur.†

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* Major Strahan reports that "Mr. Doran's work for the season was entirely to my satisfaction." Messrs. Templeton, Kitchen, and Tate are commended for their accuracy. Of the sub-surveyors, Abdul Gufar is more especially noticed for his care and accuracy.

† Major Carter reports that Messrs. Wyatt, Graham, and George, and Sub-Surveyors Sheik Omar, Mr. Rozario, and Hyder Ali, "are particularly deserving of mention" for their good work.

No. 2 PARTY.

INDEX TO THE SHEETS OF THE KHANDESH & BOMBAY NATIVE STATES TOPOGRAPHICAL SURVEY,

On the Scales of 1 Inch = 1 Mile and 2 Inches = 1 Mile.

To accompany Surveyor General's Report for 1881-82.

NOTES.

Sheets published on the Scale of 1 Inch = 1 Mile

Do. Surveyed on the Scale of 2 Inches = 1 Mile and published on the Scale of 1 Inch = 1 Mile

Do. in course of publication Do. Do.

Area Surveyed in advance of Mapping completed

Do. Triangulated and Traversed in advance of detail Survey

Do. Triangulated in advance of detail Survey

Cities Surveyed on large Scales, names underlined as DHULIA.

The figures and lines in dots represent the numbers and limits of the Engraved Sheets of the Atlas of India. 36

Triangulation Chart Degree Sheets are numbered thus (V)

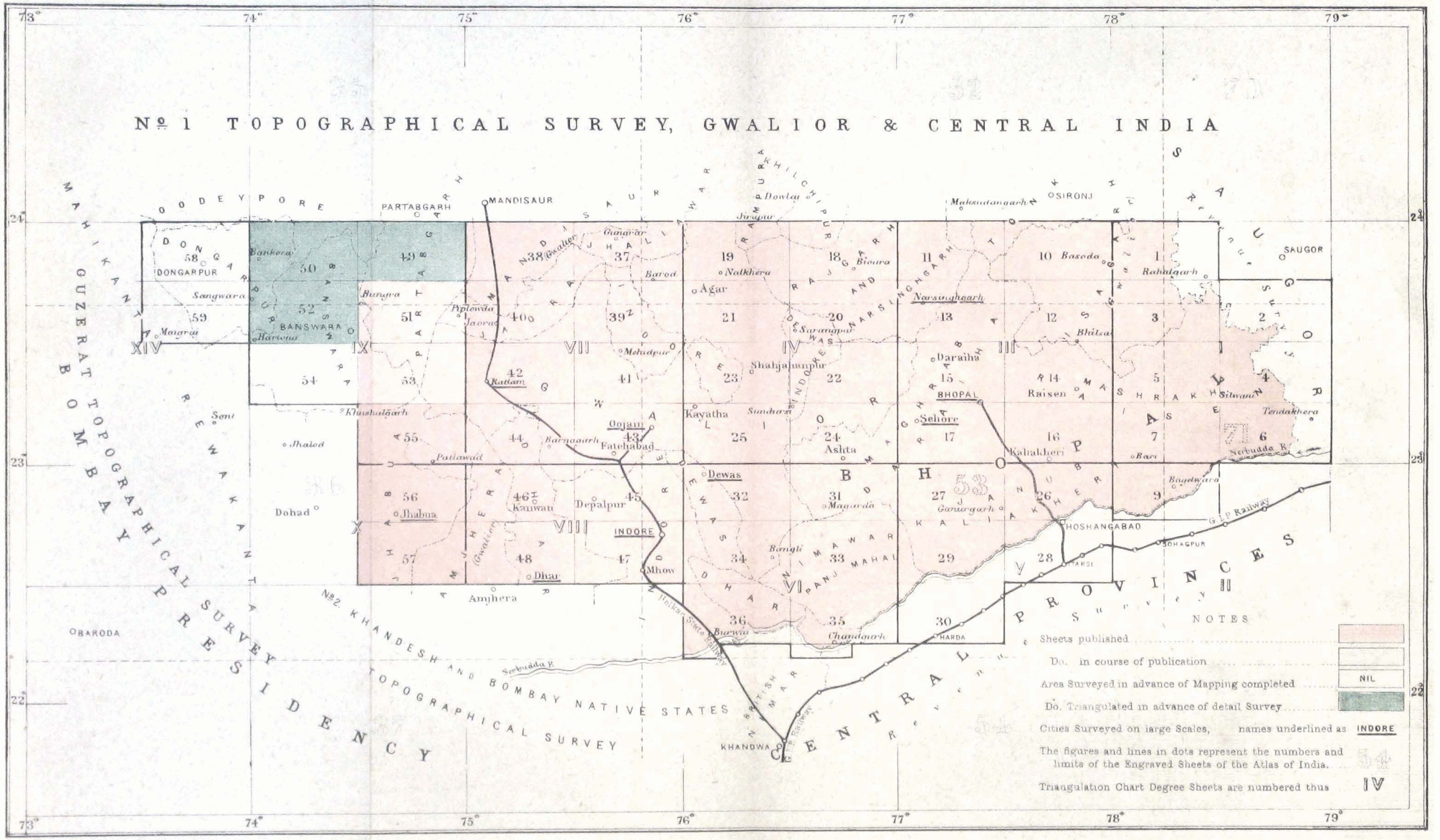
Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India, at the Surveyor General's Office, Calcutta, November 1882.

No. 5 PARTY.

INDEX TO THE SHEETS OF THE BHOPAL & MALWA TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile.

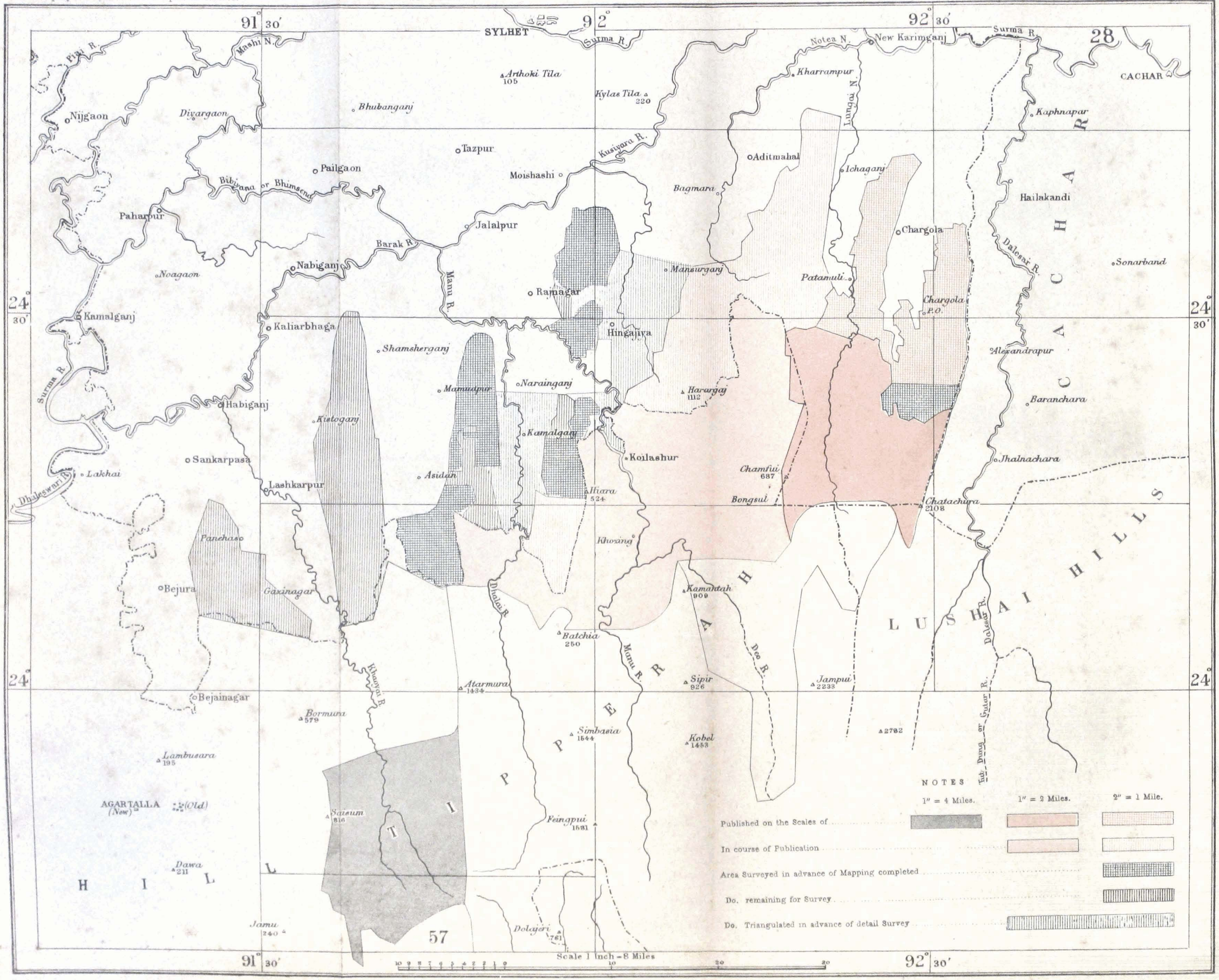
To accompany Surveyor General's Report, 1881-82.



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, January 1883.

To accompany Surveyor General's Report for 1881-82.

INDEX TO THE SURVEY OF SOUTH SYLHET AND TIPPERAH HILLS.



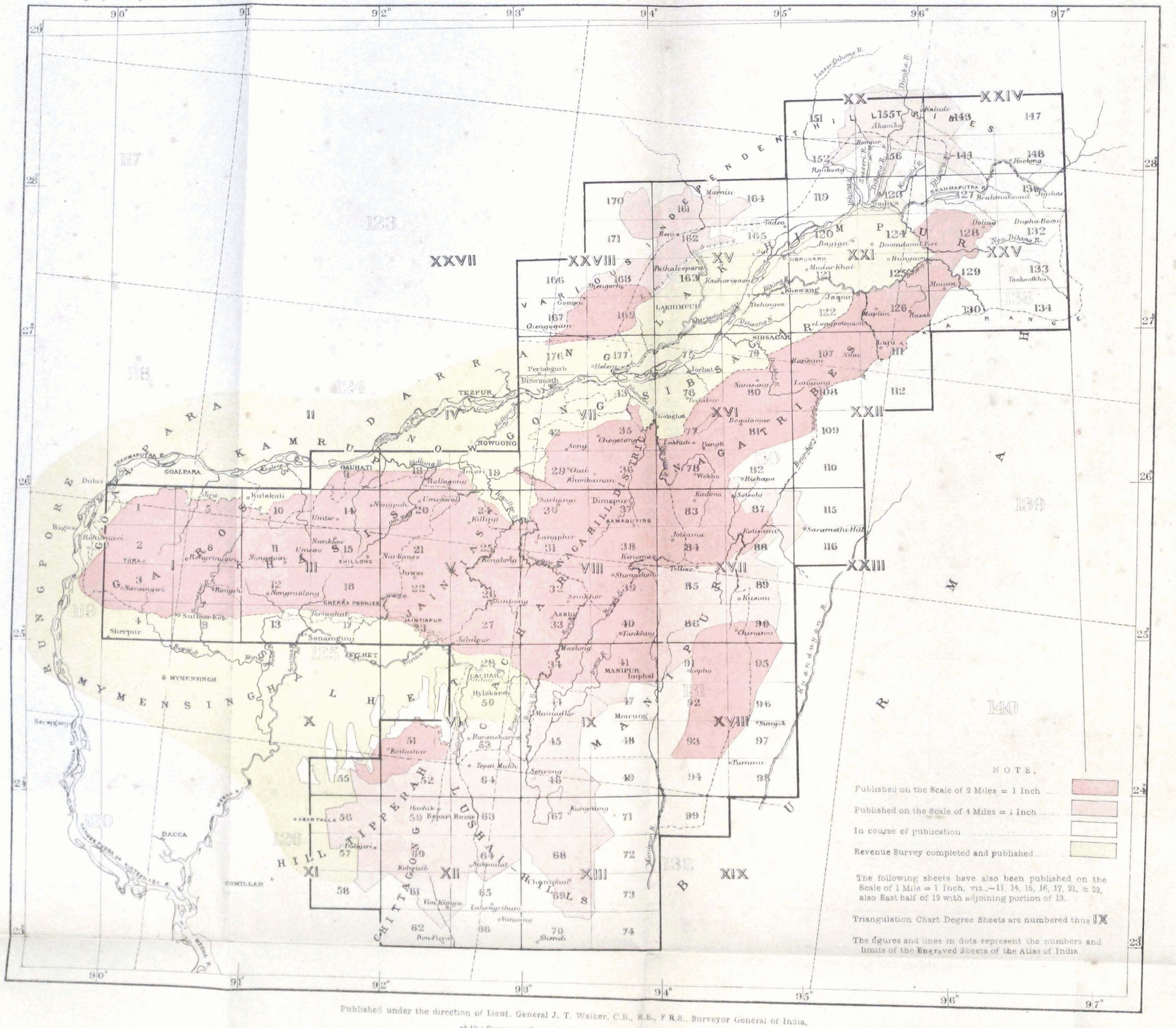
Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, November 1883.

No. 6 PARTY.

INDEX TO THE SHEETS OF THE GARO, KHASI, AND NAGA HILLS AND NORTH EAST FRONTIER TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile, ½ Inch = 1 Mile, and ¼ Inch = 1 Mile.

To accompany Surveyor General's Report for 1881-82.



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India, at the Surveyor General's Office, Calcutta, March 1883.

IV.—BHOPALAND MALWA SURVEY (No. 5 TOPOGRAPHICAL PARTY).

51. The work of this party during the season under review was in continuation of that previously carried on—a topographical survey on the scale of 1 inch = 1 mile of the Native States of Central India. The country surveyed during the season fell chiefly in the territories of Bánswára, Oodeypore, Partábgarh, and Dúngarpur. With the exception of about 190 square miles of country, which being in the table-land of Central India was open, well-cultivated country, the whole area surveyed in detail consisted of very hilly, jungly, intricate country. A considerable portion of the Mahi river fell within the season's work. The total area surveyed in detail was 1,096 square miles.

Personnel.

Major J. R. Wilmer, S C., Deputy Superintendent 4th grade, in charge.
Mr. C. F. Hamer, Surveyor, 4th grade.
" E. A. Wainright, Assistant Surveyor, 1st grade.
" H. T. Kitchen " " 1st "
" W. H. Lilley " " 1st "
" G. R. Copping " " 1st "
Sub-Surveyor Prem Raj.
" Harlal Sing.
" Kristo Dhun Chatterjee.
" Gobardhun Dass.
" Shiv Charan.

52. The triangulation completed during the season covered about 1,096 square miles. In addition to the topography on the standard scale, the cities of Bánswára and Jaora were surveyed on the scale of 6 inches = 1 mile. The party is reported to have suffered considerably from fever during the field season.

53. During the ensuing season a portion of the party will be employed in completing the topography of sheet 49, for which the requisite basis of triangulation has already been prepared. The bulk of the party will, however, be transferred from a Native State to British district, Mirzapur, with a view to completing the topography which is required in connection with the cadastral survey operations now in progress in that district. The completion of the survey of Malwa has been allotted to No. 2 Topographical Party.*

V.—SYLHET, KHASI, AND GARO HILLS SURVEY (No. 6 TOPOGRAPHICAL PARTY).

54. This party took the field early in December to carry on, at the particular request of the Chief Commissioner of Assam, the work previously commenced, of surveying the lands in South Sylhet, which, owing to their being waste, hilly ground, had been left unmapped by the revenue survey of that district. These lands are now being rapidly taken up for the cultivation of tea.

Personnel.

Bt. Lieutenant-Colonel R. G. Woodthorpe, R.E., Assistant Superintendent, 1st grade, in charge.
Mr. A. Chennell, Surveyor, 4th grade.
" J. McCay, Assistant Surveyor, 2nd grade.
" J. Keating " " 3rd "
" D. Campbell " " 3rd "
" A. Ewing " " 3rd "
Sub-Surveyor Shah Nusirudin.
" Faida Ali,
and nine others.

55. The country under survey consisted of the lower spurs of the Tipperah hills running northwards past the British boundary into the plains of South Sylhet, as well as the isolated group of low hills which lies between Fenchuganj and the Manu river. These tracts of country, hitherto described on the maps as "hills covered with impenetrable jungle," are rapidly becoming very valuable, as they are being taken up and opened out for tea cultivation. This survey is made on the scale of 2 inches equal to 1 mile, and during the season an area of 244 miles was completed. The boundaries of certain tea grants met with were also surveyed, a linear distance of 47 miles of traverse having been run in order to fix them.

56. In addition to the above, a portion of Hill Tipperah, covering an area of 222 square miles, was surveyed on the smaller scale of $\frac{1}{2}$ inch equal to 1 mile.

57. Lieutenant-Colonel Woodthorpe reports that the country is very difficult by reason of the dense bamboo and tree jungle with which all the low hills are covered, the work there being necessarily slow, as each small stream and its affluents have to be carefully traversed with compass (or plane-table) and chain, checks being made by cross lines and such independent fixings of

* Major Wilmer, after close personal inspection of the work of his assistants, commends Messrs. Hamer, Wainright, Kitchen, and Copping for the accuracy of their work, that of Messrs. Wainright and Kitchen being especially neat. Sub-Surveyor Prem Raj is also specially mentioned for good work.

position as can be obtained. The heavy storms so prevalent in March and April very much impeded, and finally put a stop to, the work at the end of the first week in April, after which work became impossible.

58. The programme of this party for the ensuing season is to continue the work westwards from where it was left off in the previous year, and it is hoped that the work in South Sylhet will be finished during the season.*

VI.—THE RAJPUTANA AND SIMLA SURVEYS (No. 7 TOPOGRAPHICAL PARTY).

59. This party, reduced in strength by the transfer of three European assistants, continued the survey of the Rajputana States, in accordance with the programme set forth in paragraph 59 of the General Report for last year.

Personnel.

Mr. G. A. McGill, Surveyor, 1st grade, officiating in charge.
Mr. J. H. Wilson, Assistant Surveyor, 1st grade.
„ G. L. Fleming „ „ 2nd „
Sub-Surveyor Madhu Sudan Dutt.
„ Kalka Persad.
„ Sher Shah.
„ Hossein Buksh,
and two apprentices.

The detail survey, which is executed on the scale of $\frac{1}{2}$ inch = 1 mile, was carried on mainly in that part of the Jodhpore State which is shown on the index map as degree sheet XX, a small portion of degree sheet XIX being also surveyed. An area of 5,611 square miles was completed.

60. The country met with in degree sheet XX is described as being "unquestionably the finest that this party has had to survey for the past five years." Here the usual rolling sand hills and ridges of the desert are replaced by extensive plains composed of sandy clay, all more or less fertile and varied by clumps of rocky hills.

61. The triangulation was continued during the season northwards over degree sheet XVIII, and the remaining portion of degree sheet XIX (*vide* index map), embracing an area of 3,500 square miles. Degree sheet XVIII is described by Mr. McGill as being the worst bit of desert ground he has seen, being almost devoid of villages, and water being exceedingly scarce, and, when met with, often poisonous. These troubles are fortunately in part compensated for by the extreme healthiness of the climate during the winter months.

62. This party has now been transferred to Burma, and will be merged into the Burma Topographical Party, the country remaining for survey being handed over to No. 1 Topographical Party for completion, as already stated in paragraph 46.†

VII.—THE MYSORE SURVEY (Nos. 8 & 9 TOPOGRAPHICAL PARTIES).

63. The operations of this survey during the year under review have been conducted by Major Thuillier, R.E., who resumed charge of the party on the 20th October 1881 after returning from furlough.

Personnel.

Major H. R. Thuillier, R.E., Deputy Superintendent, 1st grade, in charge.
Lieutenant F. B. Longe, R.E., Assistant Superintendent, 3rd grade.
Mr. E. S. P. Atkinson,* Surveyor, 3rd grade.
„ L. Pocock* „ 3rd „
„ A. J. James „ 3rd „
„ F. Kitchen, Assistant „ 1st „
„ W. Stotesbury „ „ 1st „
„ H. Todd „ „ 1st „
„ J. Kennedy „ „ 3rd „
„ J. A. Higgs „ „ 3rd „
and 10 native sub-surveyors.

* During the recess only.

64. The European establishment during the field season was reduced to six Surveyors and Assistant Surveyors. This was due to casualties from the effects of the malarious climate in the Western Ghâts, where the party had been employed during the two previous years, and which resulted in the death of the senior Surveyor, Mr. Chew, and necessitated the transfer of two of the Assistant Surveyors to other parties working in more healthy districts. It was found necessary therefore to modify the programme proposed in the last report.

* Lieutenant-Colonel Woodthorpe speaks in the highest terms of the work of Mr. Ogle, not only in Manipur, where he assisted Major Badgley, but also in the many difficult and dangerous undertakings in which he has been associated with Colonel Woodthorpe. Mr. Chennell and sub-surveyor Shah Nusirudin are also mentioned as having specially distinguished themselves.

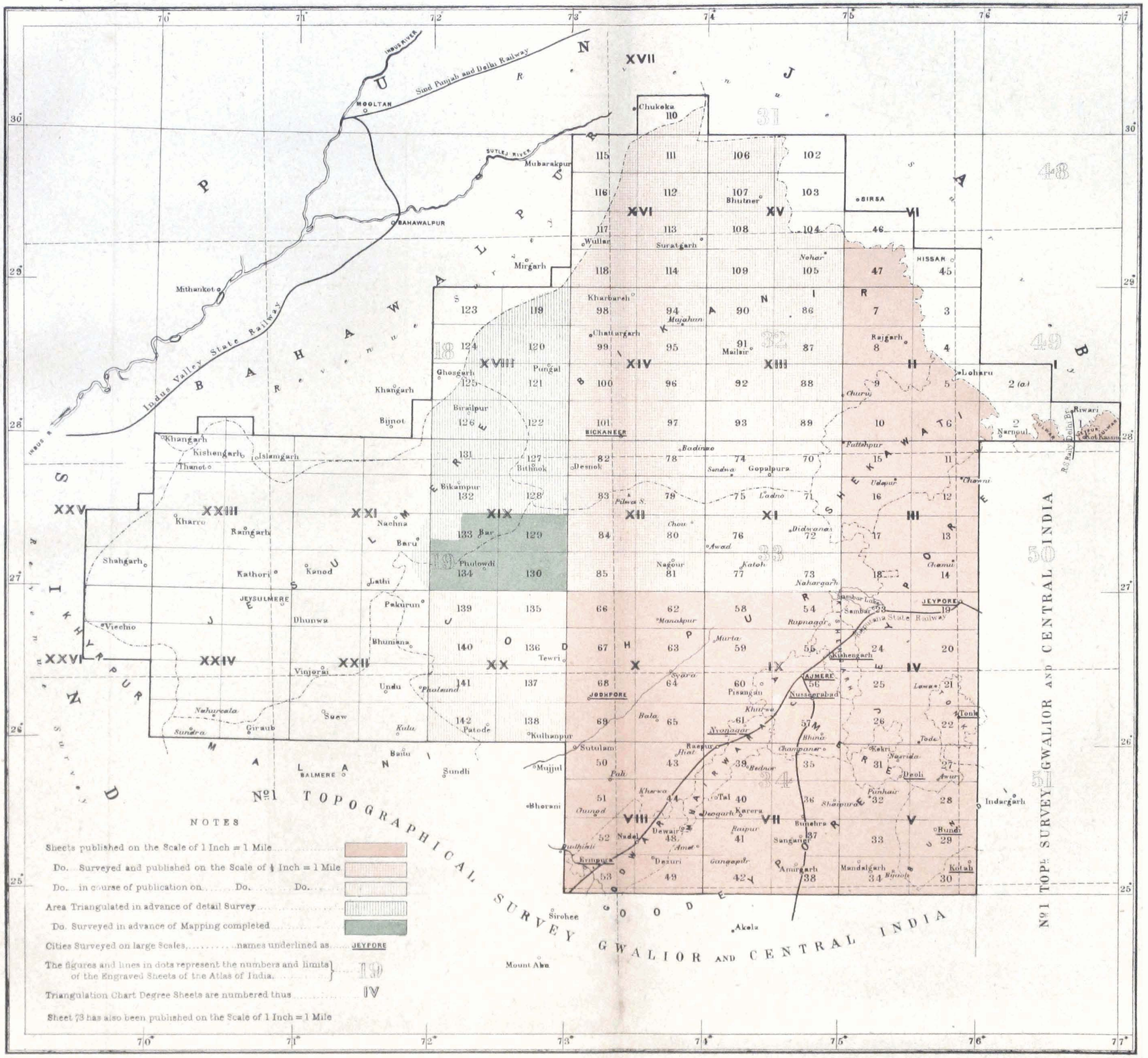
† Mr. McGill reports favourably of Messrs. Wilson and Fleming, and of his sub-surveyors, specially commending the cheerful and zealous manner in which they have conducted themselves.

No. 7 PARTY.

INDEX TO THE SHEETS OF THE RAJPUTANA TOPOGRAPHICAL SURVEY,

On the Scales of 1 Inch = 1 Mile and ½ Inch = 1 Mile.

To accompany Surveyor General's Report for 1881-82.



NOTES

Sheets published on the Scale of 1 Inch = 1 Mile

Do. Surveyed and published on the Scale of ½ Inch = 1 Mile

Do. in course of publication on Do. Do.

Area Triangulated in advance of detail Survey

Do. Surveyed in advance of Mapping completed

Cities Surveyed on large Scales, names underlined as JEYPORE

The figures and lines in dots represent the numbers and limits of the Engraved Sheets of the Atlas of India. 19

Triangulation Chart Degree Sheets are numbered thus IV

Sheet 73 has also been published on the Scale of 1 Inch = 1 Mile

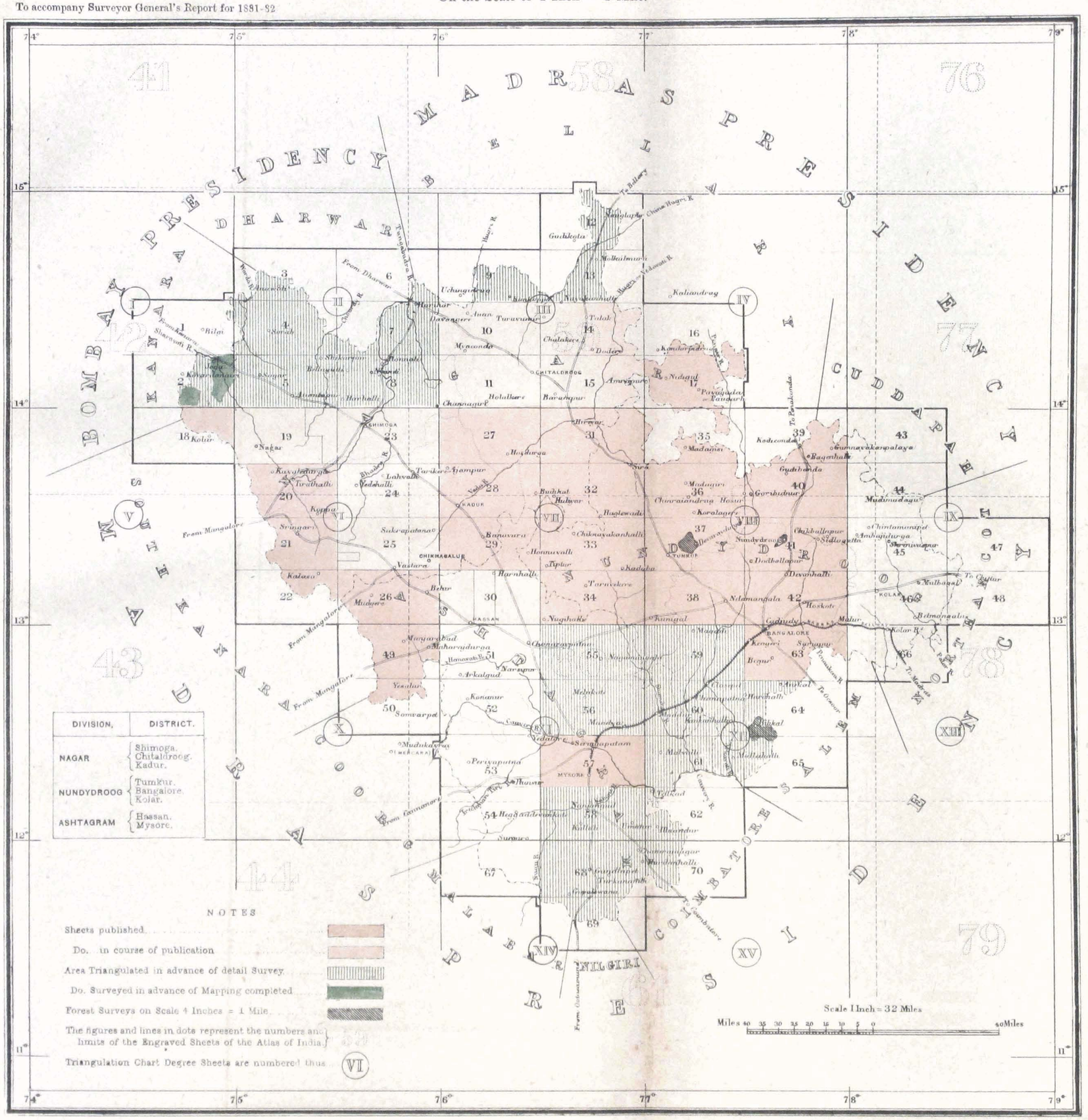
Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, November 1882.

Nos. 8 & 9 PARTIES.

INDEX TO THE SHEETS OF THE MYSORE TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile.

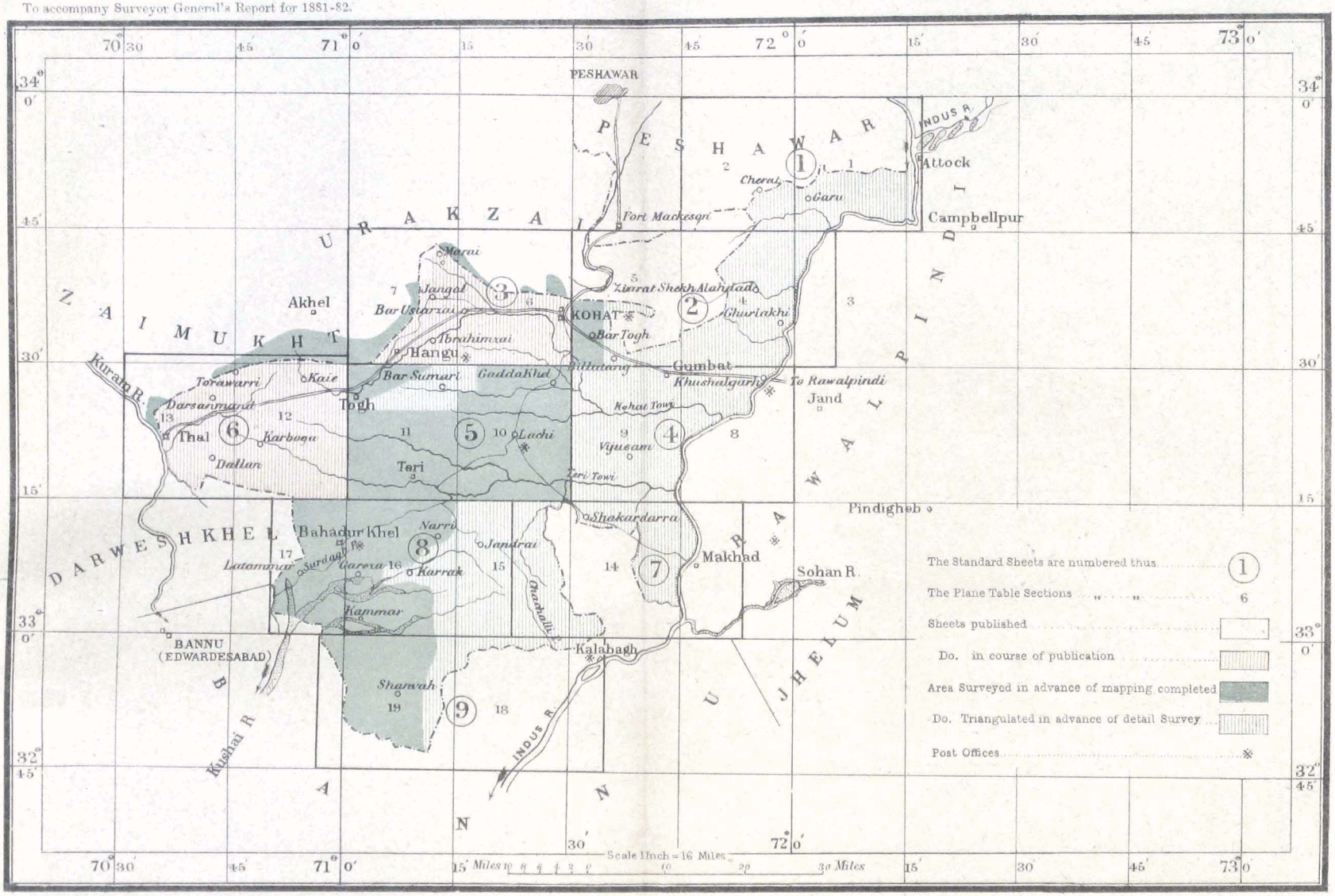
To accompany Surveyor General's Report for 1881-82



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, November 1882.

INDEX TO THE SHEETS OF THE TOPOGRAPHICAL SURVEY, DISTRICT KOHAT.

To accompany Surveyor General's Report for 1881-82.



Published under the direction of Lieut. General J. T. Walker, C.B. R.E., F.R.S., Surveyor General of India

Surveyor General's Office, Calcutta, October 1882.

65. As a large area of ground had been previously prepared for survey no further triangulation was required, and the operations were confined to topography. The districts in which the operations have been carried on during the year are Shimoga, Kadur, Hassan, and Chitaldroog; the two first being in the Malnád or highland region, and the others in the Maidan or open and undulating country.

66. The out-turn of detail survey on the scale of 1 inch = 1 mile embraces an area of 4,226 square miles, of which 1,460 square miles are in the Malnád and 2,766 square miles in the Maidan. In the former the work was exceedingly difficult, and the same obstacles to progress were met with as had been before encountered in the western parts of the province and previously described, the constant use of the chain being necessary. The work has been tested by 423 linear miles of check line and traverses, and was found to be accurately and carefully done. Numerous heights have been fixed, which will greatly increase the value of the final maps.

67. The results of this season's work will furnish material for the publication of standard sheets 10, 11, 14, 15, 19, 23, 24, 25, and 30. This very satisfactory out-turn of work, with its consequent low relative cost, Major Thuillier attributes in a great measure to the unusually good health enjoyed by the surveyors.

68. During the ensuing season the triangulation will be continued in degree sheets XI and XIV, the detail survey being carried on in sheets 1 to 9 inclusive, and sheets 12, 13, 55, and 56.*

VIII.—KOHAT DISTRICT SURVEY.

69. This party is engaged in making a standard topographical survey of the Kohat district on the scale of 1 inch=1 mile, and also in bringing up the final mapping of the surveys in Northern Afghanistan, which were executed during the late war. It took the field in December, weak both in European and Native Surveyors, and was subsequently still further weakened by casualties.

70. Major Holdich himself was not able to take the field on the 4th February, having to pass a military examination, which required him to reside for a time at a military station for the purpose of preparing for it.

Personnel.

Brevet-Major T. H Holdich, R.E., Deputy Superintendent, officiating 3rd grade, in charge.
Mr. T. E. M. Claudius, Surveyor, 4th grade.
" W. W. McNair " 4th "
" R. F. Warwick, *Assistant " 3rd "
Sub-Surveyor Esuf Sharif.
" Imam Bux.*
" Syad Ullah.
" Hira Sing.
" Atma Sing.
" Kadar Sharif.*
" Syad Mahbub.

* During the recess only.

71. The triangulation was carried on by two separate parties. Major Holdich took the north-east corner of the district, and triangulated that portion of country lying between Khushálgarh and Attock. He covered an area of about 500 square miles, and reports the country as generally very rugged, but not difficult for triangulation. The secondary triangulation of this district, which was executed some 30 years ago, was found of great assistance, and a large saving of time resulted from employing the points then fixed. Mr. McNair was employed in triangulating the country lying between Latammar and Bannu, which consists mainly of flat, open, sandy ground, its very flatness rendering it difficult to find and fix points by triangulation.

72. The country topographically surveyed consisted of the upper valleys of the Kohat and Teri rivers, the Surdag hills, and the Lawághar hills, with the low-lying plains at their foot on the west, bordering the Bannu district. A total area of 1,344 square miles was completed, a great portion of which was very intricate ground, requiring great care in delineation.

73. In addition to his other work, Mr. McNair fortunately succeeded in forming such friendly relations with one of the Waziri Chiefs that he was taken under tribal protection to make a reconnaissance of the tract of independent territory lying east of the Kurram river and immediately north of Bannu,

* Major Thuillier acknowledges the good services of Lieutenant Longe, R E., and highly commends his energy and perseverance. He also reports very favourably on the work of all his European assistants, and of Sub-Surveyors Janki Dass Raghavyengar, Lachman Daji, and Balaji.

which is inhabited by the Daresh Khel Waziris, and embraces the well-known range of hills culminating in the Kafir Kot, which Mr. McNair is the first European to have visited. During the forthcoming season the topography will be continued, and probably completed in this district. A large scale plan of Kohat City will also be undertaken.

74. During the recess Major Holdich and his party were chiefly employed in constructing the final mapping of the surveys in Northern Afghanistan.*

IX.—THE GUZERAT TOPOGRAPHICAL SURVEY.

75. During the year under review the charge of this party has again devolved on Colonel Haig. Four descriptions of work have been carried on, viz.—

First, the ordinary topographical survey of Native States, executed on the scale of 2 inches = 1 mile, and published on the 1-inch scale.

Second, the preparation of a series of maps on the 2-inch scale, comprising British territory in detail and foreign territory in skeleton, and for the former utilising the maps of the Bombay revenue and settlement surveys as far as practicable

Third, the survey of the Dang Forests on the 4-inch scale.

Fourth, the survey of the city, cantonment, and environs of Surat on the scale of 12-inches = 1 mile.

Personnel.

Colonel C. T. Haig, R.E., Deputy Superintendent, 2nd grade, in charge.
Captain J. R. Hobday, S.C., Assistant Superintendent, 2nd grade.
Mr. A. D'Souza, Surveyor, 1st grade.
" A. D. L. Christie " 4th "
" C. H. McAfee " 4th "
" C. Tapsell, Assistant " 1st "
" G. D. Cusson " 1st "
" S. F. Norman " 3rd "
" C. A. Norman " 3rd "
" A. George " 3rd "
" H. G. Ferns, Draftsman.
Sub-Surveyor Gopal Vishnu.
" Lakshman Ghorpade.
" Bhau Govind,
and 16 others.

76. The ordinary topographical work was carried on over an area of 1,287 square miles, contiguous to and in continuation of the area previously surveyed. It is territorially divided as under—

British ...	Surat Collectorate	296	square miles.
	Khandesh "	6	"
Foreign ...	Baroda State	796	"
	Pálanpur "	25	"
	Bánsda "	83	"
	Dharampur "	81	"

The ground surveyed is situated in four sheets, 76, 35, 36, and 37, two of which—76 to the north and 35 to the south—comprise the Native States, and have therefore been drawn on the 2-inch scale for reduction and publication on the 1-inch scale. Of sheet 36 only the western half has been surveyed; its publication must therefore lie over till the whole is complete. The country surveyed in the fourth sheet consists of irregular areas outlying the Dangs. When the large scale survey of the Dangs is reduced, this work will be incorporated with it, and the ordinary standard sheet on the scale of 1 inch = 1 mile, published.

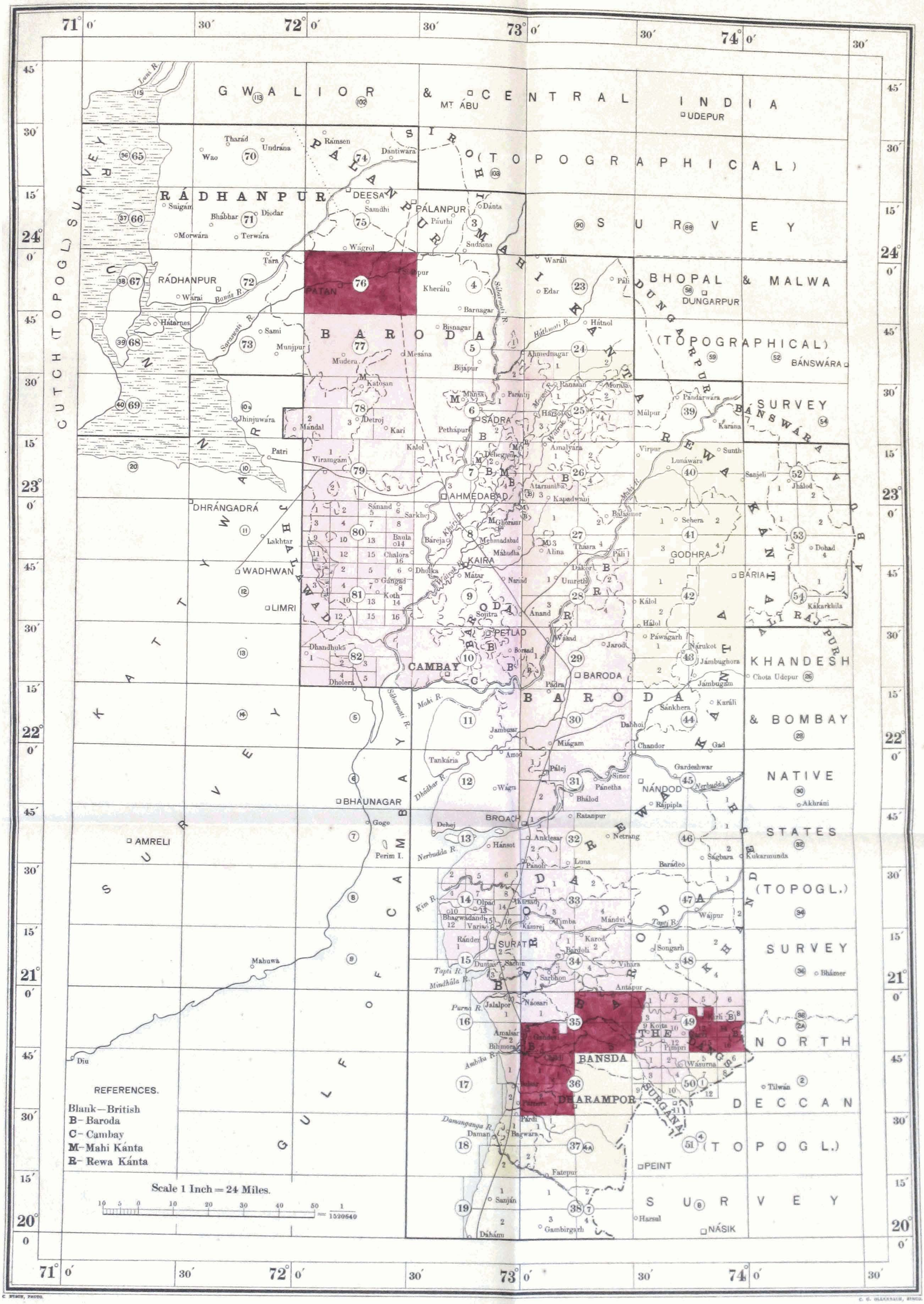
77. An area of 152·3 square miles in the Dang Forests has been surveyed on the 4-inch scale, adding five sheets to this series of maps. Four-fifths of this area were surveyed on the contour system by means of water-levels, contours being drawn at vertical intervals of 25 feet. This work was done experimentally, and for the most part by Native surveyors, with a view to ascertaining whether the system might be introduced without any material increase of cost in supersession of the long-established system of eye-sketched horizontal hachures. The water-level contours are of course a great improvement on the eye-hachures, and it was found that they could be executed almost as rapidly, even with little practice, and that the delay at first may be entirely put down to the change from one system to another. It is expected that the survey of the Dangs will be completed during the ensuing field season.

78. The survey of the city, cantonment, and environs of Surat includes an area of nearly 25 square miles, of which, however, 2·7 square miles within the city walls, having been previously carefully mapped and published on a large scale by the Guzerat Revenue Survey, was merely reduced to the 12-inch scale and incorporated with the new work.

* Major Holdich speaks of the work of Mr. McNair as being highly creditable to him. Sub-Surveyor Esuf Sherif's work is described as "very good," and that of Syad Ullah as "accurate."

SURVEY OF INDIA.

INDEX CHART of the GUZERAT SURVEY.



Note.—Sheets 1 and 2, 20 to 22 and 55 to 64 are wanting, because of transfers to other Surveys and a revision of the numbering, which have been made since the last edition of this Index was prepared.

The numerals (3) (4) &c., indicate the sheets of the Survey on the scale of 1 inch to the mile.

The small numerals thus (5) indicate the sheets of adjoining surveys.

The originals of the 1-inch sheets are drawn on the 2-inch scale and are divided into 4 sections, known as N. E., N. W., S. E., and S. W.

Numbered sections in sheets 14, 49, 50, 80, 81 and 82 indicate publications on scale of 4 inches to the mile.

Ditto 2 in other sheets indicate 2-inch scale publications of British Territory.

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, November 1882.

Denotes country Topographically Surveyed up to 1880–81

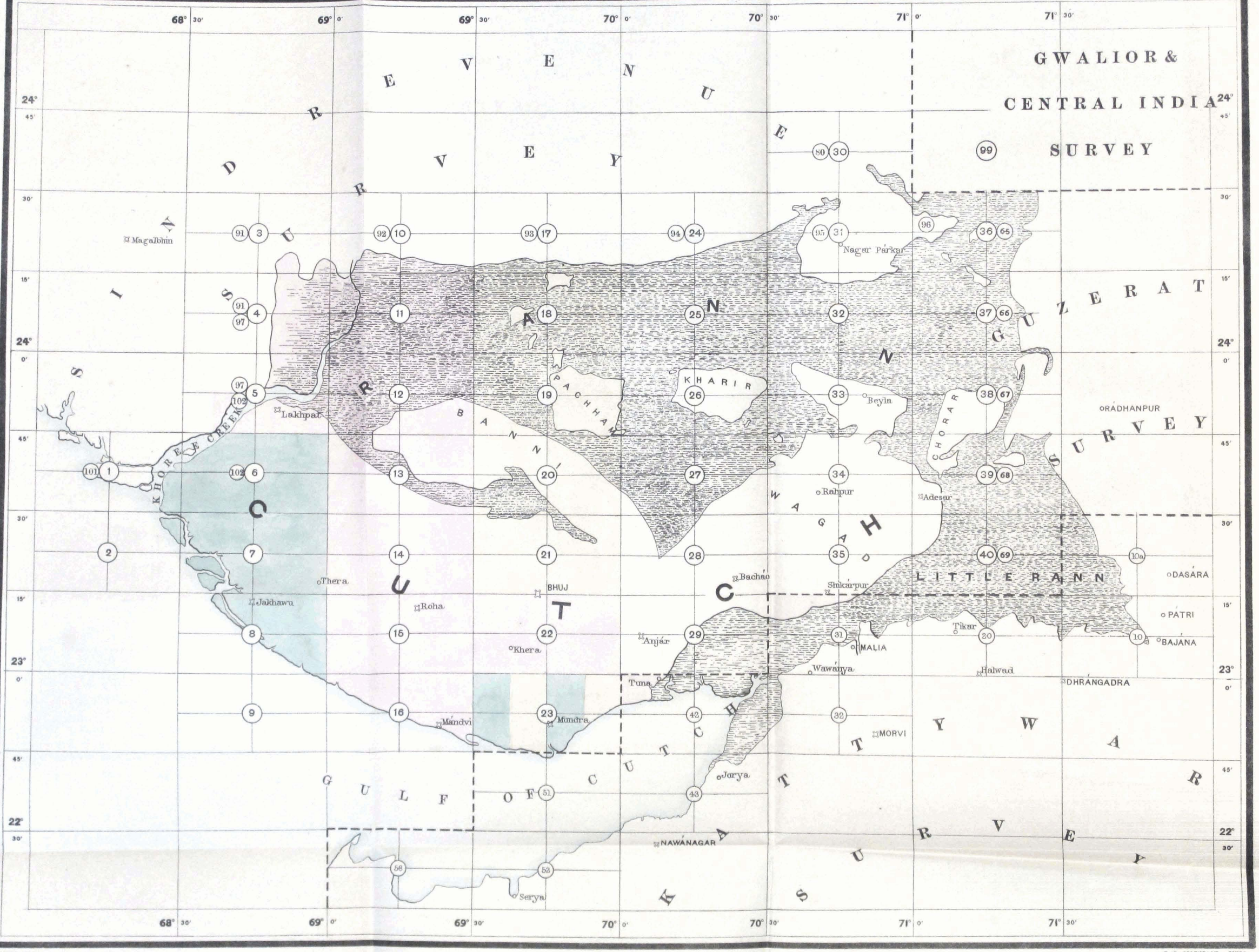
Do. do. do. do. in 1881–82

Do. do. Triangulated in advance.

Trigl. Branch, Dehra Dún 21—11—82—430

TRIGONOMETRICAL BRANCH, SURVEY OF INDIA.

INDEX CHART OF THE CUTCH TOPOGRAPHICAL SURVEY.



C. DYSON, PHOTO.

The numerals (1) (2) (3) &c., indicate the sheets on the scale of 1 inch to the mile.

The smaller numerals as (92) or (65) or (51) indicate the sheets of adjoining surveys.

The originals of the 1-inch sheets are drawn on the 2-inch scale and are divided into 4 sections, N.E. N.W. S.E. and S.W.

Scale 1 inch = 18 miles 10 5 0 10 20 30 40 50 = 1/1140480

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, November 1882.

C. O. GILENBACH, ZINCO.

Denotes country Topographically Surveyed up to 1880-81

" " " " in 1881-82

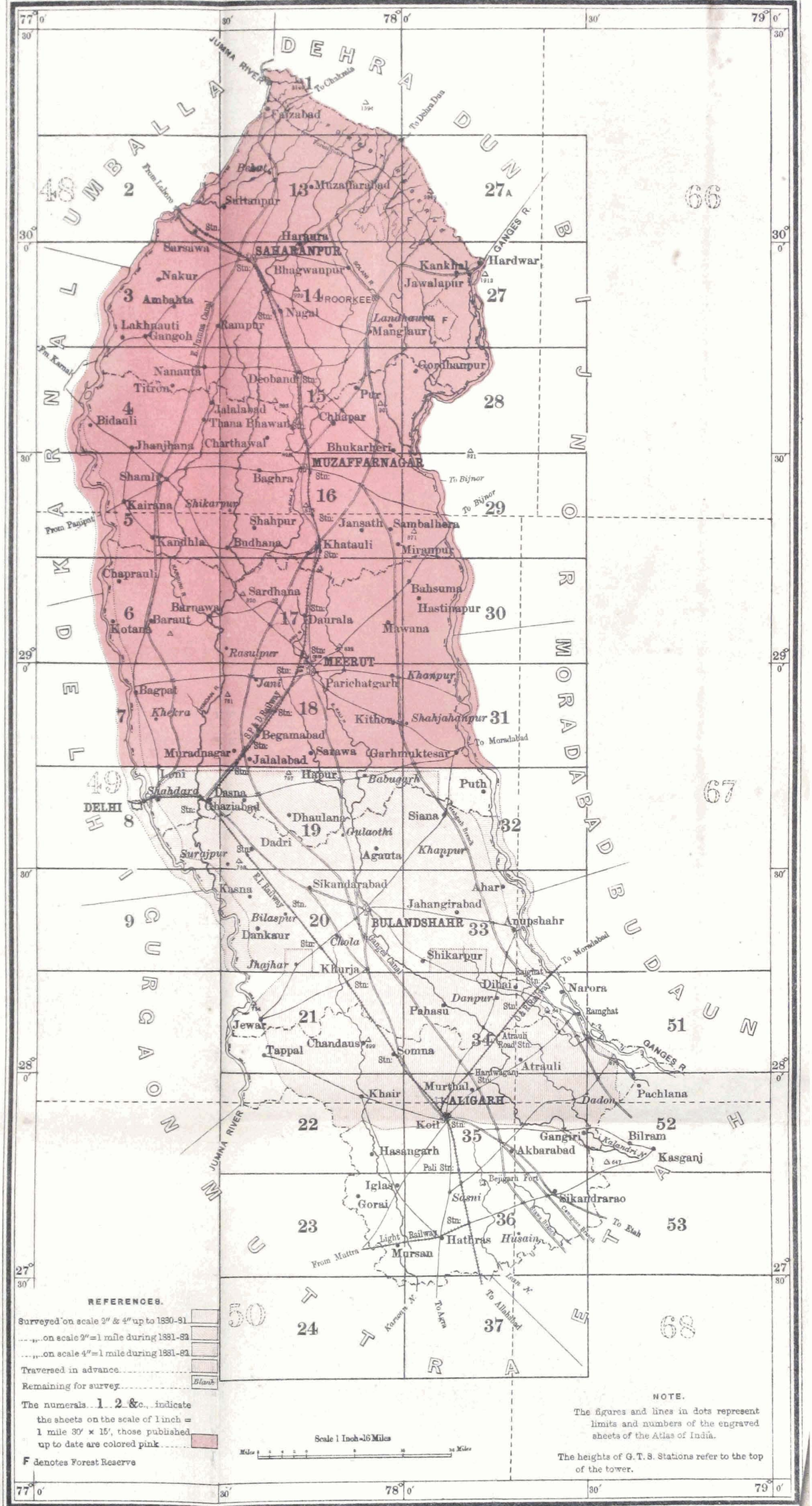
" " Triangulated in advance.

Trigl. Branch, Dehra Dún. 8-11-82-430

INDEX TO THE

N. W. PROVINCES SURVEY

No. 3 REV. PARTY.



REFERENCES.

Surveyed on scale 2″ & 4″ up to 1880-81

...,,...on scale 2″=1 mile during 1881-82

...,,...on scale 4″=1 mile during 1881-82

Traversed in advance

Remaining for survey — Blank

The numerals 1 2 &c., indicate the sheets on the scale of 1 inch = 1 mile 30′ × 15′, those published up to date are colored pink

F denotes Forest Reserve

Scale 1 Inch=16 Miles

Miles 0 1 2 3 4 8 12 16 Miles

NOTE.

The figures and lines in dots represent limits and numbers of the engraved sheets of the Atlas of India.

The heights of G.T.S. Stations refer to the top of the tower.

Photozincographed at the Surveyor Generals Office, Calcutta.

Published under the direction of Lieut. General J.T.Walker, C.B-R.E-F.R.S., Surveyor General of India.

Surveyor Generals Office, Calcutta, January 1883.

79. The operations of the past season bring the total area topographically surveyed in Guzerat up to about 15,686 square miles, leaving about 14,850 square miles to be done hereafter. Though the out-turn of work on the 2-inch scale is rather less than that of the previous year, the deficiency is more than counterbalanced by the largely increased area of work executed in the Dangs and the Surat large scale survey.

80. During the season an area of 1,705 square miles was prepared by triangulation and traversing for final survey, making, with the area prepared in previous seasons, an aggregate in advance of 3,400 square miles.

81. To meet the requirements of the Forest Department, the Bombay Government has expressed a wish that the survey of the Godhra, Kalol, and Halol talukas of the Panch Mahals should be prepared on the scale of 4 inches = 1 mile, the scale of the survey as hitherto executed in Guzerat being too small to suit the special requirements of forestry. This will be commenced during the ensuing season. A request has also been made by the Government of Bombay that certain villages in the Kolwan taluka, in the Nasik district, should be surveyed at an early date on the increased scale of 8 inches to 1 mile, with a view to the settlement and demarcation of the forests therein.*

X.—THE CUTCH TOPOGRAPHICAL SURVEY.

82. The operations of this party were conducted in a manner similar to that of last year, the mainland of Cutch being surveyed on the scale of 2 inches = 1 mile for publication on the 1-inch scale, while the sandy waste composing the Rann was mapped on the $\frac{1}{2}$-inch scale. Of the former, an area of 1,619 square miles was completed, and of the latter 598 square miles, all lying immediately to the north of Bhuj, the capital of the province. This admits of the publication of sheets 17, 18, 19, 20, and 21 of the surveys, the two first on the $\frac{1}{2}$-inch scale and the remainder on the 1-inch scale.

Personnel.

Lieutenant-Colonel A. Pullan, S.C., Deputy Superintendent, 3rd grade, in charge.
Mr. N. C. Gwynne, Surveyor, 4th grade.
" W. A. Fielding, Assistant Surveyor, 1st grade.
" George Hall " " 2nd "
" P. F. Prunty " " 3rd "
Sub-Surveyor V. R. Gadbole.
" N. D. Patwardhan.
" G. R. Bhopatkar,
and seven others.

83. Six hundred and twenty-two linear miles of traverse with chain and theodolite were carried over the work as a check on the plane-table survey, and also to furnish points for the $\frac{1}{2}$-inch survey of the Rann. An area of 1,377 square miles was triangulated in advance on the western extremity of the Cutch Peninsula, which it is proposed to survey in detail next season.

84. The season under review was an unhealthy one, most of the Europeans and Natives being at one time or other laid up with fever.†

XI.—THE SURVEY OF DISTRICTS MEERUT AND BULANDSHAHR, NORTH-WEST PROVINCES (No. 3 PARTY, REVENUE BRANCH).

85. The field operations of this party were resumed on the 9th October 1881, whilst the party was under the superintendence of Major W. H. Wilkins. On Major Wilkins' transfer to No. 8 party in British Burma he made over charge, temporarily, on the 4th November, to Mr. James Todd, surveyor, who held it till 20th November, when he was relieved by Mr. E. T. S. Johnson. Field work was closed on the 15th April, when the party moved up to recess quarters at Mussoorie.

Personnel.

Mr. E. T. S. Johnson, Deputy Superintendent of Survey, 3rd grade, transferred from No. 6, or late Jaunpur Survey, on 21st November 1881.
Major W. H. Wilkins, Deputy Superintendent of Survey, 3rd grade, transferred to British Burma from 4th November 1881.
Mr. G. H. Cooke, Assistant Superintendent, officiating 1st grade, appointed to the party on return from furlough on 10th June 1882.
Mr. J. Todd, Surveyor, 3rd grade, in charge from 4th to 20th November 1881.
Mr. R. C. D. Ewing, Assistant Surveyor, 1st grade, transferred to the Deputy Surveyor-General's Office from 17th June 1882.
Mr. C. W. Wilson, Assistant Surveyor, 1st grade.
" C. W. F. Seyers " " 1st "
33 sub-surveyors, computers, &c.

86. The chief work of the party has been a topographical survey in districts Meerut and Bulandshahr on the 2-inch scale; but for the low-lying lands extending

* Colonel Haig reports:—"To Captain Hobday much credit is due for the energetic way in which he instructed the hands, both European and Native, in the use of the water-level and pushed on the work in the Dangs." He also reports very favourably of the work of each of the other members of the party.

† Lieutenant-Colonel Pullan reports that, thanks to the example of determination and pluck set by Mr. Hall, the Native surveyors strove well against the unhealthy climate, and worked on in spite of occasional attacks of fever.

along the Ganges and Jumna rivers in district Bulandshahr, the scale has been increased to 4 inches. With the 4-inch survey along the Jumna a small area of the Delhi district of the Punjab has also been surveyed, so as to include the entire area liable to be covered by the river in one series of maps; and, similarly, on the Ganges river, small portions of the Moradabad and Budaun districts have been surveyed and mapped with the opposite low-lying tract of Bulandshahr. On the maps of the 2-inch survey, village boundaries have been inserted by transfer from the settlement maps; with the 4-inch survey, village boundaries have been surveyed. The survey has extended down to the parallel of latitude 28°15′, and the area surveyed on the different scales and in the several districts is given in the following statement:—

Districts.	2-inch scale, in square miles.	4-inch scale, in square miles.	Total square miles.
Meerut	323·03	.....	323·03
Bulandshahr	1,173·02	138·00	1,311·02
Delhi	.....	5·51	5·51
Moradabad	.....	7·00	7·00
Budaun	.....	6·47	6·47
Total area ...	1,496·05	156·98	1,653·03

In addition to the above, 1,385·10 square miles have been traversed in districts Bulandshahr and Aligarh, in preparation for topographical survey in season 1882-83.

87. The same system of survey has been followed as in previous seasons, and the 2-inch survey has been made as minute as the scale will allow. Check lines aggregating 309 linear miles were measured as a test of this detail survey. The angular observations of the traverse survey were checked by 61 azimuths, observed at suitable intervals along the main circuits, and connections with stations of the Great Trigonometrical Survey enabled the chain measurements of the circuits to be adjusted to accord with trigonometrical distances.

88. The transfer of the village boundaries from the settlement maps to the 2-inch sheets was provided for by adopting the trijunctions of the boundaries, which had been permanently marked at the time of the settlement survey, as traverse stations. These trijunctions, which originally were low masonry platforms, are the only permanent marks which have been left at traverse stations; and these are not very satisfactory, as many of the platforms were found in a dilapidated condition. Under instructions of the Government Resolution No. 458, dated 4th September 1882, paragraph 5, the permanent marking of all the stations, of which there are many more besides the stations at the trijunctions, will in future be attended to.

89. During next season, the detail survey of district Bulandshahr will be completed, and that of district Aligarh will be continued. The preparatory traverse survey will be extended into district Etah.

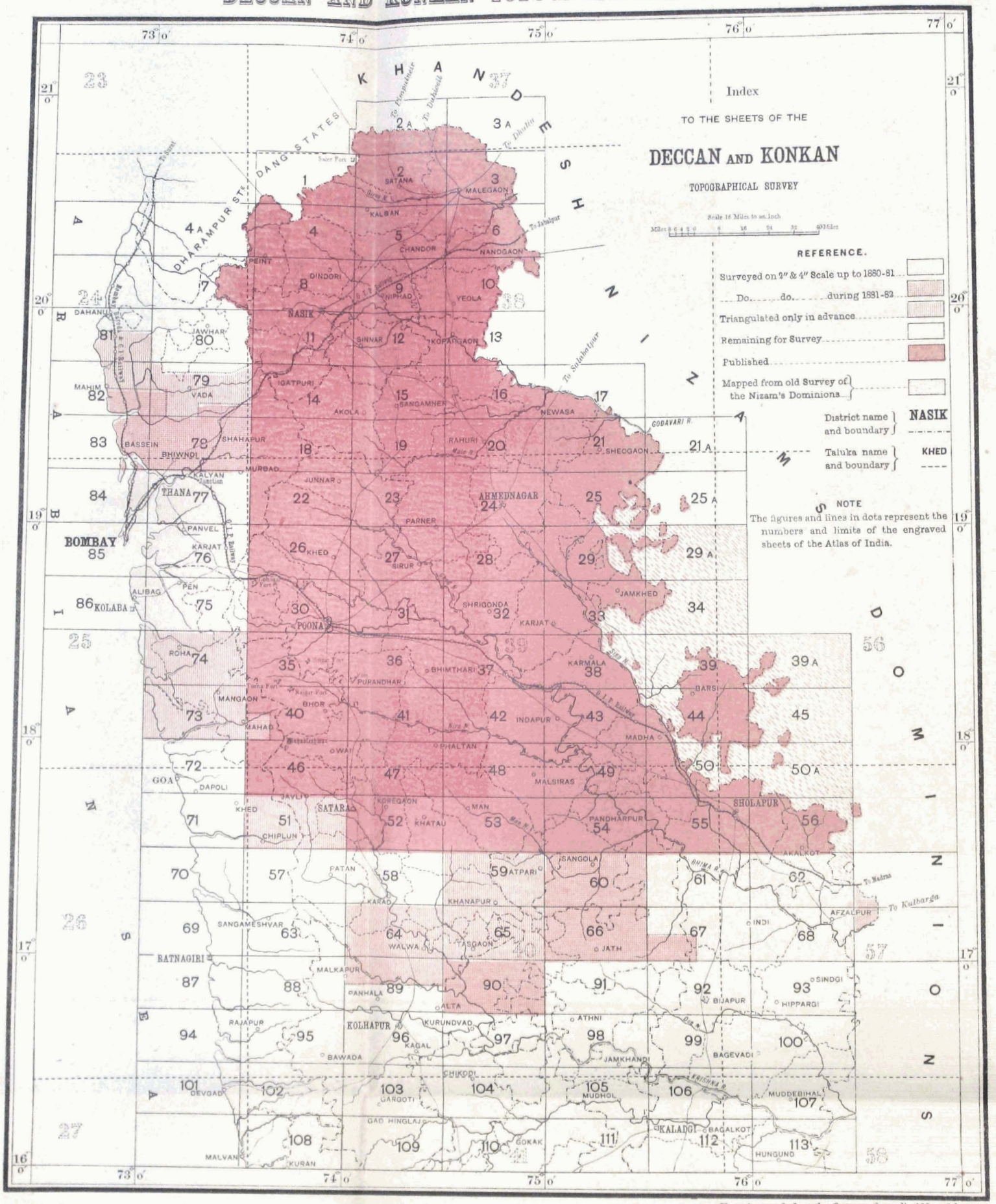
90. The fair maps of the completed area have been drawn and submitted ready for publication by photozincography. They consist of—

19 sheets on 2-inch scale for publication on same scale.
19 sheets on 2-inch scale for reduction to 1-inch scale.

The sheets of the Ganges and Jumna rivers survey, 27 in number, have also been drawn, but these will not be published. Tracings of them have been furnished for record in district offices.*

* Mr. Johnson reports very favourably on the services of Mr. G. H. Cooke, Mr. Todd, Mr. Ewing, Mr. Wilson, and Mr. Seyers, and names the following members of the native establishment as having done well and given satisfaction, viz. Kedar Nath, Bhugobutty Churn Chuckerbutty, Didar Bux, Surfraz Khan, Nejabut Hosain, Mahomed Zakaria, Alladad Khan, Bashirudin, Boithram, and Abdul Karim.

DECCAN AND KONKAN TOPOGRAPHICAL SURVEY.



Published under the direction of Lieut-General J.T.Walker, C.B.-R.E.-F.R.S., Surveyor General of India.

Surveyor General's Office, Calcutta, January

1883.

XII.—THE SURVEY OF THE SOUTHERN COLLECTORATES OF THE DECCAN BOMBAY PRESIDENCY (No. 11 PARTY, REVENUE BRANCH).

91. The field operations of this party were resumed, under the control of Major D. C. Andrew, on 10th November1881, and closed on 10th May 1882. The survey has been entirely topographical, on the scale of 2 inches to a mile, and is mainly comprised in standard sheets 60, 66, and 90 of the Deccan series. A few small portions in other sheets have also been surveyed, and the survey has operated in several collectorates and native states, as is shown in the following statement:—

Personnel.

Major D. C. Andrew, Deputy Superintendent, 3rd grade.
Mr. S. M. Smylie, Surveyor, 3rd grade.
„ J. Hickie, Assistant Surveyor, 1st „
„ G. C. Swiney „ „ 1st „
„ W. H. Penrose „ „ 2nd „
transferred to No. 8 Party, Bassein District Survey, from 1st November 1881.
Mr. G. A. Knight, Assistant Surveyor, 2nd grade.
18 sub-surveyors and others.

	Square miles.
Sholapur collectorate	472
Satara ditto and 3 dependent states	742
Kaladgi ditto	51
Belgaum ditto and 1 dependent state	70
Kolaba ditto	72
Kolhapur state and 7 other dependent states under the Southern Mahratta Agency	537
Nizam's dominions	130
Total ...	2,074

The portion of the Nizam's dominions has been surveyed, as there are no maps of this tract forthcoming with the records of the Hyderabad survey.

92. Besides the above area of topographical survey, 2,016 square miles have been triangulated and traversed in advance for topographical work next season.

The topographical survey has represented the features as minutely as the scale would admit of, and grass-lands have been carefully separated from cultivation. This work has been tested by 368 linear miles of measured check surveys. The heights of 113 stations have been determined trigonometrically. The country is reported to be undulating and possessing no features worthy of note, except a range of hills separating the Sholapur from the Satara district. The villages are few and far apart, and the scanty supply of good drinking-water was severely felt by the party when the hot months set in.

The triangulation stations have been well marked with stones about 2 feet long sunk in the ground, over which, after completion of the observations, mounds of stones and earth were raised. The traverse stations have, as a rule, been placed on demarcated trijunctions of fields, a special mark being cut on the demarcation stones which have been adopted as stations.

93. The fair drawing of the standard-sized sections has all been completed during the recess, 33 two-inch sections having been drawn and sent to Calcutta ready for publication on the 1-inch scale by photozincography.

The survey of the city of Sholapur on the scale of 80 inches to a mile, at the expense of the municipality of that town, has been completed, and the sheets, 59 in number, finally drawn and rendered in a style fit for printing by photozincography. The printing will be done in the Government Photographic Press at Poona, according to the arrangements that may be made by the Sholapur Municipality for defraying the printing charges. A survey of the town of Pandharpur, in the Sholapur district, on the 80-inch scale, at the expense of the municipality, has been commenced.

94. The recess office of the party was inspected at Poona during August by the Deputy Surveyor-General, who was satisfied that much care had been taken to render the survey searching and accurate.*

* Major Andrew reports that his assistants, Messrs. Smylie, Hickie, Swiney, and Knight, have afforded him entire satisfaction.

95. The order for undertaking this survey was communicated in letter No. 98, dated Simla, the 3rd September 1881, from the Secretary to the Government of India, Revenue and Agricultural Department, to the Surveyor-General.

Personnel.

E. T. S. Johnson, Esq., Deputy Superintendent, 3rd grade, in charge up to 15th November 1881.
Major S. H. Cowan, Officiating Deputy Superintendent, 4th grade, in charge from 7th April 1882.
Lieutenant-Colonel E. P. Leach, V.C., R.E., Assistant Superintendent, 1st grade, in charge from 16th November 1881 to 6th April 1882.
Mr. J. S. Pemberton, Surveyor, 3rd grade.
„ J. S. Swiney, Assistant Surveyor, 1st grade, transferred to No. 7 party on 14th April 1882.
Mr. C. S. Kraal, Assistant Surveyor, 3rd grade.
„ P. C. H. Smart „ „ 3rd „
31 sub-surveyors and others.

96. The want of a reliable survey of the Hooghly river, brought up to date, had been felt for some time, and had been noticed by the Torpedo Committee in 1871, by the Bengal Chamber of Commerce in 1872, by the Port Commissioners in 1875, and finally by the Port Officer of Calcutta, who addressed the Bengal Government in March 1881, stating that an exact triangulation and topographical survey of the banks of the river were much needed to be used as a basis for new river charts, and asking that the co-operation of the Survey Department might be obtained.

97. The Surveyor-General had long been aware of the defective state of the maps of the Hooghly river, the best of which had been compiled in 1875 to meet the requirements of the Torpedo Committee; but this map is on a scale (4 inches = 1 mile) quite inadequate to the proper delineation of the country bordering the river in the vicinity of Calcutta: and the only materials available for the greater part of the compilation had been the surveys of the 24-Pergunnahs in 1847–49 and district Hooghly in 1869–73. He accordingly took advantage of the opportunity offered by the completion of the cadastral survey of Jaunpur district, which left No. 6 party of the Revenue Branch at his disposal, and recommended to the Government of India (letter No. 166F, dated 17th June 1881) that the resurvey of the Hooghly river should be commenced in the ensuing field season.

98. The party assembled at Barrackpore on the 10th November 1881, under charge of Mr. E. T. S. Johnson, who was relieved on the 16th by Colonel Leach. Colonel Leach remained in charge until the 7th of April 1882, when he went on furlough and was succeeded by Major S. H. Cowan.

99. On the left bank of the Hooghly river the tract to be surveyed extends from the northern limit of the 24-Pergunnahs near Kanchrapara station of the Eastern Bengal Railway, by Barrackpore, Baranagar, Calcutta, Akra, Atchipur, Diamond Harbour, and Channel Creek to Pitt's Point on the sea-face of the Sundarbans; on the right bank, from a point opposite Kanchrapara through Hooghly, Chinsurah, Chandernagore Serampore, Bali, Howrah, Fort Glo'ster, Ulubaria, Gewankhali, &c., to the Sola Mohan Creek in district Midnapore. The width of the strip surveyed on each bank varies from a quarter mile to one mile and upwards. The suburbs of Calcutta known as Alipur, Kidderpur, and Garden Reach are to be surveyed, and also the whole of Saugor Island. Barrackpore, Calcutta, and the Government estate of Punchannogram on the left bank, and Chandernagore on the right bank, are excluded.

100. The Port Officer at first asked that the survey from Calcutta to Diamond Harbour might be made on the scale of $\frac{1}{12,000}$ (5·28 inches to a mile), and from Diamond Harbour to the sea on the scale of $\frac{1}{24,000}$ (2·64 inches to a mile); but the Vice-Chairman of the Port Commissioners recommended in November 1881 that a uniform scale of six inches to a mile, or $\frac{1}{10,560}$, should be adopted: and this scale has been used from Atchipur downwards. Above Atchipur the scale is 16 inches to a mile.

101. The field season commenced on the 10th November, but the early operations were completely paralyzed by a severe outbreak of cholera among the khalassies on the 17th, 18th, and 19th of November, which resulted in 14 seizures and 14 deaths, and necessitated the insulation of the men. There had been unfortunately no opportunity of preparing traverses in advance, so that there was considerable delay before the detail survey could be fairly commenced. The establishment was withdrawn from the field between the 15th and 25th of June.

No. 6 REV. PARTY.

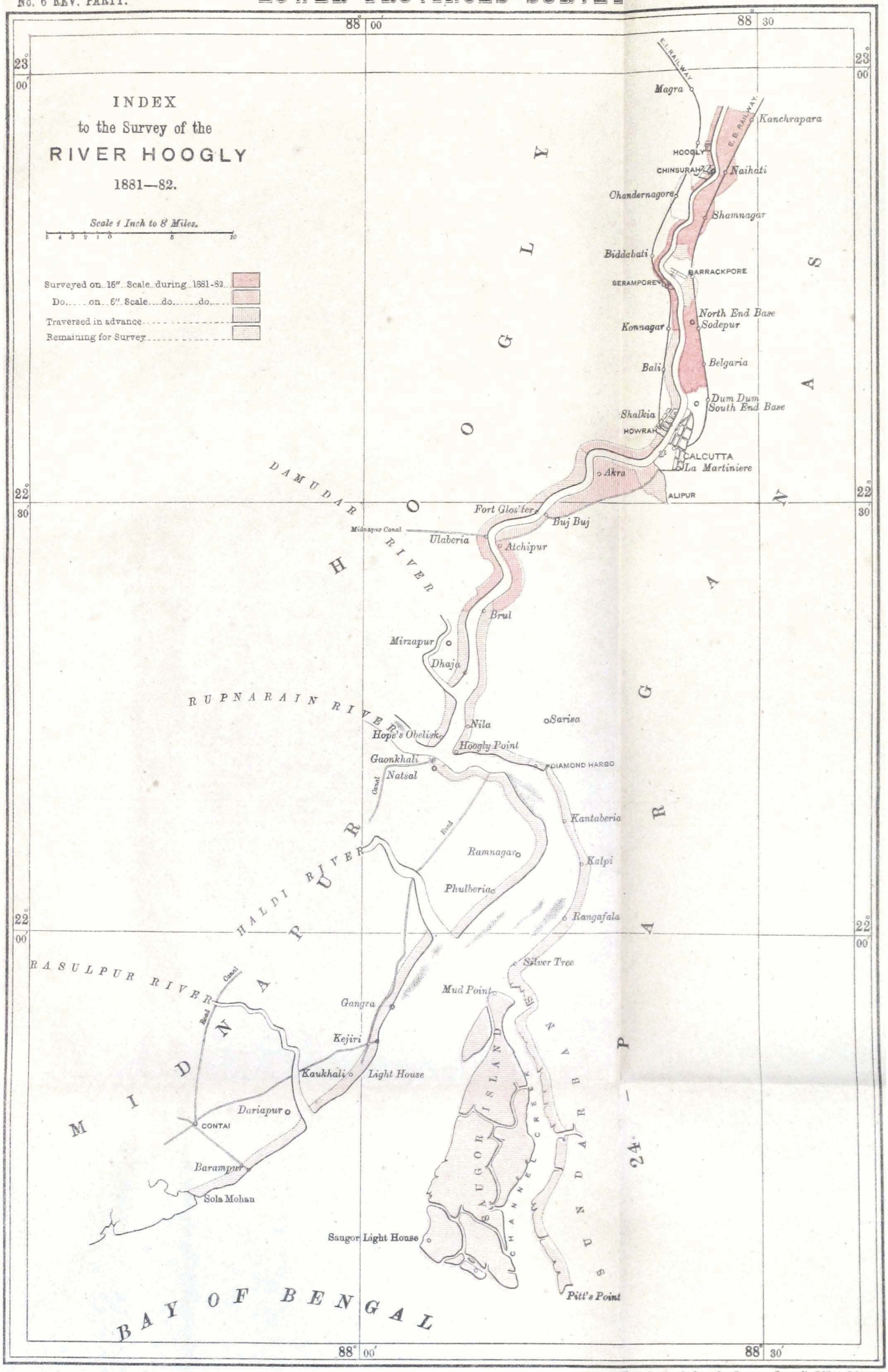
LOWER PROVINCES SURVEY

INDEX
to the Survey of the
RIVER HOOGLY
1881—82.

Scale 1 Inch to 8 Miles.

5 4 3 2 1 0 5 10

Surveyed on 16" Scale during 1881-82.
Do. on 6" Scale do. do.
Traversed in advance
Remaining for Survey



Photozincographed at the Surveyor General's Office, Calcutta.

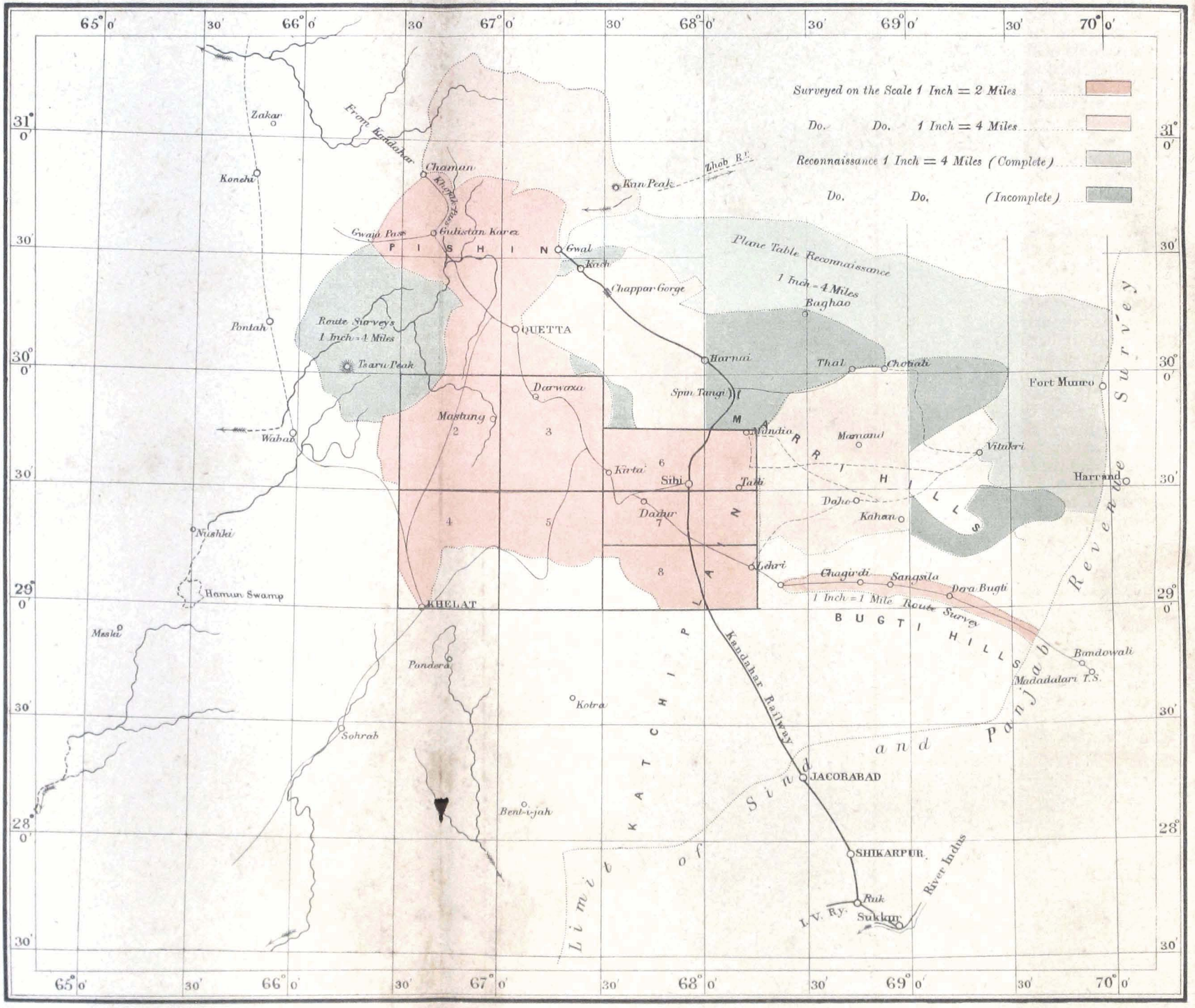
Published under the direction of Lieut-General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India.

Surveyor General's Office, Calcutta, January
1883.

INDEX to the SHEETS of the BALUCHISTAN SURVEY.

To accompany Surveyor General's Report for 1881-82.

On the Scale of 1 Inch = 2 Miles, and 1 Inch = 4 Miles.



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India at the Surveyor General's Office, Calcutta, December 1882.

102. During the past field season the left bank survey was completed down to the Punchannogram boundary near Cossipore, excepting the tract immediately round Barrackpore and some small areas near Baranagar. All the country between the river and the Eastern Bengal Railway was surveyed; and in places where the railway approaches the river, the survey was carried beyond it, so as to give the tract a uniform width of about one mile. The right bank has been completed from the northern limit opposite Kanchrapara down to Konnagar, but on this bank the strip surveyed is only a quarter mile wide. Large scale maps of this tract, sufficient for most purposes, have already been published (1873); and to have worked up to one mile from the river would have increased the work enormously, as a large proportion of the area is closely built over. The above work has been surveyed and plotted on the scale of 16 inches = 1 mile. A commencement has also been made of the 6-inch work, and both banks of the river from Atchipur to near Brul Semaphore Tower, or for about 6 miles, have been surveyed on this scale. The total area surveyed on the 16-inch scale was 21,063 acres (32·91 square miles), and on the 6-inch scale 9,137 acres (14·28 square miles). The areas remaining for survey in 1882-83 are estimated at:—16-inch work, 20,874 acres = 32·6 square miles; 6-inch work, 1,12,960 acres = 176·5 square miles.

103. The area surveyed on 16-inch scale has been closely tested by lines of check surveys and by resurveys of small blocks. The measured traverses have been connected with the numerous stations and points of the Great Trigonometrical Survey falling within the area surveyed, and the chain measurements have been corrected to accord with the trigonometrical distances. The bearings of the traverse lines were checked by 16 stellar observations and 4 azimuths of the Great Trigonometrical Survey.

104. The 6-inch work of this party has already been utilised by the River Survey Department, and a chart, showing the Atchipur Bar and the reach of the River Hooghly from Atchipur to Raipur, was printed in July 1882, in which the shore details were copied from the original field sheets of No. 6 party and the soundings were taken during the month by the River Survey Department. During next field season the survey of the shore details from Calcutta to the sea will be completed on the same scale, and will similarly be made available to the public as fast as the soundings of the various reaches of the river most urgently requiring revision are completed. This work is being energetically pushed on by Lieutenant Petley, R.N., and the result of the joint surveys and of the leveling, now in progress, will soon be to furnish an admirable survey of the River Hooghly.

105. Iron sockets have been planted by the River Survey Department along the banks at an average distance apart of about one mile: between each of these another permanent mark will be fixed by No. 6 party; the positions of all these marks will be carefully determined and plotted, and they will afford the means of accurately recording all future changes in the channel of the river, besides being always useful as points for the River Survey to work upon in running their lines of soundings, which, owing to the incessant fluctuations of the sands and shoals in the river, require continual attention and revision.*

XIV.—THE BELUCHISTAN SURVEY.

106. The work in hand by this party, at the time of publication of last report, was continued throughout the winter by it under Major Beavan, in the country lying between Quetta and Kelat; the season's work comprising more especially that part adjacent to the Bolan and Rodbar passes. The topography was executed on the $\frac{1}{2}$-inch scale, but with varying degrees of detail and accuracy, according as the country was more or less safe for the surveyors to work

Personnel.

Major R. Beavan, S.C., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. J. T. U. Coxen, Assistant Surveyor, 1st grade.
" H. Corkery " " 2nd "
Sub-Surveyor Abdul Rasul.
Ditto Barkat Ali,
and one other.

* Major Cowan speaks highly of his European assistants, Messrs. Pemberton, Kraal, and Smart; and while commending all the members of the Native establishment, makes particular mention of sub-surveyor Dilwar Khan.

in. Thus the triangulation could not always be pushed forward in advance of the topography as is desirable, but in several instances the two operations had to be carried on simultaneously, the triangulation correcting instead of furnishing a basis for the topography. About 4,300 square miles of country were thus mapped.

107. Major Beavan himself received orders to accompany a military expedition under Brigadier-General H. C. Wilkinson to open out the routes between Thal Chotiali and Dera Ghazi Khan. In addition to making a plane-table reconnaissance of such portions of the route taken—*viâ* Mandai, Thal, and Chamalang—as were hitherto unsurveyed, Major Beavan took advantage of such opportunities as occurred for getting observations to complete the Sewestan triangulation. Subsequently Major Beavan, accompanied by Mr. Corkery and under the protection of an escort of Marris, furnished by the Assistant Agent, pushed forward into the Marri country in order to continue, as far as possible, the survey of that district.

108. The party left the field for recess quarters on the 25th March, having been in the field uninterruptedly for 12 months.

109. This survey will be continued during the coming season, the Native surveyors resuming work near Kelat to continue their previous work, and the European assistants being employed in extending the triangulation over the Khetran country and the Bugti hills.*

MAUZAWAR OR VILLAGE SURVEY.

XV.—DERA ISMAIL KHAN, MUZAFFARGARH, AND RAWALPINDI DISTRICTS (No. 1 PARTY, REVENUE BRANCH).

110. This party, under charge of Lieutenant-Colonel D. Macdonald, on leaving its recess quarters at Murree, took the field in two sections. One section proceeded to the Derajat to continue the survey of pargana Leiah of district Dera Ismail Khan, and to undertake the survey of the *Thal* portion of district Muzaffargarh; the second section proceeded to the "Kala Chitta Pahar" to continue the survey of that portion of the Rawalpindi district. Both sections completed the areas assigned for survey in each of the tracts, and the work accomplished is shown in the following statement:—

Personnel.

Lieutenant-Colonel D. Macdonald, Deputy Superintendent, 2nd grade, in charge.
Mr. G. B. Scott, Surveyor, 3rd grade, detached under settlement officer of Rawalpindi from 13th December 1881.
Mr. W. S. Buttress, Surveyor, 3rd grade.
" A. J. Gibson " 3rd "
" R. Todd, Offg. " 4th "
" G. Campbell, Assistant Surveyor, 2nd grade, returned from furlough and joined this party on the afternoon of 21st September 1882.
Mr. J. C. Kelly, Assistant Surveyor, 3rd grade.
22 sub-surveyors and others.

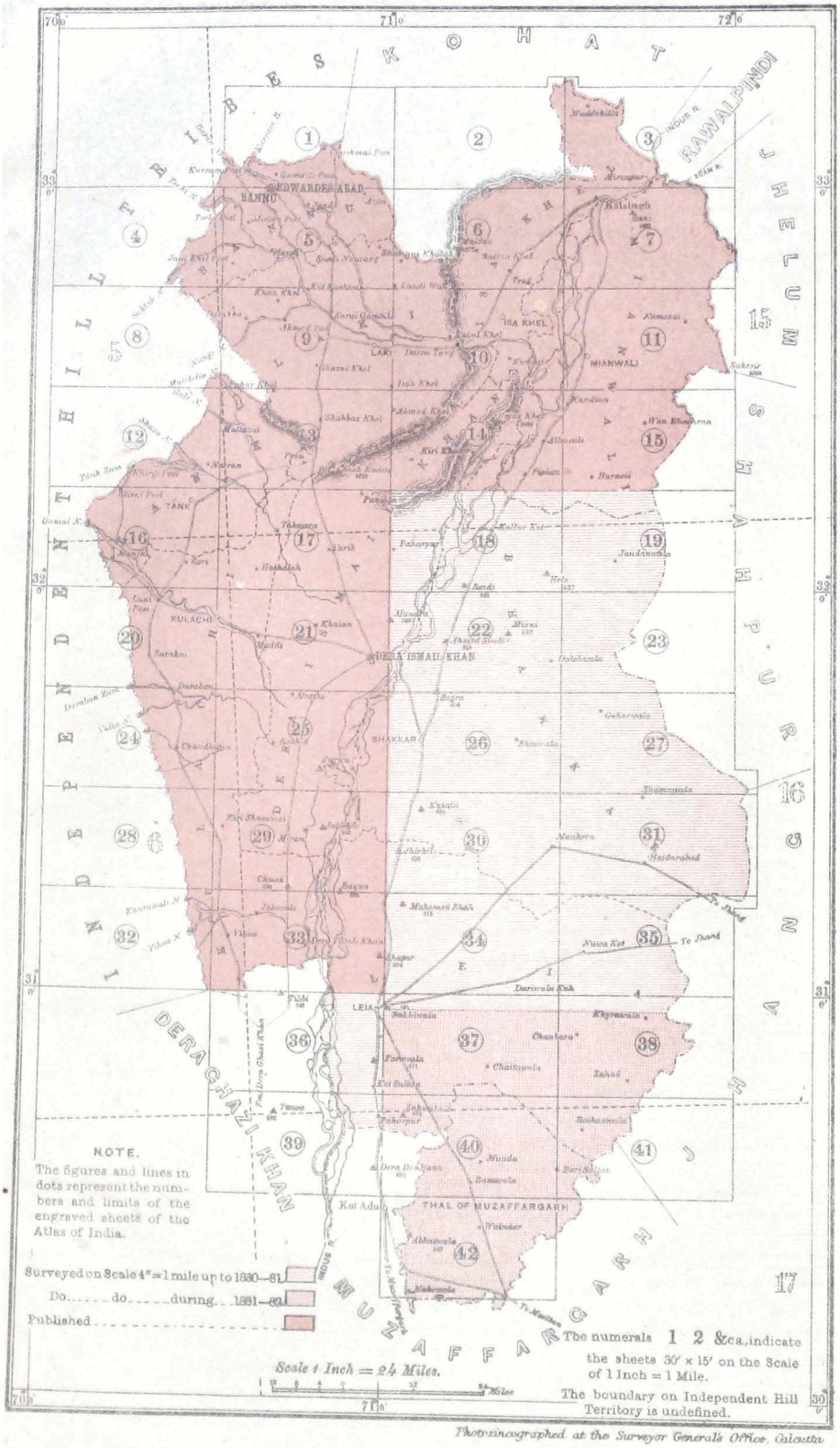
District.	Pargana and locality.	Number of villages.	Area in square miles.	Scale of survey.
Dera Ismail Khan	Leiah	23	889·44	4 inches=1 mile.
Muzaffargarh	Pargana Sinanwan (Thal portion) ...	43	785·22	Ditto.
Rawalpindi	Kala Chitta Pahar...	.....	190·20	Ditto (for the use of the Forest Department).
Total ...		.....	1,864·86	

111. In the Derajat, pargana Leiah of Dera Ismail Khan had been prepared for survey by skeleton traversing during the previous season, and the topographical survey was therefore first undertaken there. Meanwhile, the traversing of pargana Sinanwan of Muzaffargarh was taken in hand, and both traversing and topography were completed in that pargana in one season. The portion of pargana Sinanwan which has been surveyed is the entire tract of *Thal* country included in district Muzaffargarh, and which had been surveyed on the 1-inch scale without village boundaries being delineated, when the rest of the Muzaffargarh district was surveyed on the 4-inch scale during 1855-56. The 4-inch survey of the district is now complete. In pargana Sinanwan four principal stations of the Great Trigonometrical Survey have been incorporated with the measured traverses, the latter being corrected to correspond with the trigonometrical distances by introducing corrections which

* Major Beavan reports favourably of all his assistants.

PUNJAB SURVEY

No. 1 REV. PARTY. INDEX MAP OF DISTRICTS DERA ISMAIL KHAN & BANNU.



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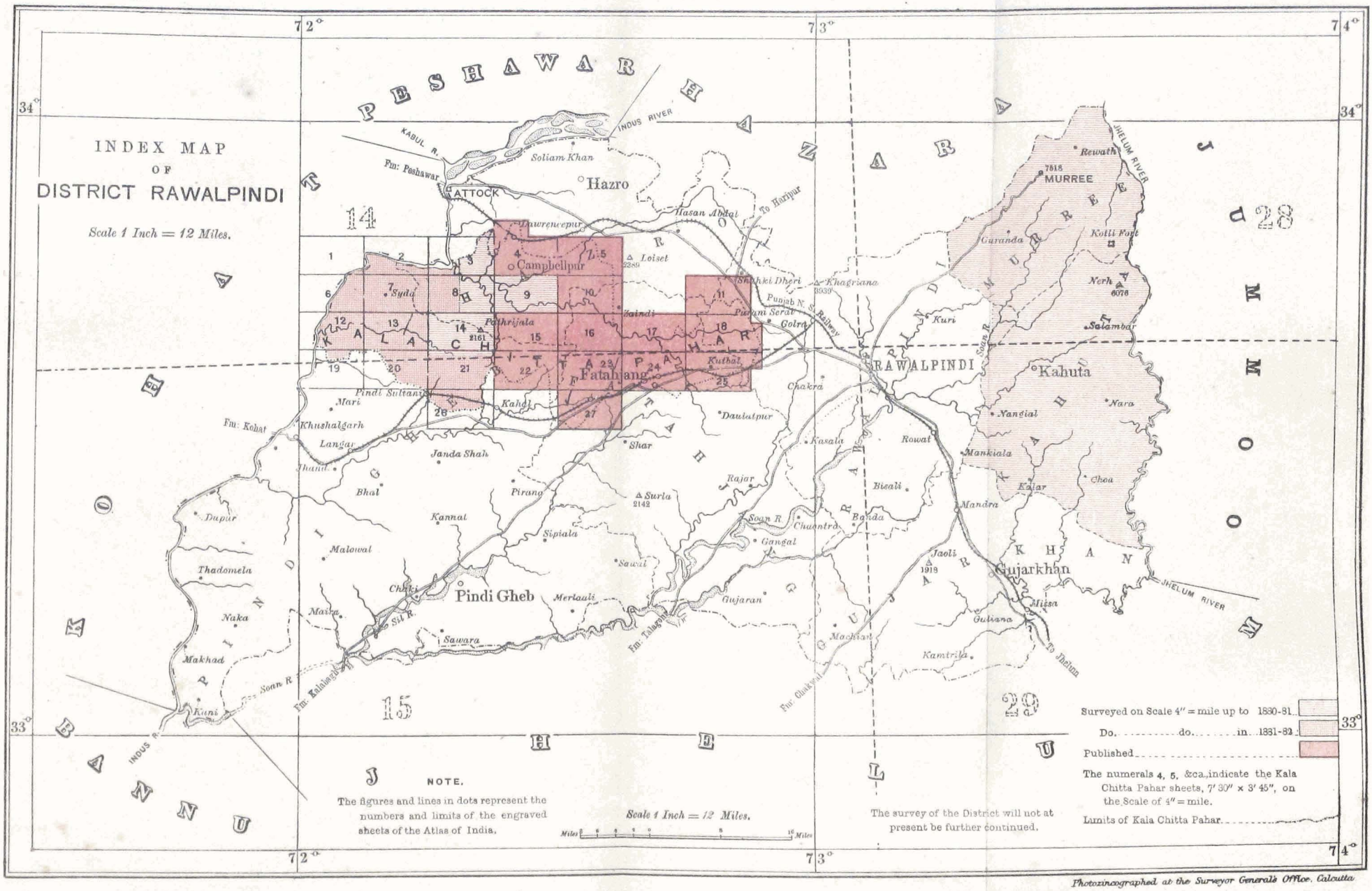
1883.

No. 1 REV. PARTY.

PUNJAB SURVEY



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1883.

averaged 5·2 feet per mile. Observations for azimuth were taken at 23 traverse stations, and 242 linear miles of check surveys were measured.

112. In the Kala Chitta Pahar, owing to the rugged nature of the country, the topography was based on points fixed by triangulation, not on measured traverses. Colonel Macdonald, who has drawn up a few "notes" on the entire range, which are printed in the appendix at page 30, thus briefly describes the country under survey last season:—

"The hills were very broken, rough, and precipitous. There was a great scarcity of water. Provisions were difficult to procure, and had to be brought long distances."

The rate of progress of the topographical survey in such country was necessarily slow. One-third of a square mile was the daily average outturn of each topographer, which is less than a quarter of the daily average of the men who were employed in the Derajat. The accuracy of the survey in all the sheets was tested, either by check surveys or by examination *in situ*.

113. The season's out-turn of fair maps is as follows:—

Of pargana Leiah 37 four-inch sheets (projected on rectangular co-ordinates) have been drawn, which complete the series for the Dera Ismail Khan district.

Of pargana Sinanwan, district Muzaffargarh, a special separate series of 69 sheets, each sheet comprising $3\frac{3}{4}'$ latitude $\times$ $3\frac{3}{4}'$ longitude, has been drawn.

Of the Kala Chitta Pahar, 14 sheets have been drawn, completing a series of 27 sheets of the standard size of $3\frac{3}{4}'$ latitude $\times$ $7\frac{1}{2}'$ longitude for the entire tract.

The drawing of the 4-inch sheets of Murree and Kahuta tahsils, surveyed by this party from 1877 to 1880, is still incomplete, awaiting the adjustment of the forest boundaries.

114. Mr. G. B. Scott, one of the surveyors of this party, was deputed, at the request of the Government of the Punjab, during September, October, and November 1881, to the Sialkot district to survey two portions of the Chenab river, where there were disputes of long standing regarding the boundary between British territory and the territory of his Highness the Maharajah of Kashmir. Some village lands adjoining the disputed boundaries were also required to be surveyed, and Mr. Scott surveyed in all an area of 11·3 square miles. Mr. Scott's maps, showing also the lines of old boundaries by transfer from previous survey maps, which he prepared under the superintendence of Colonel Macdonald, have been photozincographed, and copies of them were furnished to the Government of the Punjab during January 1882.*

XVI.—THE SURVEY OF THE THANA DISTRICT (KONKAN), BOMBAY PRESIDENCY (No. 10 PARTY, REVENUE BRANCH).

115. The field operations of this party were resumed under the direction of Major H. Lees Smith on the 25th of November 1881. During the field season Major Lees Smith suffered much from malarious fever; he ought to have proceeded on leave for the benefit of his health, but he remained devotedly at his post and succumbed to the disease at Poona on 23rd April. Major Lees Smith was possessed of considerable mathematical talent, and his loss to the department is much regretted. Mr. A. M. Lawson received charge of the party on the death of Major Lees Smith, and under his

Personnel.

Major H. Lees Smith, Officiating Deputy Superintendent, 3rd grade, in charge to date of death, 23rd April 1882.
Major J. Hill, R.E., Deputy Superintendent, officiating 3rd grade, in charge from afternoon of 23rd June.
Captain G. W. Martin, Officiating Assistant Superintendent, 2nd grade, joined this party on the 24th June 1882, and was transferred to Bombay Mint on September 1882.
Mr. A. M. Lawson, Surveyor, 3rd grade, in charge from 24th April 1882 to 23rd June.
Mr. J. Newland, Assistant Surveyor, 1st grade.
" W. M. Kelly " " 2nd "
" R. R. Dickinson " " 2nd "
20 sub-surveyors and others.

* Colonel Macdonald reports as follows on his assistants:—

"Mr. W. S. Buttress is a very steady, able, and painstaking assistant."
"Mr. Gibson as an excellent hill surveyor and a good draftsman; he did good service both in field and office."
"Mr. Todd, as usual, worked very hard. He is a very good plane-tabler, and never spares himself."
"Mr. Kelly is a steady assistant."

The following men of the native establishment are specially brought to notice, viz. sub-surveyors Eed Mahomed, Ramtonoo Chuckerbutty, and Goordit Singh, and English writer Elahi Bux.

charge field operations were brought to a close on 31st May. Major J. Hill relieved Mr. Lawson of the charge at Poona on 23rd June.

116. The scale of survey was 4 inches to the mile in place of the ordinary Deccan and Konkan scale of 2 inches to the mile. The change has been made under authority of Government of India, Home Department, letter No. $\frac{F.}{850}$, dated 20th September 1881, in accordance with the resolution of the Government of Bombay, representing that maps on the 2-inch scale are insufficient for the administration of forests, which cover large areas of the Thana district. It had been expected that the forests only need have been surveyed on the increased scale; but after due inquiry it was found to be advisable, on account of the forests being so much scattered over all parts of the district, to survey the whole tract on one scale. Another reason for surveying the whole tract on the 4-inch scale was, that the boundaries of the forests had not been finally determined.

The forest officers, when recommending the adoption of the 4-inch scale for forests in the portion of the Thana district remaining for survey, have also urged the necessity for remapping the forests that had already been surveyed on the 2-inch scale. Their recommendation, for the present, has not been allowed, but maps on the 2-inch scale have been printed specially for forest purposes, in addition to the usual publication of the topographical maps on the 1-inch scale.

117. The agreement with the Government of Bombay concerning the increase of scale is that the Forest Department of that presidency is to be charged with the additional cost of the more expensive survey. The area surveyed by the party was 940 square miles, costing Rs. 50,181; of which, as extra cost of 4-inch survey, Rs. 18,624 have been debited to the Government of Bombay.

In addition to the area which has been mapped, 450 square miles have been triangulated and traversed for detail survey next season.

118. The traverse stations of the survey are fixed on field demarcation stones with a special mark cut upon them. The heights of 208 points have been determined trigonometrically, fixing many valuable points, such as hill-passes, junctions of streams, wells, and mile-stones. The topography has been executed by a close survey of all the details, and at the request of the Forest Department particular attention has been paid to recording the names of all peaks, valleys, passes, springs, shrines, &c. The conformation of the hilly ground has been indicated by the system of horizontal shading, a vertical interval of 25 feet being preserved between the *hachures*. Towards the coast, the country surveyed is much cut up with tidal creeks and salt marshes; inland, towards the ghâts, there is a very large area of hilly ground covered with forest; and in the centre of the tract, a small extent of open and cultivated country. The party suffered severely from the unhealthiness of the country from the time of taking the field up to January, and a large number of men were permanently incapacitated.

119. The drawing of 24 four-inch sections of the standard size, comprised within sheets Nos. 78, 79, 82, and 83 of the Deccan and Konkan series, has been completed, and the sheets will be published on the original scale. Reductions of the sections are being drawn for publication, similarly to the other sheets of the series, on the 1-inch scale.

120. The recess office of the party was inspected at Poona during August by the Deputy Surveyor-General, who expresses himself well satisfied with the style of the work which had been executed.*

---

* Major Hill reports as follows on the assistants of his party:—

He speaks highly of the services of Captain G. W. Martin during the short time he was attached to the party.

"On Mr. Lawson," he says, "an unusual responsibility was imposed during the latter part of the field season and early part of the recess owing to the illness and death of Major Lees Smith, which he well sustained as officer in charge of the party."

Mr. Newland is spoken of as "a cheerful, zealous and hard-working assistant, of high character and devoted to his work."

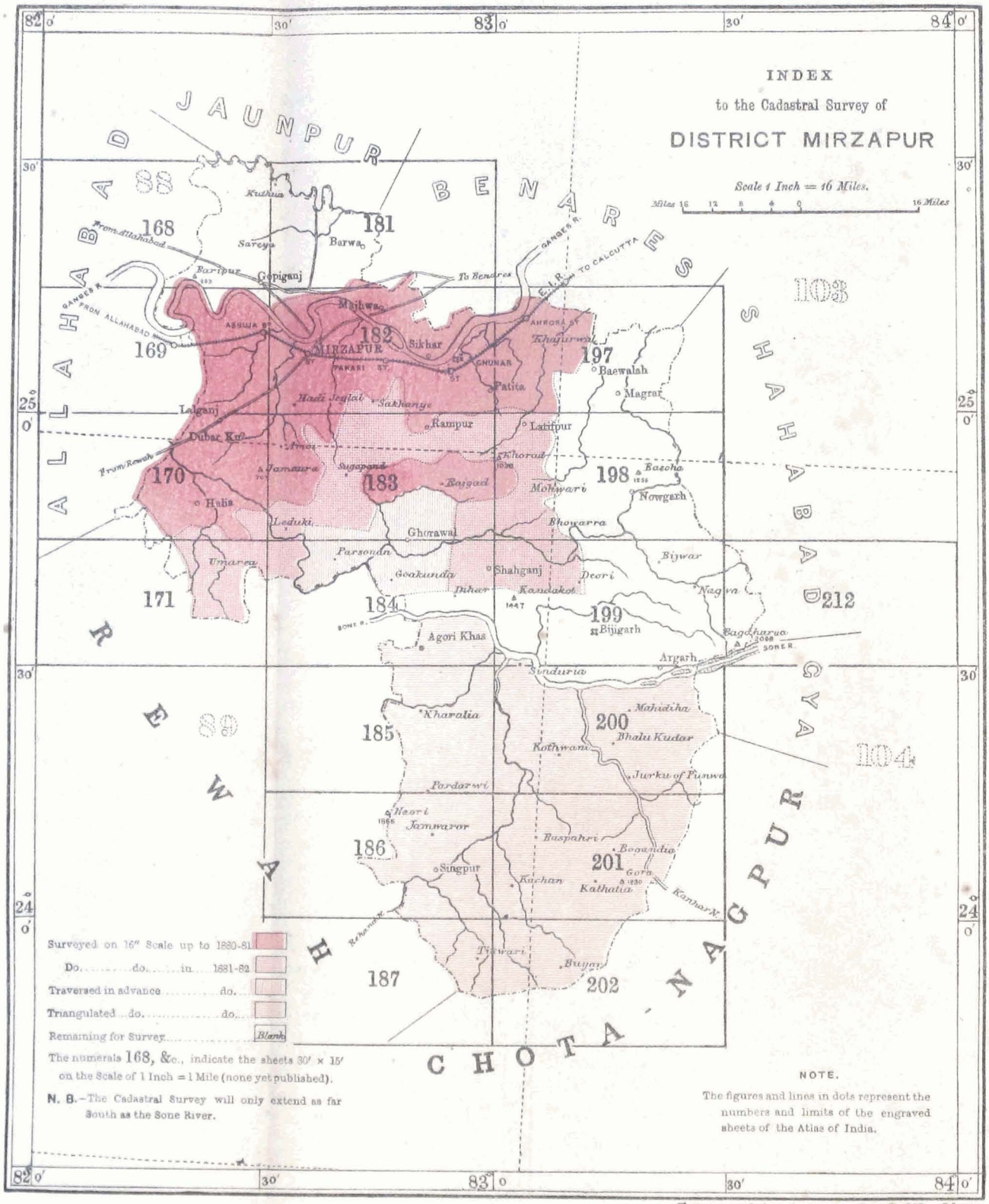
Mr. Kelly is said to have worked well and steadily, but he had not paid sufficient attention to details in his topography.

Mr. Dickinson is said to be a very good hill-surveyor and draftsman, of whom Major Hill further says he has every reason to be satisfied.

Sub-surveyors Fyzulah Khan and Nathu Lall are named as being deserving of special commendation.

No. 5 REV. PARTY.

N. W. PROVINCES SURVEY



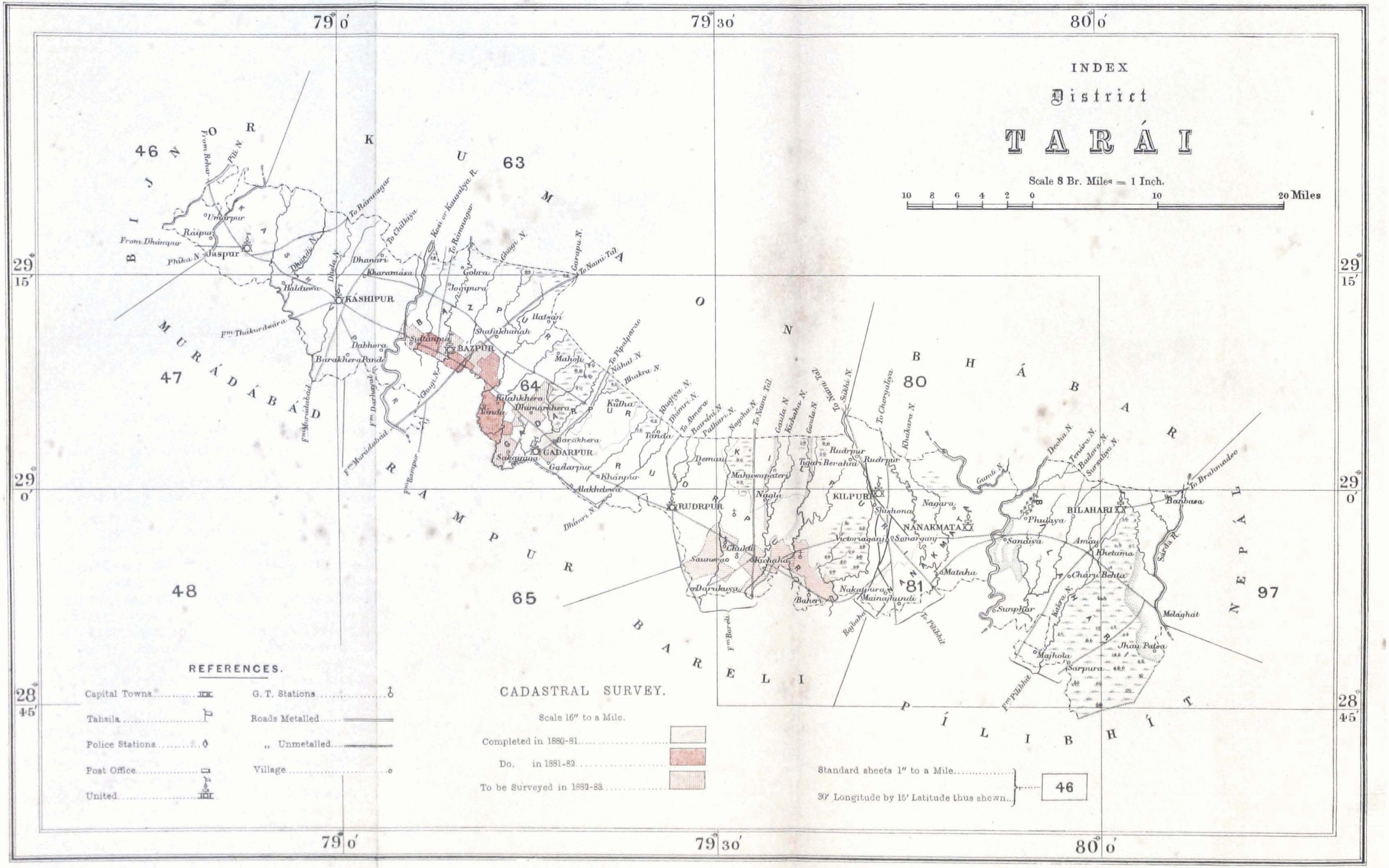
Photozincographed at the Surveyor General's Office, Calcutta

Published under the direction of Lieut-General J. T. Walker, C.B., R.E., F.R.S., *Surveyor General of India.*

Surveyor General's Office, Calcutta, January 1883.

No. 5 REV, PARTY.

N. W. PROVINCES SURVEY



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at the Surveyor General's Office, Calcutta. January 1883.

CADASTRAL OR FIELD SURVEY.

XVII.—MIRZAPUR DISTRICT, NORTH-WEST PROVINCES (No. 5 PARTY, REVENUE BRANCH).

Personnel.

Colonel F. C. Anderson, Deputy Superintendent, 1st grade, in charge.
Mr. C. W. Campbell, Surveyor, 1st grade.
" E. S. P. Atkinson " 3rd " transferred from No. 7 Topographical Survey Party from 1st October 1881, and transferred to Mysore Topographical Survey from 30th April 1882.
Mr. E. G. Little, Surveyor, 4th grade.
" R. B. Smart, Assistant " 1st " transferred to No. 8 Revenue Party from 1st November 1881.
Mr. T. F. Freeman, Assistant Surveyor, 1st grade, on sick leave from 1st May 1880.
Mr. T. Shaw, Assistant Surveyor, 1st grade.
" W. D. Corbett, " " 1st " transferred from No. 4 Revenue Party from 1st October 1881.
Mr. E. P. S. Hill, Assistant Surveyor, 2nd grade.
" O. D. Smart, " " 3rd " appointed from 1st October 1881.
20 sub-surveyors and others.

Temporary Establishment.

253 field surveyors and others.

121. This party, under charge of Colonel F. C. Anderson, returned from recess quarters at Nainital and resumed field work in the Mirzapur district on 1st November. The season's operations in this district have included portions of parganas Bhagwat and Ahraura, situated in the Gangetic valley, and portions of parganas Kantit and Barhar, forming part of the up-lands. A small detachment of the party has been employed during the season in continuing the cadastral survey of a few villages in parganas Bazpur and Gadarpur, of district Tarai. The survey in both districts has been done on the 16-inch scale, and the areas accomplished are shown in the following statement:—

District.	Number of villages.	Square miles.
Mirzapur	645	734
Tarai	19	16
Total	664	750

122. In the Mirzapur district, north of the Sone river, the preliminary boundary traversing of 329 square miles has been done in preparation for cadastral survey in 1882-83; and in the same district, south of the Sone, 1,790 square miles, comprising parganas Singrauli, Agori, and Dudhi, where a cadastral survey is not required, have been triangulated in preparation for a topographical survey.

123. Besides purely survey work, to which the operations of the Survey Department in carrying out cadastral surveys in the North-Western Provinces have hitherto been restricted, this party has been engaged during the past season in preparing, simultaneously with the maps, the village *khasras*, which in former years and in other districts have been drawn up by a separate establishment, working under the orders of a settlement officer, after the maps have been completed. This new duty of writing the khasras has been undertaken at the request of the Board of Revenue, in accordance with a scheme submitted by Colonel Anderson, who had been consulted by the Board and asked to suggest a remedy for the high aggregate cost of the entire operations going on in the permanently settled districts of survey and subsequent preparation of papers connected with the Record of Rights. Colonel Anderson considered that no appreciable reduction would be possible on the present cost of the survey, except, it might be, by an increase to the annual grant, so as to provide for a larger subordinate staff and an increased outturn; but he was confident that a large saving could be effected in the expenditure for the Record of Rights by utilising the survey staff:—

1st.—To fill in all the columns of the khasra by making the necessary inquiries during the progress of the measurements.

2nd.—To supervise the *putwaris* in the preparation by the latter of a copy of the khasra *pari passu* with the survey.

3rd.—To compile from the khasras the "*jummabundi* slips," *i.e.* the separate statements of fields held by each cultivator, leaving the rent columns to be filled in by the putwaris.

4th.—To prepare fair copies of the khasras after the work of the settlement staff as regards disputes had been completed and attestations of proprietors and cultivators obtained.

Colonel Anderson estimated that the extra duties, as sketched above, would add Rs. 10 per square mile to the cost of the survey.

124. By Colonel Anderson's scheme, the *khewats* (statements showing the shares of rent paid by the proprietary body) would be prepared by the putwaris, and the adjustment of disputes as to names entered in columns 3, 4, and 5 of the khasra would be the first duty of the settlement staff, the existence of disputes being brought to notice by the surveyors in a list attached to the khasra. The settlement staff would then obtain the attestations of the proprietors and cultivators to the rent rolls; and finally, the fair copies of the khasras would be written in the Survey Office.

The Board of Revenue approved of the scheme as an experimental measure, and requested it might be carried on provisionally, leaving the question of its adoption for other districts to be considered when the experiment would be completed by the work of the settlement staff during the following season.

In practice, one very great advantage to the survey work itself resulted from the new duty of writing the khasra, in so much that the surveyors were able to secure the regular attendance of zemindars and cultivators to point out the boundaries of the fields, and thus their labour was much reduced by being saved from having to survey interior subdivisions of fields for want of information regarding the true field boundaries. When khasras are being written, the putwaris, to whom all the field boundaries are as a rule well known, must also be present. Specimens of the *khasras* and *jammabandi* slips, specially designed by Colonel Anderson in consultation with the Collector of Mirzapur, are given at page 93 of the appendix.

125. The area surveyed included a large aggregate extent of hilly and uncultivated country which, it had been expected, might have been surveyed on the 2-inch scale; but the cultivated tracts were found to permeate through all parts of the hills, and it was deemed more advantageous to include the whole country in the large scale survey than to separate small detached tracts for a two-inch survey. Out of the entire area of 734 square miles, the waste tracts and plots of waste mixed up with the cultivation are said to cover 371 square miles. In the cultivated tracts, 346,140 fields have been surveyed, giving ·67 of an acre as the average size for each field if calculated on the cultivated area only, and 1·36 acres if calculated on the total area.

126. The field survey has been carefully tested by check lines measured by the European assistants and Native inspectors, 207 linear miles of checks having been done by the former and 1,256 by the latter officers. The chain traverses have been connected with six Great Trigonometrical Survey stations, and a comparison of the results of the corrections shows that there was an average error in the chaining of 1·9 feet per mile. Azimuth observations were taken at 11 traverse stations. In the triangulation south of the Sone, which has been based on the rays connecting four principal stations of the Great Trigonometrical Survey, 29 secondary stations have been fixed, from which the positions of 330 intersected points have been determined.

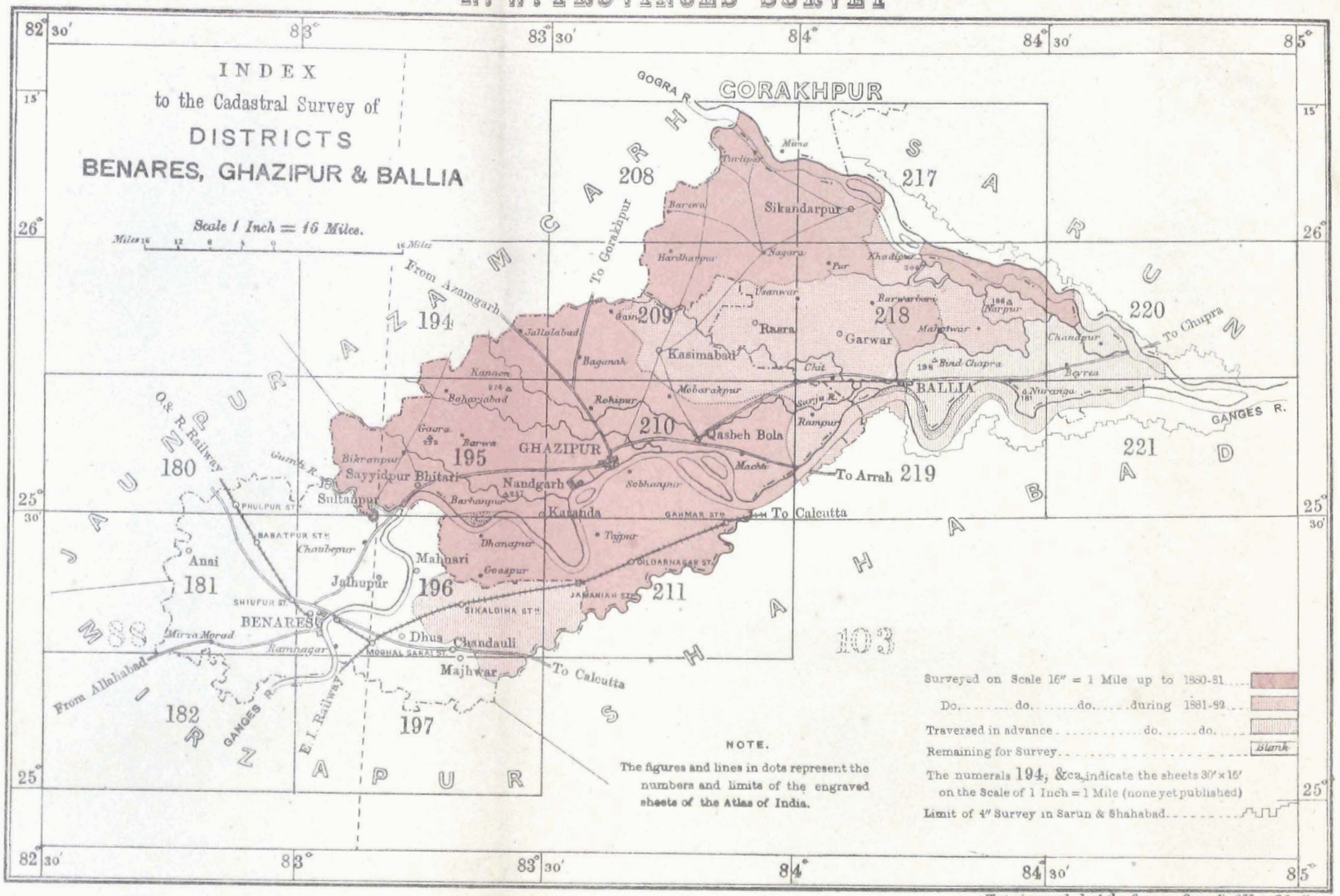
The trijunctions of village boundaries had been, as usual, permanently marked by the district staff previous to survey. In addition to these marks, the theodolite stations of the boundary traverses have been marked by the surveyors with specially cut stones, the cost of which, as they are regarded as part of the boundary demarcation, is to a certain extent borne by the land-owners. The surveyors have again been engaged in relaying many lines of boundary, according to the maps of Captain Wroughton's survey of 1839–41, where disputed lines could not otherwise be settled.

127. The cadastral survey in Mirzapur has been mapped on 955 sheets, and in Tarai on 22 sheets. Of these, all the Tarai sheets and 573 Mirzapur sheets have been lodged in the Calcutta office; more than half the remainder are kept back on account of disputed boundaries. There are also 64 sheets of previous seasons awaiting final disposal pending the adjustment of boundaries. The general maps of Mirzapur are being drawn on the 2-inch scale for publication on the 1-inch; none have yet been completed, as there are still unsurveyed portions within the margins of the standard-sized sections.

The general maps of the Banda district on the 4-inch scale, which were remaining, have been completed and lodged; and one-inch maps of this district from drawings made in Calcutta are now under publication.

No. 4 REV. PARTY.

N. W. PROVINCES SURVEY



Photozincographed at the Surveyor General's Office, Calcutta

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Surveyor General's Office, Calcutta, January 1883.

128. The Deputy Surveyor-General inspected the office of the party at Nainital during October. He considers that Colonel Anderson is deserving of great credit for the readiness with which he has set himself to acquire a knowledge of the new duties connected with writing the village khasras, and for the manner in which he has instructed his establishment in the new work required of them.*

XVIII.—DISTRICTS GHAZIPUR, BALLIA, AND BENARES, NORTH-WEST PROVINCES (No. 4 PARTY, REVENUE BRANCH).

129. The field operations of this party were resumed under control of Major Barron on 25th October 1881, and were continued up to 10th April 1882. During the season the cadastral survey of district Ghazipur has been completed, and that of district Ballia continued. The scale of cadastral survey has been 16 inches to a mile, except in the case of a few villages in Ballia, where the scale was increased to 32 inches to a mile on account of the very small size of the fields.

Personnel.

Major W. Barron, Deputy Superintendent, 3rd grade, in charge.
Mr. W. A. Wilson, Surveyor, 3rd grade.
„ H. T. Hanby „ 4th „
„ W. C. Price „ 4th „
„ S. O. Madras, Assistant Surveyor, 1st grade.
„ W. D. Corbett „ „ 1st „ transferred to No. 5 party with effect from 1st October 1881.
Mr. E. B. M. Drew, Assistant Surveyor, 3rd grade.
„ L. F. Berkeley „ „ 3rd „
30 sub-surveyors and others.

Temporary Establishment.

200 field surveyors and others.

130. The party has also been engaged on the survey, on the 4-inch scale, of a line of villages in district Shahabad of Bengal, on the banks of the Ganges, opposite to district Ghazipur. This work has been undertaken, on account of the Government of Bengal having determined to take advantage of the cadastral survey progressing along the Ganges and Gogra rivers, to have a line of river villages in districts Shahabad and Sarun surveyed simultaneously, so that the entire breadth of low-lying country, over which the above rivers are liable to flow, may be represented with full details of the boundaries of villages and estates in one series of maps for both provinces. A survey of this nature for all large rivers was sanctioned by the Government of India, Revenue and Agricultural Department, by letter No. 103, dated 3rd September 1881, to the Surveyor-General.

131. The separate areas surveyed in the different districts and on the different scales are shown in the following statement:—

District.	Description and scale of survey.	Number of villages.	Area in square miles.	Remarks.
Ghazipur	Cadastral: 16-inches to a mile.	664	224·58	Twenty-five villages in district Ballia, in area 4·15 square miles, were surveyed on the 32-inch scale.
Ballia	Ditto ...	1,177	409·98	
Total of cadastral survey ...	.....	1,841	634·56	
Shahabad	Mouzawar: 4-inches to a mile.	66	30·79	

An overlap of 12·50 square miles has been surveyed in district Azamgarh on the 2-inch scale. In the cadastral area, 9,88,157 fields have been surveyed, having an average area of ·41 of an acre. Preparatory traverse work has been extended over 162 square miles in the Ballia district, and the Benares district having been assigned to the party for cadastral survey, under authority of Government, North-Western Provinces and Oudh, conveyed in letter No. 93, dated 20th January 1882, preparatory traversing has been carried out in that district extending over 179 square miles.

132. In the cadastral survey, the system of plotting the field measurements directly on the skeleton maps of the traverses, without recording the measurements in field books, continues to work most advantageously. The work is done more rapidly than under the former system of keeping field books, and the same standard of accuracy is maintained. The usual checks and tests have been carried out, both by inspections of the work in progress and by subsequent

* Colonel Anderson reports very favourably of Messrs. Little, Shaw, Hill, and O. D. Smart.

comparisons of measured test lines. Of the latter, 567 linear miles were measured by the European staff, and 1,186 miles by Native inspectors.

133. The permanent marking of theodolite stations has been carefully attended to. At every station—there are 11,398 in the season's work—a pottery cylinder has been imbedded, at an average cost of 3 annas 7 pie per station. These marks are in addition to the stone marks which are placed at the trijunctions of village boundaries under the authority of settlement officers and at the expense of land-owners. Connections have been made with five stations of the Great Trigonometrical Survey, and the chain measurements of the traverses have been adjusted to agree with trigonometrical distances. The average error of the chaining was found to be 2·73 feet per mile. Azimuth observations were taken at 50 traverse stations, at an average distance of six miles apart.

134. The area surveyed cadastrally has been mapped on 1,323 sheets, of which, on 1st October, 977 sheets had been sent to Calcutta to be printed. There are nine standard-sized sheets of the 4-inch survey of the Ganges river villages in district Shahabad, on which a line of villages on the Ghazipur side of the river has been introduced by reduction from the cadastral maps, so as to represent the entire low-lying area in one projection. The general maps on the 2-inch scale of Ghazipur and Ballia are under preparation, nine having been finally completed and 20 partially drawn. On these sheets, the survey of parganas Bhadaon and Sikandarpur (now of Ballia, but formerly of district Azamgarh, and cadastrally surveyed in 1874–76), is being introduced, so that the map of district Ballia may be complete. A reduction of the maps of district Ghazipur to the scale of the Atlas of India has nearly been finished.

135. It is expected that the party will complete the survey of district Ballia and of the riverain villages on the Ganges and Gogra during 1882-83. District Benares will occupy season 1882-83 and part of season 1883-84, and a new district will be required to be allotted to give sufficient work to the party for the latter season.

136. The recess office of the party was inspected by the Deputy Surveyor-General at Naini Tal during October. The work of the party in all its branches was found to be highly satisfactory, reflecting great credit on Major Barron's skill and close supervision.*

XIX.—HANTHAWADDY DISTRICT, BRITISH BURMA, AND ARAKAN WASTE LAND GRANTS (No. 2 PARTY, REVENUE BRANCH).

137. This party has been under the charge of Major J. R. McCullagh, R.E., throughout the season.

Personnel.

Major J. R. McCullagh, R.E., Deputy Superintendent, 4th grade.
Mr. E. J. Jackson, Assistant Superintendent, 1st grade, returned from furlough and transferred to No. 2 party on the forenoon of 5th December 1881.
Mr. F. Grant, Surveyor, 2nd grade.
„ D. A. King, Officiating „ 4th „
„ J. McHatton, Assistant „ 1st „
„ G. E. Parker „ „ 2nd „
„ J. Murphy „ „ 2nd „
„ B. M. Wilson „ „ 2nd „
32 sub-surveyors and others.

Temporary Establishment.

135 field surveyors and others.

Leveling.

Mr. Fredric Rencontre, leveler, transferred to professional native establishment of No. 2 party from 1st November 1881.
Mr. Alexander Munro entertained as leveler from 1st November 1881.
Mr. Frank Rencontre entertained as leveler from 1st November 1881.

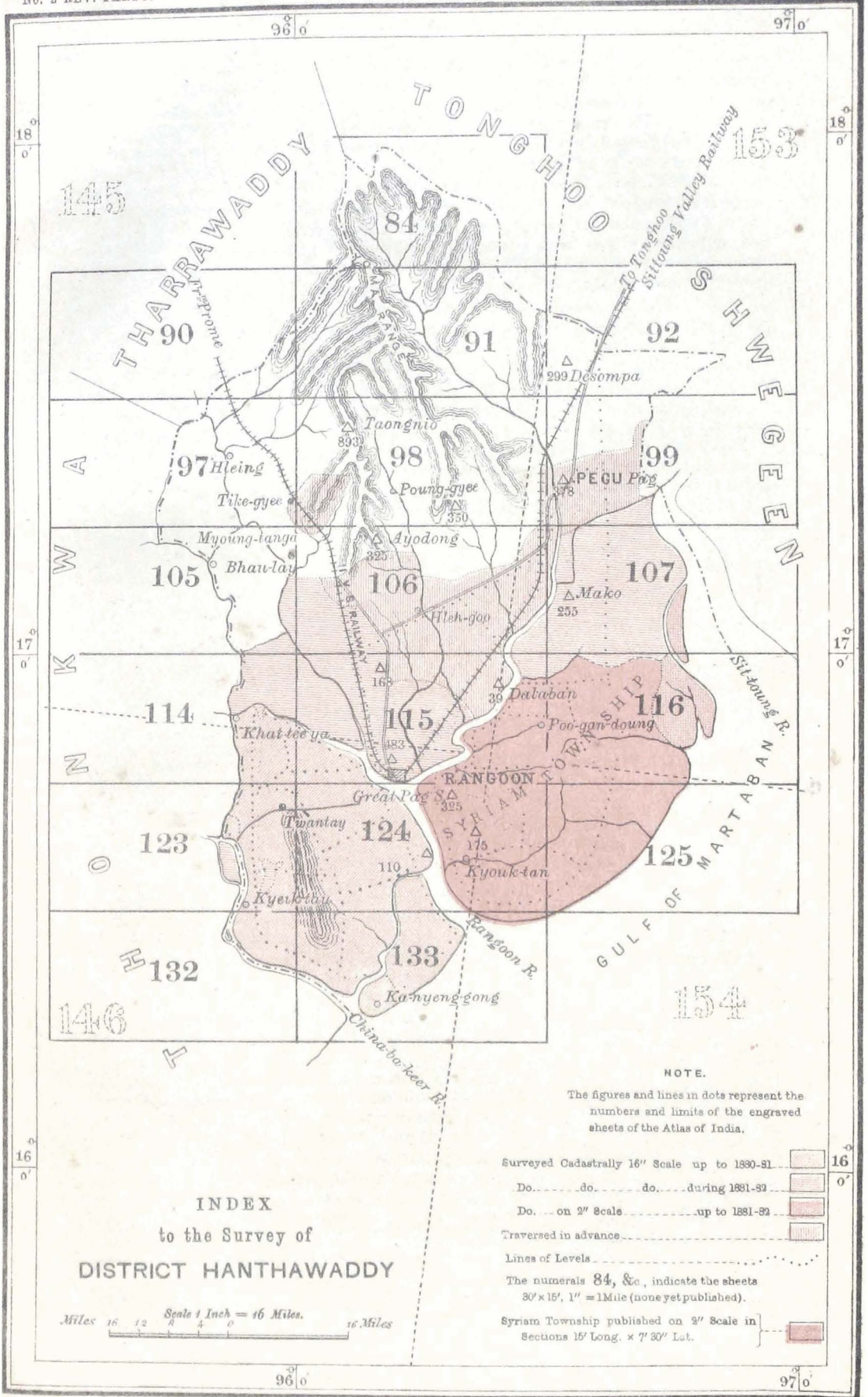
Small field parties were employed in the Rangoon town district during October and November 1881, and the cadastral field work was resumed in the Hanthawaddy district on the arrival of the field establishments from India during the early part of December. Field operations were continued up to the end of May.

138. The cadastral survey has chiefly been carried on in the Pegu and Hmawbee townships. In Angyee township the contouring of a small area of high land, remaining over from last season, has now been completed; and the field work of the cadastral survey of the Rangoon town district has been finished. Adjoining the Pegu township, a tract of country along

* Major Barron reports that Messrs. Wilson, Hanby, and Price, respectively in charge of three sections of his establishment, have conducted their duties to his entire satisfaction. He says:— "They are zealous, hardworking surveyors, and aim at turning out a high standard of work."
The assistant surveyors, Messrs. Madras, Drew, and Berkeley, are said to have performed their duties satisfactorily.
The following members of the native establishment are reported to have done well and to deserve commendation, viz. Ibu Hasan, Jamaloodeen, Mahmood Bux, Enayetoollah' Bhawani Pershad, Meer Ujjudallee, Lalmohana Gungopadhyn, Sew Narain, Kannya Lall, and Zakirally. The rest of the members of the professional and cadastral establishments have worked well and heartily.

No. 2 REV. PARTY.

BRITISH BURMA SURVEY



NOTE.

The figures and lines in dots represent the numbers and limits of the engraved sheets of the Atlas of India.

Surveyed Cadastrally 16″ Scale up to 1880-81

Do. do. do. during 1881-82

Do. on 2″ Scale up to 1881-82

Traversed in advance

Lines of Levels

The numerals 84, &c., indicate the sheets 30′ × 15′, 1″ = 1 Mile (none yet published).

Syriam Township published on 2″ Scale in Sections 15′ Long. × 7′ 30″ Lat.

INDEX

to the Survey of

DISTRICT HANTHAWADDY

Scale 1 Inch = 16 Miles.

Miles 16 12 8 4 0 16 Miles

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Surveyor General's Office, Calcutta, January 1883.

the sea-coast, devoid of cultivation and covered with *kain* grass and jungle, has been surveyed topographically on the 2-inch scale. A commencement has been made on the survey of the forest reserves in Hanthawaddy. The several areas are shown in the following statement:—

District and Township.	Area in Square Miles.		Remarks.
	16-inch scale.	2-inch scale.	
Hanthawaddy ... { Pegu, Hmawbee, and Twantay ...	739·5	91·7	
Hanthawaddy ... { Forest reserves	4·5	.....	
Rangoon Town district	19·5	.....	
Total	763·5	91·7	

In addition to the above, preparatory boundary traversing for the cadastral survey of next season has been done over an area of 458 square miles in the Pegu and Hmawbee townships, and 42 square miles of forest reserves have also been traversed in preparation for next season's survey.

139. A small sub-party of field surveyors under an assistant surveyor is now regularly organized as a section of this establishment set apart for the duty of carrying out the revisions of the maps of the previous season, so as to bring them into accord with the settlement papers, which are prepared one year subsequent to survey. During the season 719 square miles were brought under settlement, and the revisions were completed over the whole area, the work (which involves frequent references between the two departments) having been greatly facilitated by an arrangement for locating the Assistant Surveyor in the Settlement Officer's camp. On the subject of the revisions, Major McCullagh reports:—

"Revisions are due to the following causes:—

"1*st*.—Errors of survey; that is, faulty measurements or incorrect inking up.

"2*nd*.—Changes in the boundaries of fields and kwins.

"3*rd*.—Imperfect or indistinct demarcation, especially of garden lands.

"4*th*.—Extensions of cultivation.

"I have endeavoured to ascertain the percentage under each of the above heads, but unfortunately the rolls kept up have not enabled me to do so very accurately. The percentage of errata is calculated on the number of fields, and does not in any way represent area. It has been found to vary very considerably in different circles; the maximum being 30 per cent in Tawkoo, and the minimum 6 per cent in Kyouk Choung. The average for the 11 circles is 15 per cent; and of this I think it may be approximately taken that the figures 1, 5, 5, and 4 represent respectively the proportion of fields revised under the four different headings. The actual area of the cultivation opened out between the time of survey and settlement (extensions) amounts to 11,881 acres, or 18½ square miles."

140. The greater part of the area cadastrally surveyed in the Pegu township consists of an open cultivated plain requiring no particular description; but it included a strip of high-land (*kondan*) in which the cultivation and garden lands were difficult and tedious to survey, and a belt of country on the western margin, where unusually small fields, averaging about 7 to the acre, were met with. In the Hmawbee township, the greater part of the area likewise consisted of open country, chiefly under rice cultivation; but a very considerable extent of *kondan* was surveyed, where (to quote from Major McCullagh's report) the—

"ground is much broken and undulating, and for the most part covered with valuable gardens. The general appearance is that of heavy forest until examined more closely, when the trees are found to be fruit-bearing, with dense garden cultivation underneath. The boundaries of the gardens are very irregular, and have to be measured right round. Where rice cultivation extends up into the kondan, the fields are also irregular and very small."

141. The permanent demarcation of kwin boundaries has been effected by the survey establishment in the usual manner, by means of pottery cylinders imbedded at the theodolite stations. As a rule, the cylinders are not more than half a mile apart, but in many places, where the boundaries are irregular, they are much closer; pottery cylinders are also imbedded at certain selected stations in the interior of kwins.

142. The field survey has been carefully tested by check lines, amounting in the aggregate to 499 linear miles, measured by the European officers and by

the Native inspectors. All the stations of the Great Trigonometrical Survey lying within the area under survey have been connected with the traverses, and the direct trigonometrical distances have been used to correct the errors of the chain measurements. The angular work of the traverses has been checked by observations for azimuth at 36 stations. The number of fields surveyed is 5,09,763, showing a large increase on the number of former seasons, and giving a diminution of the average size of the field from 1·4 acres of last year to ·93 acre for the present season.

143. A large number of Burmans have been employed in different situations, but it has been found extremely difficult to keep up anything like a fixed establishment of Burmans, owing to the constant drain on the party for men to fill other situations.

Major McCullagh says of the Burmans:—

"A few of the field surveyors have done remarkably well, but on the whole they have not come up to my expectation, and there are many of them decidedly indifferent. My predecessor, Major Sandeman, bestowed such unqualified praise on the Burmans in their capacity as surveyors, that I may have been led to expect too much; but certainly my short experience tends to a conclusion much less favourable than his. The Burmans have some good qualities; they are quick, cheerful, and willing at learning, and, when under supervision, are fairly industrious and painstaking; but they have little idea of submission to discipline, and are wanting in habits of method and order: and let the eye of authority be taken off them, they are up to quite as many tricks, and just as much scheming, as any other race I am acquainted with. It appears to me, of course with some exceptions, that it is with them a case of time service. They have no love for the work, and take no real interest in it as a means of earning a livelihood or of gaining a name. The survey is a stepping stone to something else; and as long as they can do enough to qualify for a certificate, the aim and object of their service is satisfied. I am fully aware how much importance is attached to the policy of training Burmans in the profession of surveying, and I have endeavoured to carry out the views of Government to the utmost of my ability; but I must confess to feelings of disappointment, after all the care and attention bestowed, the large sums expended, and the many inducements held out to really deserving men, that the results are not more satisfactory."

144. The 16-inch sheets, 1,007 in number, of the area where the settlement and revision survey operated, were all sent to Calcutta to be photozincographed between 14th March and 21st July, after the revisions were entered. Photozincograph copies have been supplied to the district authorities.

145. The drawing of 860 new cadastral sheets surveyed during the season has been completed, and manuscript tracings have been given for the ensuing season's settlement operations. Of the general maps of the Hanthawaddy district, four sheets in 11 sections, comprising country surveyed cadastrally during previous seasons, have been completed and photozincographed. Several others are partially drawn, and the drawing is being continued as photozincographs of the cadastral sheets are available for reduction.

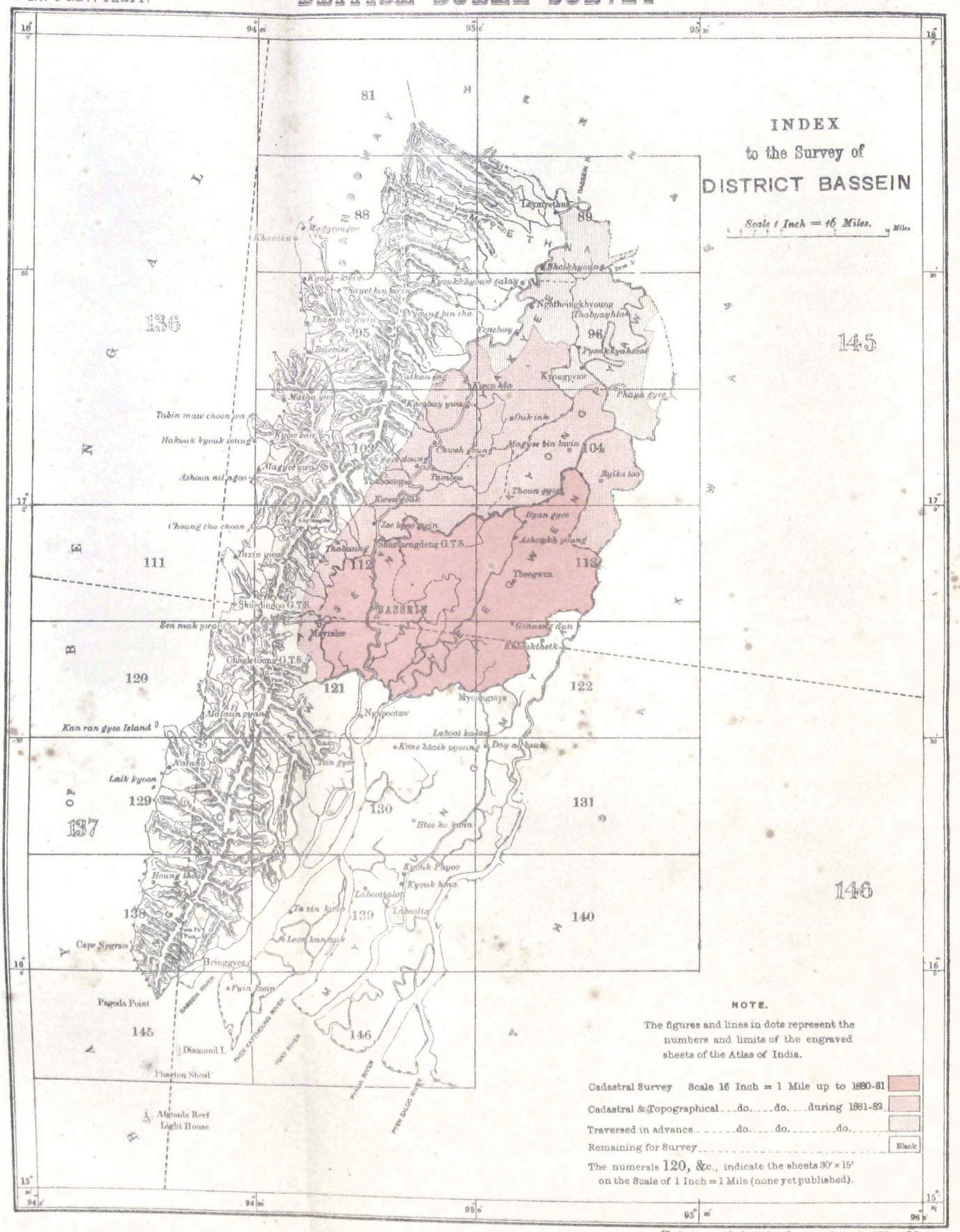
146. The detachment of this party which had been employed, during season 1880-81, in the Akyab district, surveying the boundaries of waste land grants, returned to Arakan in November 1881 for the purpose of carrying on the boundary survey of the remaining grants. Mr. H. Dowman was again sent in charge, and was furnished with an establishment partly from India and partly from Burma. The grants for survey lay in three districts, viz.—

	Grants.
Akyab	1
Kyouk-Phyoo	7
Sandoway	2
Total ...	10

On the completion of the survey of these in February 1882, Mr. Dowman was prepared to take up the adjustment of the boundaries of such of the grants surveyed during the previous season as might have been found on settlement investigation to have excessive areas; but the settlement investigations had not been carried out (an officer not having been available for the duty), and it was determined to employ the detachment during the remainder of the season, in rendering the existing demarcation more permanent than at first provided. This second demarcation was taken up too late in the year to allow of all the grants being done, and 54 only had been completed when the setting in of the

No. 8 REV. PARTY.

BRITISH BURMA SURVEY



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Surveyor General's Office, Calcutta. January 1883.

rains put a stop to the work. Before the detachment left Akyab, Mr. T. C. Mitchell, Settlement Officer, arrived there and commenced his investigations regarding the areas held by the grantees. Consequent on these investigations, the boundaries can now be made final, and the detachment under Mr. Dowman will return to Arakan next season to aid in the permanent demarcation.

147. The British Burma Government maintains a survey school at Rangoon in connection with the survey party, over which Major McCullagh has exercised a general superintendence.

Two squads of levelers are attached to the party, whose work is reported on with the other leveling operations of the department. See page 56.

148. The office of the party at Rangoon, and one of the field camps in the Hanthawaddy district, were inspected during April by the Deputy Surveyor-General, who reports very highly on the style of the work which was being executed and of Major McCullagh's excellent management of his establishment.*

XX.—BASSEIN DISTRICT, BRITISH BURMA (No. 8 PARTY, REVENUE BRANCH).

149. Major W. H. Wilkins received charge of this party at Rangoon on the 25th November 1881 from Major E. H. Steel, on the departure of the latter officer on medical leave to Europe. The office establishment of the party, which had recessed at Rangoon, proceeded to Bassein during the first week in December, on the arrival of the field establishments from India, and cadastral operations were resumed in the Bassein district on the 10th December. The party remained in the field until the 27th May 1882, and then returned to recess quarters in Rangoon.

Personnel.

Major E. H. Steel, Assistant Superintendent, 1st grade, in charge up to 24th November 1881.
Major W. H. Wilkins, Deputy Superintendent, 3rd grade, in charge from forenoon of 25th November 1881.
Mr. H. R. Littlewood, Surveyor, 3rd grade.
" J. H. O'Donel " 4th " transferred to Deputy Surveyor-General's office from 1st April 1882.
Mr. R. B. Smart, Assistant Surveyor, 1st grade, transferred from No. 5 party from 1st November 1881.
Mr. T. H. Dunne, Assistant Surveyor, 1st grade.
" E. J. Martin " " 1st " transferred from No. 6 party from 1st October 1881, transferred to No. 7 party from 1st November 1881.
Mr. W. H. Penrose, Assistant Surveyor, 2nd grade, transferred from No. 11 party from 1st November 1881.
Mr. G. Campbell, Assistant Surveyor, 2nd grade, rejoined from furlough and transferred to No. 1 party, Hissar District Survey, from afternoon of 21st September 1882.
Mr. C. W. J. Ford, Assistant Surveyor, 2nd grade.
" W. H. D. Ewing " " 3rd "
28 sub-surveyors and others.

Temporary Establishment.

170 field surveyors and others.

150. The survey has been done entirely on the 16-inch scale, and the completed area is shown in the following statement, viz.—

Township.					Area in square miles.	Remarks.
Thaboung	...	...	...	...	378·6	
Kyon-Pyan	...	...	...	...	334·4	
Yay-gyee	...	...	...	...	99·7	
			Total	...	812·7	

In addition to the above, boundary traversing has been done over an area of 350 square miles in preparation for cadastral survey next season. The number of fields in the cadastral area is 3,49,790, of an average size of ·44 acre calculated on the cultivated area, and of an average size of 1·49 acres calculated on total area.

* The following are extracts from Major McCullagh's report on his assistants :—
"Mr. Jackson, Assistant Superintendent, has a thorough knowledge of the work in all its details, and he has cheerfully and ably assisted me in every way."
"Messrs. Grant and King, in charge of cadastral camps, have shown much tact and judgment in the discharge of their onerous duties I am much indebted to both for * * * the energy and endurance they have displayed."
Mr. Dowman is spoken of as an experienced, careful, and painstaking officer, who carried out the duties entrusted to him with much ability.
"Mr. McHutton, in charge of the revision camp, had very arduous duties to perform, into the execution of which he brought sound judgment and excellent temper to bear."
"Messrs. Parker and Murphy gave great satisfaction ; they are both hard-working and painstaking assistants."

151. The tract surveyed includes a very large area of waste land mixed up with the cultivation, as has been the case with the tracts previously brought under cadastral survey in Bassein, the separate areas for the present season being 240 square miles of cultivation and 573 square miles of waste. Major Steel, who held charge of the party during the previous season, gave much attention to the question of the survey of these large waste areas, in view of the fact that the survey of waste land brings no direct profit to Government; and, with the object of reducing expense, he proposed to the Chief Commissioner that the survey of the waste land should be done on the 2-inch scale, separately from the cultivation. The scheme being approved of by the Chief Commissioner, Major Wilkins introduced the system of separate surveys on the different scales of 16 inches and 2 inches at the commencement of the field season; but he did not maintain it for long, as, on account of the cultivation permeating through all parts of the waste, he found in practice that a complete survey, done in one operation on the large scale and mapped on one series of sheets, was more expeditious than the proposed system of omitting the details of the waste from the large scale survey, to be done in a subsequent operation on another series of sheets.

152. The revision survey in the area surveyed during the previous season, to bring the maps in accord with the settlement papers, was a very laborious undertaking, and added largely to the work of the party, one assistant surveyor and about one-fifth of the entire establishment of field surveyors having been exclusively employed on the revisions throughout the field season. The work included the determination of the boundaries of 908 parcels of *pottah* lands, situated, in many instances, in the heart of the jungle, the existence of which was brought to light during settlement investigations.

153. The preliminary and temporary demarcation of *kwin* boundaries has, as usual, been done in advance of the survey by the district authorities, and the permanent demarcation by the survey party. For permanent marks, the pottery cylinders of the previous year have again been used; these have been imbedded at two out of three theodolite stations on the *kwin* boundaries, and, for use as reference marks when extensions in the cultivation have to be mapped, at many stations in the interior of the *kwin* lands. About one-fourth of the field surveyors of the establishment employed last year were Burmans. It is not advisable to employ Burmans in a large proportion, as the work of these men is slow—they do less than a third of the average monthly outturn of the Hindustanis—and consequently costly. Major Wilkins has taken great interest in the Burmans of his establishment, recognising the great importance of the professional survey leaving in the district a school of trained surveyors; but he expresses disappointment in his experience of these men after what he had been led to expect of them, and he states that the praise bestowed on the Burmans in last year's report cannot be given this year.

Major Wilkins also writes:—

"It is greatly to be regretted that a few Burmans have not been found able to become qualified to undertake an inspector's duties, for such men would be invaluable in teaching other Burmans. * * * * * * *

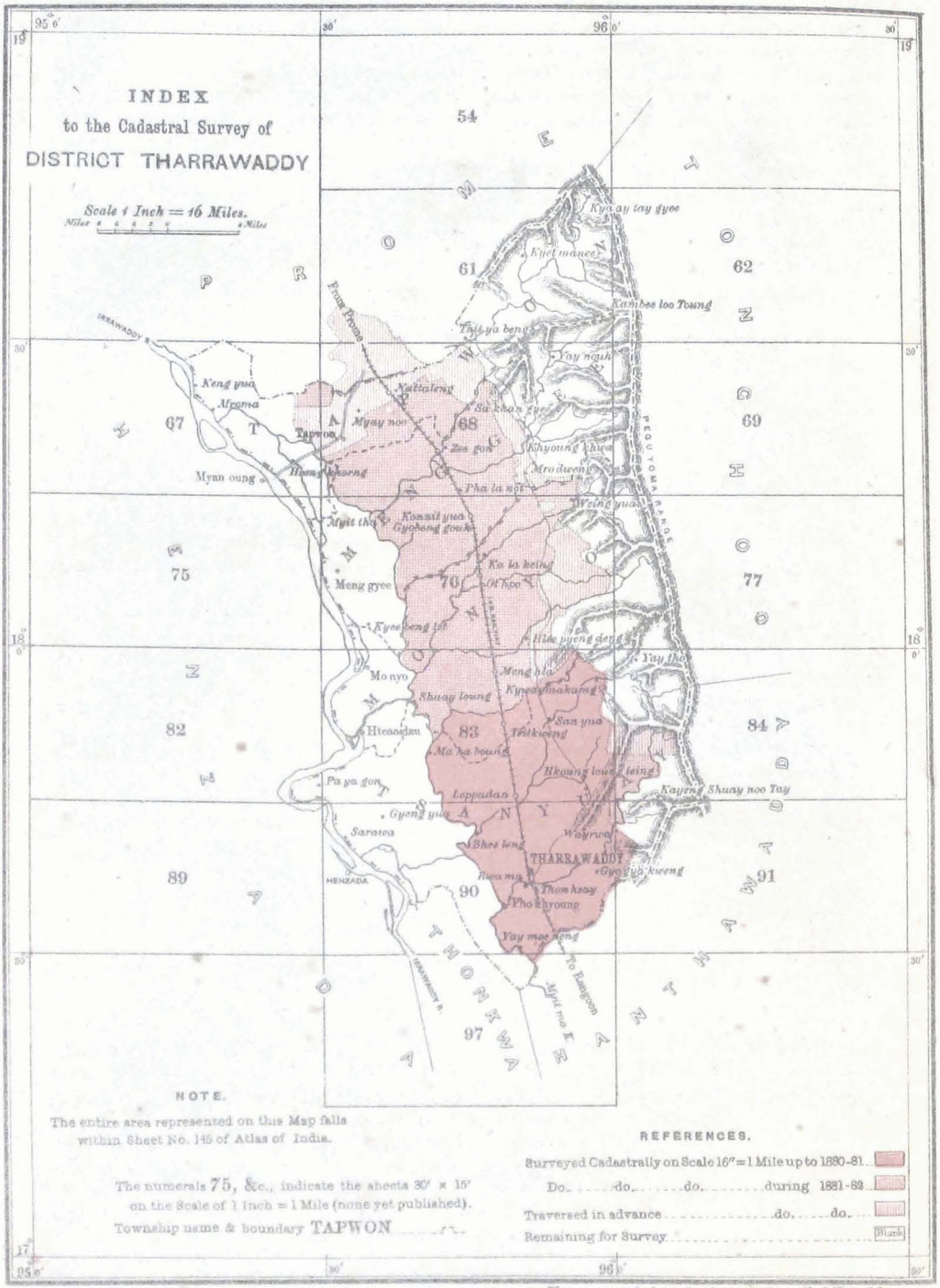
If two or three suitable Burmans can be found, endeavours will be made to train them for the post of inspector, and, by the offer of a liberal salary, to restrain them from leaving the department. At present, the hope of getting other employment is the only inducement for a Burman to become proficient in the various duties of a cadastral surveyor. To train himself for the duties of an inspector or general surveyor, so that he can impart his knowledge to his fellow countrymen and become of real assistance to the European officers of a party, is not within the scope of his ambition."

154. A survey school in connection with the party has been kept up by the Educational Department in the town of Bassein, over which Major Wilkins has exercised a general supervision.

Major Wilkins reports that he and the European officers of the party constantly visited the field surveyors while they were working in the field, to see that they were surveying on correct principles. Check surveys, aggregating 909 linear miles, were also carried out in the most rigorous manner. Observations for azimuth to check the angular work of the traverses were taken at 64 traverse stations.

No. 7 REV. PARTY.

BRITISH BURMA SURVEY



NOTE.

The entire area represented on this Map falls within Sheet No. 145 of Atlas of India.

The numerals 75, &c., indicate the sheets 30′ × 15′ on the Scale of 1 inch = 1 Mile (none yet published).

Township name & boundary TAPWON

REFERENCES.

Surveyed Cadastrally on Scale 16″=1 Mile up to 1880-81

Do. do. do. during 1881-82

Traversed in advance do. do.

Remaining for Survey

Photozincographed at the Surveyor General's Office, Calcutta.

Published under the direction of Lieut-General J.T.Walker, C.B.R.E.-F.R.S., Surveyor General of India.

Surveyor General's Office, Calcutta, January 1883

155. The 16-inch sheets, 1,031 in number, on which the season's outturn has been mapped, have been drawn, and tracings have been supplied for the use of the Settlement Officer. The sheets of the previous season's area, where the settlement operations were conducted, have been completed in accordance with settlement investigations, and all were forwarded to Calcutta to be printed in time for the supplementary survey of the succeeding season. The general maps on the 2-inch scale are in progress.

156. The Deputy Surveyor-General visited the Bassein district during April, and inspected the camp offices of the party, besides examining some of the cadastral plans in the field. He expresses himself as having been well satisfied with the control exercised by Major Wilkins over all branches of his large establishment, and with the style of work which was being executed.*

XXI.—THARAWADDY DISTRICT, BRITISH BURMA (No. 7 PARTY, REVENUE BRANCH).

157. This party, under charge of Mr. H. B. Talbot, resumed cadastral operations in the Tharawaddy district on the arrival of the field establishments from India towards the end of November. Field work was continued until nearly the end of May, when the party returned to recess quarters in Rangoon.

Personnel.

Mr. H. B. Talbot, Assistant Superintendent, 1st grade, in charge.
" W. R Vynll, Surveyor, 4th grade.
" G. W. Jurbo, Assistant Surveyor, 1st grade.
" J. R. Scott " " 1st "
" J. S. Swiney " " 1st " transferred from No. 6 party with effect from 1st April 1882.
Mr. E. J. Martin, Assistant Surveyor, 1st grade, transferred from No. 8 party from 1st November 1881, and on furlough from 1st April 1882.
Mr. A. W. Smart, Assistant Surveyor, 2nd grade.
" D. J. Collins, " " 3rd " transferred from the Darjeeling topographical party from 1st November 1881.
30 sub-surveyors and others.

Temporary Establishment.

165 field surveyors and others.

158. Besides the regular cadastral survey on the 16-inch scale, the party has surveyed, on the 2-inch scale, extensive tracts of waste land in the Irrawaddy Valley along the Myitmakha river, and has commenced the survey on the 4-inch scale, for the Forest Department, of the forest reserves of the Tharawaddy district, situated in the hilly tracts of the Pegu Yoma range.

159. The areas accomplished on the several scales are shown in the following statement:—

Township.	On 16-inch scale. Square miles.	On 2-inch scale. Square miles.	On 4-inch scale. Square miles.
Minhla	212	107	.....
Gyobingouk	229		.....
Tapoon	85	.....	.....
Thonzeh	.....	.....	42
Total ...	526	107	42

In addition to the above, preparatory boundary traversing has been done over an area of 276 square miles, partly in the Tharawaddy district and partly in the Prome district. An area of 25 square miles in the forest reserves of Tharawaddy has also been traversed in advance.

160. The survey of changes and extensions of cultivation in the area surveyed during the previous year and brought under settlement during the current year has also been carried out, involving, as reported by Mr. Talbot, very heavy work both in the field and in office. In the tract surveyed on the

* Major Wilkins has reported of all his assistants:—
"Mr. Littlewood (he says) is a first-rate assistant, who has his work always up to date, with a perfect temper and cool judgment that never desert him."
Messrs. O'Donel, Smart, Dunne, and Ford, who had charge of sections of the establishment, are highly reported on, and Mr. Penrose, as an assistant to the others, is said to have worked very satisfactorily.
The following sub surveyors and others are mentioned favourably by name:—
Sub-surveyors Sheikh Abdullah, Wazir Ali, and Koylas Chunder; draftsmen Rahim Bux, Shamsuddin and Gujadhar; and computer Manohar Lall.

16-inch scale a large amount of waste land has been found to be mixed up with the cultivation, the separate areas being 287 square miles of waste and 239 square miles of cultivation in the total area of 526 square miles. The number of fields in the cultivated area is 4,95,000, giving ·30 acre as the actual average size of each field calculated on the cultivated area, and ·68 acre as the average size if calculated on the total area.

161. The permanent demarcation of *kwin* boundaries has been carried out by the survey party, the marks adopted being pottery cylinders imbedded at theodolite stations, the same as in the previous year. For the purposes of the supplementary survey, which will be carried on year by year to map the extensions of cultivation, marks have also been placed at stations in the interior of the *kwins* as well as on the boundaries. In the forest reserves, the theodolite stations have been marked by posts and mounds of earth, zinc numbers in Burmese characters being nailed to the posts.

162. The survey of the forest reserves has been undertaken in accordance with the wish of the Chief Commissioner, expressed in his Secretary's letter No. 406—9, dated 13th October 1881, to the Surveyor-General. The nature of the country presented many difficulties to the surveyors, the difficulties being increased by the position of the reserves, which are situated in an almost uninhabited country, far removed from the cultivated part of the Tharawaddy district. Supplies had to be sent from a distance; and in the reserves, special arrangements had to be made for carrying water for the use of the survey squads. Sickness also was very prevalent; generally 20 per cent. of the men were unfit for work, and very often 30 per cent. The reserved tract consists of an intricate mass of hills, with many minute features, and closely jungle clad, where a ray had to be cleared for every line that was measured. A few descriptive notes furnished by Mr. G. W. Jarbo, Assistant Surveyor, who was directly employed on the survey of the tract, are printed at page 31 of the appendix.

163. Mr. Talbot reports as follows on the Burmans of his field establishment:—

"The work of the Burman field surveyors was generally found correct, and they certainly hold their own against the Hindustani surveyors as far as accuracy is concerned; but they are lamentably slow, and require far greater supervision. The 35 Burman field surveyors employed during the whole of the field season gave less than half the daily average of work performed by Hindustani surveyors, viz.—

	Acres per day.
Burmans	12
Hindustanis	28

which was a loss of 480 acres per man per month, or 144 square miles in the season's outturn."

At the request of the Chief Commissioner, six Burman apprentices were attached to the topographers employed on the survey of the forest reserves for instruction in topographical surveying. These men could only be induced to join by the offer of high subsistence allowances; and the experiment of training them has not been very satisfactory, as, it is said, the men will not take employment as forest surveyors, which was the object of their being instructed. The work of the field surveyors was carefully tested by the measurement of 1,010 linear miles of check lines carried out by the European officers and by Native inspectors. The European officers also frequently inspected the field survey work during its progress. The traverses have been connected with seven stations of the Great Trigonometrical Survey, and the trigonometrical distances have been used to correct the errors in the chain measurements. Observations for azimuth have been taken at 61 traverse stations.

164. The present season's out-turn of 16-inch survey has been mapped on 660 sheets, of which tracings have been furnished for the use of the settlement officer in his operations of next season. The sheets of the previous season have been finally completed after entering the revisions and extensions, and they were sent to Calcutta to be printed in time for the settlement operations of the following season.

165. The office of the party in camp in the Tharawaddy district was inspected during April by the Deputy Surveyor-General, who expresses himself as having been well satisfied with the careful supervision exercised by Mr. Talbot over his large establishment.*

XXII.—SYLHET TEST SURVEY.

166. This survey has been carried out under the instructions of the Government of India, Home, Revenue, and Agricultural Department, conveyed in the Officiating Secretary's letter No. 445, dated 18th December 1880, to the Surveyor-General, for the purpose of testing the *mahalwar* maps of the Sylhet district, which were prepared by a local survey establishment during years 1862 to 1864.

167. The detachment of surveyors and others required for the limited area to be surveyed was furnished by No. 6 party of the Revenue Branch, and Mr. P. A. G. Cowley, Surveyor, 2nd grade, of the same party, was placed in immediate charge of the detachment. The field establishment assembled at Barrackpore on the 1st November 1881, and the detachment was finally broken up at the same station on the 25th June 1882, after completion of the mapping and area calculations. The actual field work in Sylhet was carried on between 23rd December 1881 and 23rd April 1882.

Personnel.

Mr. P. A. G. Cowley, Surveyor, 2nd grade, in charge from 1st November 1881 to 25th June 1882.

4 sub-surveyors and others.

Temporary Establishment.

17 field surveyors and others.

168. Before commencing the operations, it was necessary to decide on the amount of survey work which should be done in connection with the testing. A mere testing of what is shown on the mahalwar maps would have been effected by resurveying only the boundaries of mahals, besides which no other divisions subordinate to villages were dealt with by the mahalwar survey; but a mahalwar survey, where the mahals are large, is a work of a very partial character, and wanting in information regarding many minor tenures. Therefore it was deemed to be advisable that the present operations should not be restricted to the mere skeletons of mahals (more specially as the surveyors who were being sent to Sylhet were well competent to carry out a much more comprehensive work, having been previously employed on cadastral surveys in the North-Western Provinces); and in consultation with the Chief Commissioner of Assam it was decided that the testing operations should take the form of a complete cadastral survey of fields, with which the boundaries of mahals would also be defined in a distinguishing manner. It was also decided that the operations should be confined to three blocks of villages in different parts of the Sylhet district. The particulars of the blocks (which were selected by the Deputy Commissioner of the district) are given in the following statement:—

Sub-division.	Number of villages.	Area in square miles.	Remarks.
Karimganj	14	9·06	
Habiganj	20	8·30	
Sadr	16	8·40	
Total ...	50	25·76	

At the request of the Chief Commissioner, the surveyors were required to prepare, simultaneously with the survey, village registers (khasras), particularising (1) name of mahal, (2) owner of mahal, (3) name of cultivator of field, (4) nature of crop.

* Mr. Talbot reports very favourably of his assistants, Messrs. Vyall, Jarbo, Scott, and Smart. He also says:—

"The care and trouble bestowed by Mr. Scott in teaching the Burmans deserve much praise.

"Mr. Jarbo also deserves great praise for the steady way he conducted the forest reserve survey in the Pegu Yoma; though sick himself, he still worked on and set a good example to his men."

Messrs. Swiney and Martin are also said to have done well. The following members of the native establishment are said to deserve mention as having worked well, viz.—Venketsawmy, Nundlall Chatterjee, Soomair Singh, Shoshi Bhushan Ghosal, Issan Chunder Ghosal, and Mr. La Rive.

169. Before stating the results of the testing operations, a few remarks are desirable on the character of the maps which had to be tested. The mahalwar survey of Sylhet was done entirely by magnetic bearings, on a system adopted for all the districts of Lower Bengal after the old system of sketching without instruments had been abandoned. The first part of the operation was the survey of the village boundary—the *thakbust*—done by taking bearings at each successive bend of the boundary to the forward bend, and measuring the distances between the bends. The map was then projected by laying off the magnetic bearings at each successive distance. On completing the projection, it would generally happen, when the village was large, that the polygon would not close, and an adjustment had to be made by distributing the error all round the boundary. The mahals were then surveyed, working inwards from all sides of the boundary, by taking the bearings and measuring the lengths of the sides and diagonals, and adding the plot of each mahal to the one adjoining it. A frequent occurrence during the plotting of the mahals was that the plots from the different sides of the village would overlap, and an adjustment had to be made by contracting the areas of some of the mahals, or it might happen that the plots of mahals actually touching one another would not meet. These would generally be left as plotted, thus unduly expanding the size of other mahals. The general character of mahalwar maps prepared in the manner described is that the plots of the mahals situated on the boundaries of villages, and those to a certain distance towards the centre, are usually correct; but when the plotting from the different sides has met, the dimensions and shapes of mahals are usually inaccurate, and the relative positions are, as a rule, much vitiated.

170. The cadastral maps of the villages selected for resurvey have been plotted on the same scale as the mahalwar maps—16 inches to a mile. This has enabled the testing of the mahalwar maps to be done by direct comparison, tracings of these maps on vellum cloth being superimposed over the maps of the present survey, and the differences or coincidences noted. It is evident from the comparisons which have thus been made that a large amount of careful and laborious work was done during the mahalwar survey; and great numbers of mahals, very many of small size, are found to have been accurately measured, as is shown by the excellent agreement of numerous mahals in all the villages tested. But the agreement is for the most part only true when the superimposed tracings are shifted, so as to make single plots coincide; and there is found, mixed up with a great deal of good work, a very large amount of mapping which is most inaccurate,—so much that the survey cannot be considered to be otherwise than quite unreliable, and the errors being of such a character that there would be very great danger of the maps being most misleading if they were to be accepted as the final authoritative records of the positions or areas of properties. The differences between the present and former maps, which have hitherto been referred to, are those arising from faulty survey; but besides these, there are numerous differences, due to the changes in the boundaries of mahals, and occurring both by the amalgamation as well as by the subdivision of the mahals as these are shown on the former maps.

171. The areas of fields—and by summation the areas of mahals—have been calculated from the present cadastral maps, and comparisons have been made with the areas of the old mahalwar registers, with results similar in character to those obtained on comparing the two sets of maps. Where the mahalwar survey is accurate, the areas have been rightly calculated, and the agreement is excellent in a large number of cases; but there are also numerous and great discrepancies. Very many of the discrepancies in the areas are, however, due to the changes in the boundaries. One point which deserves to be prominently brought forward, as having been fully established by the present testing operations, is the unsuitability of the system of survey on which the mahalwar maps were constructed to deal with large village areas enclosing numerous subordinate plots. To secure a map on which all properties will be represented in their true positions and with correct dimensions, an accurate frame-work obtained by theodolite traversing must be provided.

172. There are 61 sheets of the cadastral survey of the tested villages; of these, 16 sheets have been photozincographed and copies furnished to the local Government of Assam, by whom the final report on the results of the

testing will be submitted to the Government of India. Comparative statements of mahal areas, according to present and former surveys, have also been furnished to the local Government.*

XXIII.—SURVEYS IN THE DARJEELING DISTRICT.

173. The existing map of the hill tracts of the Darjeeling district, lying west of the Teesta river, is mainly based on a survey which was executed during 1865-67 by a Revenue survey party under Mr. Johnson. This party had been previously employed solely in the plains, and it had no experience of hill topography. But at that time a survey of the boundaries of Government lands and of private estates, tea plantations and 'locations,' was urgently demanded by the local authorities for purposes of administration, and with a view to the future allotment of grants of waste lands. The party had had much experience of boundary survey work in the plains, and were well skilled in its performance, whereas, on the other hand, the topographical survey parties, which were well skilled in hill sketching, were not organised to undertake a large amount of boundary survey work in addition to topography. Thus the choice of the party devolved on the one which was best adapted to satisfy the immediate requirements of the local authorities.

Personnel.

Captain H. J. Harman, Assistant Superintendent, 1st grade, in charge.
E. C. Ryall, Esq., Offg. Assistant Superintendent, 1st grade.
Mr. J. A. May, Surveyor, 3rd grade (for portion of field season).
Mr. W. J. O'Sullivan, Surveyor, 4th grade.
" W. Robert, Assistant " 1st "
" W. C G. Barckley " " 2nd "
(for recess only).
Sub-Surveyor Sahai Din.
" Bhowani.
" Mahomed Khan.

174. As the boundary survey progressed, the principal roads and water-courses were traversed, and some attempt was made to sketch in the hill features broadly; but exact topography was unattainable with the existing agency, and was not attempted. The maps thus prepared were considered sufficient until latterly, when the operations of Captain Harman's party in surveying new boundary lines and relaying old ones, of which the original marks had disappeared, brought to light the necessity for the revision of the hill topography throughout, and for the rectification of some of the traverses, which having been carried over mountain slopes and precipices, and very difficult ground generally, and being unchecked by triangulation, were found to be erroneous.

175. These circumstances were brought prominently to the notice of the Bengal Government at Darjeeling by Major Hutchinson while residing there, when acting for Captain Harman during the recess of 1881. Consequently a requisition was made for the survey of the whole of the Hill Tracts west of the Teesta river to be revised as speedily as possible. Already a large amount of triangulation had been executed in connection with the recent operations under Captain Harman; this was extended to cover the whole of the area for revision; the old traverses were connected with, and adjusted on the trigonometrical points, and much of the detail of roads and water-courses of the first survey was found to fit in well with the new work. The hill sketching, however, had to be entirely revised. The 2-inch scale, which had been adopted for the first survey, was retained for the second. The total area for revision was about 450 miles.

176. During the field season all the requisite additional triangulation was completed by Mr. O'Sullivan; a considerable length of road was traversed with chain and compass by native surveyors, plotted on a large scale, and then reduced by pantagraph on to the plane-tables of the revisionary survey. The hill sketching was then proceeded with, and 155* square miles were completed. What remains for revision and hill topography should be completed in the next field season.

* By Captain Harman 24 sq. miles.
" Mr. Ryall ... 94 "
" Mr. May ... 37 "

177. At the commencement of the field season Captain Harman bravely endeavoured to reach the neighbourhood of the Kanchinjinga mountain, to complete a portion of the survey of Sikkim, notwithstanding that he had not by

* Mr. Cowley, from beginning to end of the operations, has carried on the work entrusted to him most satisfactorily.

any means recovered from the disastrous effects of his previous excursions to the snowy regions on the borders of Tibet But his health again failed him, and after a few weeks' struggle onwards he had to abandon the attempt and return from Sikkim, occupying himself for the remainder of the field season in the lower hill tracts around Darjeeling.

178. The prosecution of the survey of Sikkim with the adjoining portions of Nepal and Tibet has thus devolved almost wholly on Mr. Robert, who completed 180 square miles of East Sikkim, and in addition was able to survey and sketch with varying degrees of accuracy, on the $\frac{1}{2}$-inch scale, upwards of 720 square miles of Nepal and 690 of Tibet.

179. During the recess the party was very fully occupied in completing the fair maps of the previous field season's work Of those sent into the Surveyor-General's office, the principal are—(1) Hill territory, British Sikkim in 4 sheets, scale 2 inches equal to 1 mile; (2) Terai Pergunnahs in 4 sheets, scale 2 inches equal to 1 mile; (3) Jotes in the Terai Pergunnahs in 9 sheets, scale 4 inches equal to 1 mile. Captain Harman has also sent in a most carefully executed panoramic profile of the great ranges of Sikkim, the point of sight being the observatory hill at Darjeeling. It is drawn to scale for horizontal and vertical distances: thus the bearings and elevations of the different peaks are shown. A table of distances of the principal points is also entered on the sheet. This panorama has been reproduced by photozincography for publication at the Surveyor-General's office, and it is in much demand by visitors to Darjeeling. Captain Harman has discovered that the mountain which is always pointed out from the neighbourhood of Darjeeling as Mount Everest is not that mountain, the true Mount Everest being that immediately to the left (or south) of the peak which generally passes for it.

180. Though repeatedly warned by his medical advisers to cease from working and take leave of absence for the benefit of his health, Captain Harman retained the charge of his party until the close of the recess, and then handed it over to Lieutenant-Colonel Tanner on the return of that officer from furlough. In the coming field season Colonel Tanner will supervise the completion of the revisionary operations in the Darjeeling Hill Tracts. But he will be principally employed in survey operations on the Nepal boundary for the purpose of carrying out a proposal made by the Resident in Nepal, and approved by the Government of Bengal, that the portion of the boundary between British and Nepal territory from Bikna Thori in Champarun to the point on the Kusi river in Bhagulpore where the survey of 1875 under Captain Samuels ended, should be resurveyed, and the boundary pillars and posts renumbered. While thus employed, Colonel Tanner will endeavour to fix, by triangulation, all the most prominent hill peaks in Nepal between the British frontier and the great snowy ranges. The chief peaks of the latter were long ago fixed by triangulation, but as yet this has not been done for the points on the lower ranges, and it is very necessary with a view to furnishing a satisfactory basis for constructing a better map of Nepal.

XXIV.—THE BURMA-MANIPUR BOUNDARY.

Personnel.

Major W. F. Badgley, S.C., Deputy Superintendent, 3rd grade, in charge.
Mr. M. J. Ogle, Surveyor, 4th grade.

181. As mentioned in the report for last season, Major W. F. Badgley was deputed to the survey of part of the Burma-Manipur boundary, the demarcation of which was being undertaken by the Political Agent and Boundary Commissioner, Colonel Johnstone.

182. Accompanied by Mr. Ogle, Major Badgley left Shillong on the 4th November, and after a tedious march through the hills and a delay of a week at Cachar owing to the difficulty of procuring coolies, reached Manipur on the 27th November. From this point Major Badgley carried forward a survey eastwards in the direction of Kungal thana, where Colonel Johnstone had established his camp, the triangulation and topography being carried on *pari passu*, as is necessary in such work.

183. After an unsuccessful attempt to open negotiations with the Burmese, Colonel Johnstone determined to send his Assistant Commissioner to Samjok

To accompany Surveyor General's Report for 1881-82.

INDEX CHART

TO

SURVEYS OF NORTHERN AFGHANISTAN

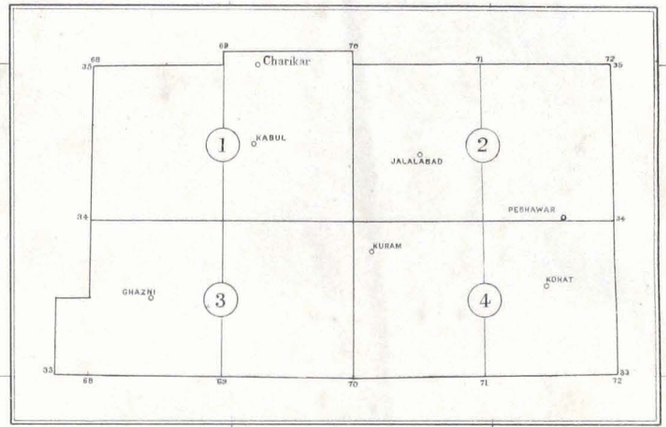
Published on One inch and Half inch scales.

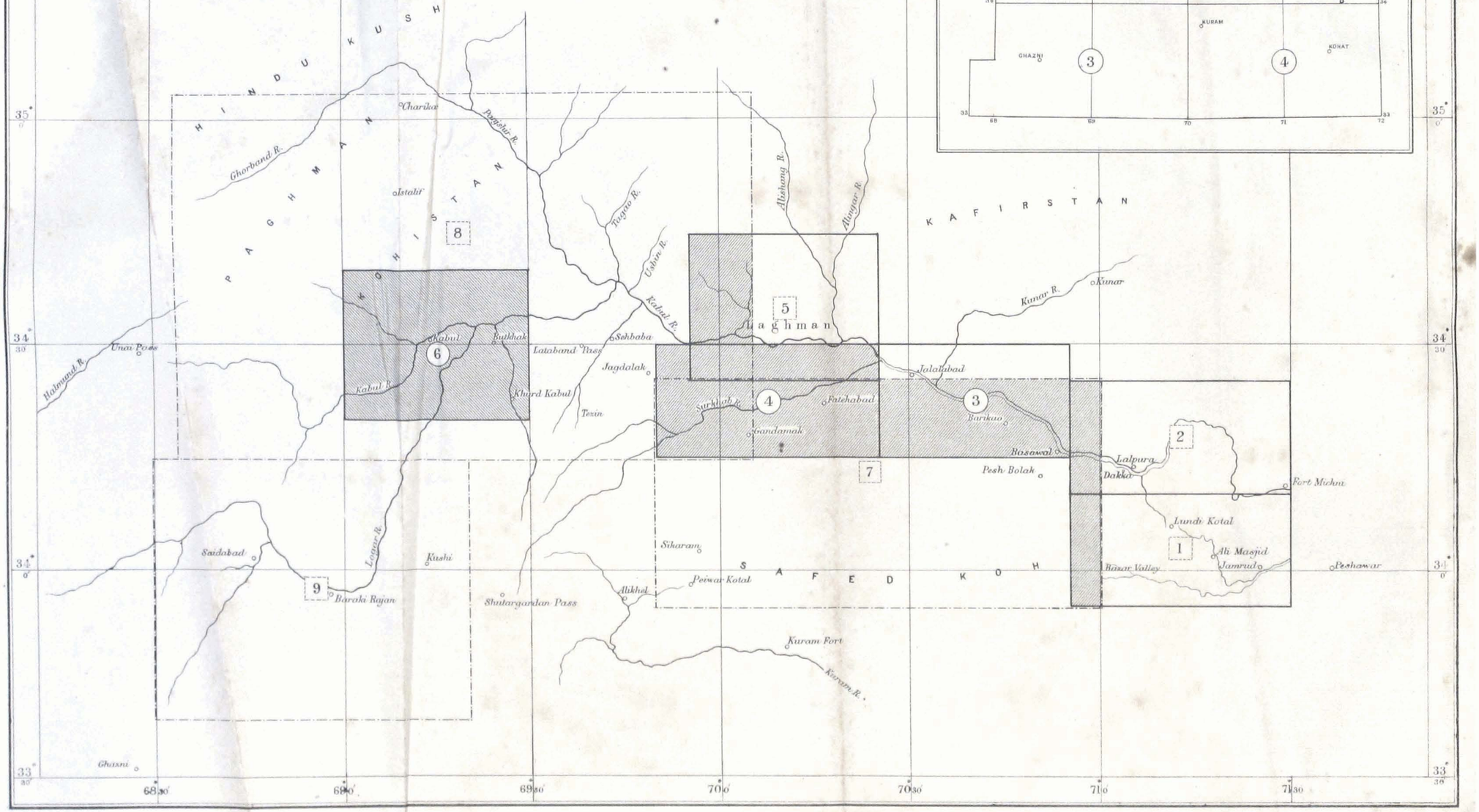
Limits of Sheets 1 inch = 1 mile..... 1

,, ,, ½ inch = 1 mile..... 7

Overlap on both scales.....

INDEX TO THE GENERAL MAP ON THE QUARTER INCH SCALE.





Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, January 1883.

to see the Rajah. Major Badgley accompanied Mr. Phayre on the expedition to this little-known spot—the easternmost point yet reached in the course of the survey operations—which is situated on the Kyendwen river, within the borders of Western Burma. His interesting description of the trip will be found in the appendix to this report. The boundary demarcation being completed by the 5th January, Major Badgley took advantage of his return journey to complete as much as possible of the survey of the Manipur territory. The ground sketched is a tract some 30 miles wide, extending roughly along the meridian of 94°30′E., and lying between the parallels of 24° and 25°30′.

XXV.—NORTHERN AFGHANISTAN.

184. No actual survey work was executed in this region during the current year, but considerable progress has been made with the final mapping of the surveys which were executed during the late war, and which have been described in the Annual Reports for 1878-81. Urgent calls for maps have been met hitherto by preliminary compilations. It still remained, however, to put all the geographical information which had been obtained beyond the British frontier into a form for final record, applying such corrections and adjustments as were required to harmonize the whole, and to bring it into accord with the many points now well fixed by triangulation, and, finally, to redraw all the maps, for as yet the fair copies had not in any instance been made. This work has been entrusted to Major Holdich and his party, who are thoroughly familiar with the country; and it has formed their chief occupation during the recess of the current year

185. The maps will be published in two series—firstly, a set of maps published on the same scale as that on which the surveys were originally executed. This will comprise a map of the country immediately round Kabul, on the scale of 4 inches to a mile, and maps on the 1-inch and $\frac{1}{2}$-inch scales of such parts of Northern Afghanistan as were actually surveyed. Proofs of these maps will be taken as they are being passed through the press to be supplied to the Quarter-Master-General's Department for such additions as will tend to enhance their military value, when they are finally published. The second series will form a general map of North Afghanistan in four sheets on the scale of $\frac{1}{4}$-inch=1 mile. The publication of these is at present suspended to permit of Major Holdich and his party resuming field operations in the Kohat district. Happily, there is no urgent necessity for immediate publication, and the delay will probably admit of additional geographical information, derived from reconnaissances which are shortly coming to hand, being incorporated into the series of maps.

XXVI.—SURVEYS IN DARDISTAN AND ON THE KISHANGANGA.

186. Colonel Tanner having proceeded to Europe on leave of absence, Native Surveyor Ahmad Ali Khan, who had for some time previously been employed under him in the survey operations around Gilgit, described in previous reports, was placed under the immediate orders of Mr. Hennessey, and deputed, with a small party of attendants, to operate in continuation of what he had done under Colonel Tanner.

187. The summer—the season of field work in these regions, though of recess in India generally—was somewhat far advanced by the time the surveyor reached his ground, and shortly afterwards he became seriously ill and had to return to Sirinagar, in Kashmir, for medical treatment. Thus the duration of his field season was much curtailed. The work assigned to him was to visit the Kishanganga-Indus watershed, and from thence to sketch as much as practicable of the Dardistan country surrounding Chilás, which juts into Kashmir territory. No survey of this tract, which in shape somewhat resembles a horse-shoe, has yet been made, because the chief of Chilás views all foreigners with suspicion, and would be specially opposed to the admission of surveyors. But a sketch of its principal features, and of the passes leading into it, may probably be made from the summits of the mountains on the periphery of the horse-shoe, which is the border line separating this region

from the territories of Kashmir, and is thus accessible to Europeans. From various points on this line views may be obtained down into the valley of the river Indus, which lies at a considerable depth below, and passes through the middle of the horse-shoe.

188. Unfortunately, the winter had already set in when Ahmad Ali reached the Kishanganga-Indus watershed, so that the features of the view before him could not be separated, covered as they were all alike with the white snow. But he succeeded in sketching an area of about 200 square miles of new ground towards Chilás, and in fixing all the passes along the watershed; and he was, moreover, able to obtain a considerable amount of supplemental topography in an area of about 600 square miles in the basin of the Kishanganga river, the first survey of which—made in the year 1858, during the mutinies—was necessarily very sketchy and imperfect, and greatly needed revision and amplification.

XXVII.—TRANS-HIMALAYAN EXPLORATIONS.

1.—EXPLORATIONS IN AND AROUND BADAKSHÁN.

189. In the year 1877, M— S—, a Native gentleman of the Mahomedan faith, a Pír, or holy man, of much repute among his co-religionists—was about to make a journey from Kashmir, across the Hindu Kush range and the river Oxus, to Koláb, beyond Badakshan, to visit the shrines of his ancestors and transact some business of his own, when he learned from one of his friends, an employé of this department, that he might obtain employment in geographical exploration if he would volunteer his services and was willing to go through a course of training. His services were readily accepted, as he was a man of considerable intelligence and good education. He was brought down to the office in Dehra Dún, where he was put through a course of training under the veteran explorer Pandit Nain Sing. He then proceeded to his destination *viâ* Kashmir, Gilgit, and Yasín, where he arrived on the 14th December 1878.

190. At Yasín he was hospitably received by Mír Pahlwan, the chief of the country and brother of Mír Wali, Mr. Hayward's murderer; but he was detained by his host on one excuse and another for nine months. At last on the 3rd September 1879 he was permitted to continue his journey. Proceeding up the Darkoth Valley, in which Hayward was murdered, he crossed the Shunder Pass and entered the head of the Mustauj Valley; then, crossing the Baroghil Pass, he entered the valley of Wakhán and struck the river Panjah, or Oxus, at Sarhad. From this place he followed the well-known route to Faizábád *viâ* Kila Panjah, Ishkásham, and Zebák.

191. It was his intention to have proceeded from Ishkásham down the valley of the Panjah river to Shignán and Darwáz, but there was enmity between the rulers of these two states, and entrance into Darwáz from Shignán was prohibited. He could not therefore reach Koláb by that route, but was obliged to proceed *viâ* Faizábád. Here he was detained for two months, while the road to Rusták was closed by the then ruler of Faizábád, Sháhzáda Hasan Khán, who was at war with the ruler of Rusták.

192. When peace was temporarily re-established, M— S— started again; but the road to Rusták being still considered unsafe, he made a diversion to the south, to the Daraím Valley, which he ascended until he reached the watershed separating it from the valley of Jirm. Towards the end of February he was able to continue his journey to Rusták and Koláb. From Atan Jalab he followed the route previously taken by the Havildar. At Koláb he left the Havildar's route and proceeded up the Doába Valley as far as Robát, beyond Javí Dara and Sághir Dasht, where he found the Kún-i-Gau Pass into Darwáz impracticable. He therefore retraced his steps to Deh Lálá, near Mominábád, where he waited awhile, until he heard that the Walwalak Pass into Darwáz was open. He then crossed into the Dara Imám Valley, and having traversed that to its head he returned on his steps, and then crossed the Walwalak Pass into the valley of the Panjah. He now followed the course of the river Panjah upwards, over ground previously unexplored, to Kila Khum, where he struck the route of the Havildar. This route he followed to the junction of Wanj

MAP of the Routes followed by

Explorer D. C. S. *from* Darjeeling *to* Shigatze *during* 1879.
,, G. S. S. *in* Nepal *during* 1880 & 1881;
,, G. M. N. *from* Shigatze *to* Khamba Jong *during* 1880;
also some routes of former Explorers
also some of the results of the Surveys by the Darjeeling Survey Party *during* 1879-82
Compiled by Captain H. J. HARMAN. R. E. *June* 1882

Scale 16 Miles = 1 Inch

References

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- a Peak *fixed by the* G. T. Survey
- *the Traverse of* G. S. S.
- ,, ,, ,, D. C. S.
- ,, ,, ,, G. M. N.
- ,, ,, ,, Explorer L. *during* 1875-76
- ,, ,, ,, *other Explorers*
- *Boundary of* British Territory
- ,, *between* Trans Frontier States
- ,, ,, Darjeeling & Jalpaiguri Districts
- Railway
- Roads
- *approximate position of* Tracks
- ,, ,, ,, Rivers

G. is a Monastery or Gompa (Tib) a Religious establishment

Scale 16 Miles = 1 Inch

Scale of 10 5 0 10 20 30 40 50 Miles

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, October 1882

C. Dyson, Photo.

C. G. Ollenbach, Zinco

Trigl. Branch, Dehra Dún 10-10-82-450

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with the Panjah, and then crossed to the south bank of the river and ascended it up to Varv, opposite Kila Yaz Ghulám, where the Havildar had been turned back because of hostilities between the people of Darwáz and their neighbours in Roshán and Shignán. At Varv he too was turned back for similar reasons. He retraced his steps to the Dara Imám, and then followed the course of the Nayán river downwards to its junction with the Panjah, and on to Kisht. Here he crossed the Panjah river and then ascended the table-land of Shiva, and explored a route, hitherto wholly unknown, taking him across the central regions of Badakshán and into the upper basin of the Panjah river, which he struck a little above Kila Bar Panjah. He now proceeded down the river, passing near Kila Wámar, and eventually reaching Varv, the point from which he had been turned back on his journey up from Kila Khum. He thus secured an important link, which had hitherto been wanting to complete the course of the Panjah river. He then retraced his steps to Akhún, and proceeded *viâ* Kila Wámar up the Bartang or Murghabi Valley, which he ascended to the highest inhabited point. He found conclusively that this river rises in the Sarez Pámír, and is not—what it has hitherto been supposed to be—a continuation of the channel of the well known Aksú river, which rises in the regions to the east of the Great Pámír. He was unable to strike into the lower valley of the Aksú; but from such information as he was able to obtain, it appears that the river merges into the Sochan river, which joins the Shákh Dara river at Yamraj, the united streams passing into the Panjah river a little above Kila Bar Panjah.

193. Returning from the Sarez Pámír down to Kila Wámar, M— S— retraced his steps to Kila Bar Panjah, where he was laid up for five months by a severe attack of rheumatism. On recovery he proceeded to explore the Shákh Dara Valley, with the intention of crossing into Wakhán over the intermediate range of hills; but the passes were then blocked with sand, and impracticable. He was thus compelled to retrace his steps to Bar Panjah. He followed the course of the Panjah to Ishkásham, along the route already traversed by Captain Trotter's explorer, A— S—, and made a connection with his former traverse at Turbat, near that place. Returning to Baroghil, he took the opportunity of visiting the Ghâz Kol lake at the source of the Yárkhun or Mustauj river; having determined its position, he turned his steps towards the Darkoth Pass, and closed his work there

194. M— S— has not only added considerably to our knowledge of the geography of Badakhshán and the countries bordering on it, but he has furnished many additional details regarding the routes which had been previously traversed. His work combines with previous surveys to furnish a well nigh complete delineation of the great bend in the Panjah river in its downward course from Wakhán through the mountains out of which it emerges into the plains, to be known thenceforth as the river Oxus.

195. He has been presented with one of the two medals which were placed at the disposal of the Surveyer-General by the Venice International Geographical Congress for award to meritorious Native explorers.

2.—EXPLORATIONS ON THE FRONTIERS OF SIKKIM.

196. In 1879 Babu D. C. S., a learned man—attached to the Educational Department under the Government of Bengal—was about to proceed to Shigatze on business of his own. Being anxious to make the most of his opportunities for acquiring new geographical information, he applied for instruction at the Surveyor-General's Office in Calcutta, where he was put through a course of training by Pandit Nain Sing, the well-known Trans-Himalayan explorer. Starting from Jongri, in Sikkim, he crossed over the Kanchinjinga range to Yamga-tshal, in Nepal, on one of the upper affluents of the Tambur river; then, taking the route which sometimes skirts, sometimes crosses, the western spurs of the Kanchinjinga, he went to the monastery of Tashichoding, near the village of Giamsar (Dr. Hooker's Khambachen); crossed over the formidable Chatang Pass, on the border line between Nepal and Tibet, into a plateau at the head of the Zemu river of Sikkim; then crossed the easier pass of Chorten Nyima Kang into the Tibetan province of Chang; traversed that province—taking a route to the west of the well-known town of Khamba Jong—and eventually reached Shigatze. On returning to India, he retraced his footsteps until he arrived near Khamba Jong.

He then took the route which leads through that town to Sikkim over the Donkia Pass, on crossing which he passed out of the region of geographical reconnaissance into that of actual survey His journey has been fruitful of information: the observations of bearings and distances have been carefully taken and recorded, and are of much value for the requirements of mapping.

197. In 1880-81 G. S. S., a Hindoo of some account among his co-religionists, who had volunteered his services for exploration in Tibet, was deputed by Captain Harman from Sikkim to proceed towards the Dingri Maidan *viâ* the valley of the Tambar river in Nepal, a line of operation which would have taken him over much new ground. Instead, however, of ascending the Tambur Valley, he passed on to the parallel valley of the Arun, which he ascended to the so-called 'Popte' range, or, more strictly speaking, watershed, which here forms the boundary between Nepal and Tibet. Crossing the watershed, he advanced to the Tibetan village of Karta, beyond which he says he was not allowed to go. His journals are far from satisfactory, the observations being few and disconnected. Still, however, he has acquired some new information, chiefly of routes in Nepal, which is useful, as so little of Nepal is known to Europeans.

198. Captain Harman has constructed a map of the routes taken by Baboo D. C. S. in his travels from Darjeeling to Shigatze and back, and has prepared a detailed account of the journey. He has also made the most of the incomplete and unsatisfactory observations of G. S. S. that can be done in the way of mapping, and prepared an account of the travels of this explorer. Captain Harman has also prepared the map of routes followed by explorers, which faces the present page, and is based on a portion of sheet 9 of the Trans-Frontier series of maps prepared in the Trigonometrical Survey Office at Dehra Dún. He has given a memorandum explanatory of the construction of this map, and another memorandum on the most probable value to be adopted for the longitude of Shigatze, both of which will be found in the Appendix. He has taken great pains in the elucidation of information regarding the geography of the regions beyond the frontiers of Sikkim; and from the stations of the survey in Sikkim, he and his assistant, Mr. Robert, have taken observations which have fixed a number of peaks on the ranges beyond the frontier, and thus extended the area of accurate framework which is of such use in compiling maps from the comparatively rough and rude observations of geographical reconnaissance.

3.—EXPLORATIONS IN GREAT TIBET.

199. In 1877 arrangements were made to send one of the explorers of this department into the regions of Northern Tibet, which are crossed by the parallel of 40° of latitude. In those days the Russian Prejevalsky had not yet made his famous journey from Guldja to Lob Nur, and there was a great belt of territory between Eastern Turkestan and Mongolia which was almost absolutely unknown. A native of India, who had accompanied the celebrated Pandit Nain Singh in his travels, was specially trained by the Pandit to undertake this new exploration. He started from India in the summer of 1878 with two companions. For a long time no tidings were received of him; but about a year ago very distressing rumours reached Nain Singh, to the effect that he and one of his companions had been seized by the authorities at Lassa; that his companion, who was a Tibetan, had been put to death for having brought a foreigner into the country; and that he himself had had his legs broken, in order to put it out of his power to make further explorations. Happily this tale turned out to be a pure fabrication, concocted very probably by his second companion, who had meanwhile robbed and deserted him. In May last, tidings were received from the Vicar Apostolic of Tibet, who resides at Ta-tsien-lu, that the explorer had reached Ta-tsien-lu in safety last February, and that he was about to return to India by the direct route *viâ* Assam. He reached Calcutta very recently, bringing with him not only his journals, but his instruments, which he has managed to secrete and preserve in some wonderful manner, notwithstanding that on two occasions he was robbed of the greater portion of his property.

200. He has taken a number of astronomical observations, and kept up a more or less continuous record of bearings and distances along the line of

his traverse. Some time must elapse before his observations can be reduced and plotted; thus at present no very definite information can be given regarding the geographical results of this last and most important trans-Himalayan exploration. The general direction of the lines of operation can, however, be indicated.

The explorer, after spending some time at Lassa purchasing merchandise for sale in the regions to which he was bound, and making arrangements to join a *kafila* of traders returning to Mongolia, eventually succeeded in making a good start. He accompanied the *kafila* as far as a place called Thingali, which may be some 150 miles to the west of lake Koko Nur. There, in December 1879, the *kafila* was attacked by a band of some hundred mounted men of the Chiamogolok tribe. They robbed the explorer of most of his property, but had the grace to leave him about Rs. 200 worth of merchandise wherewith to prosecute his enterprise, and they did not appropriate his surveying instruments. From Thingali he struck off to the north-west, and eventually reached a place called Saithang, where he had to wait for the formation of a *kafila* of travellers proceeding towards Lob Nur. There he was deserted by one of his companions, who robbed him of most of his little remaining property and his telescope. Though left nearly destitute he was resolved not to turn back, could he by any means avoid doing so. He and his remaining companion therefore took service with some Mongolians and tended their herds of horses for some months. Eventually they determined to move on with the limited funds at their disposal, and when these failed, to beg their way. They advanced to a place called Saitu, which may possibly be identical with Marco Polo's Sachiu. There they were detained seven months by Chinese Tartars, whom they were compelled to serve. Eventually a friendly Lama came to their assistance and rescued them, and in his service they returned to Saithang and proceeded south-eastwards to Barong Chaidam, some 100 miles to the west of lake Koko Nur, and then southwards 300 miles to the Thuden Gompa monastery. There they entered the service of a Chinese Tartar, whom they accompanied to Darchendo or Ta-tsien-lu, where they were kindly welcomed and helped by the Jesuit Fathers. They then commenced their return journey to India. Proceeding *viâ* Batang and Dzayul they reached Sama, a village on the eastern border of the country of the Mishmis. They endeavoured to make arrangements to cross the belt of Mishmi country between Sama and the British Frontier, but did not succeed in so doing; and being told that they would probably be murdered if they trusted themselves to such savages as the Mishmis, they turned northwards and took the circuitous route through Southern Tibet towards Lassa *viâ* Alanto and Giamda, as far as the latter place, from which they turned down south-westwards to Chetang, on the Sanpo river, avoiding Lassa. Thence they proceeded *viâ* Giangze Jong and Phari to Darjeeling, returning in safety to British territory after an absence of more than four years.

201. Sama, the village on the Mishmi border at which they turned away from the direct route to Assam, the explorer states to be situated on a river flowing into Assam, and to be the place at which two *padre sahibs* were murdered some thirty years ago. Thus it is identified with the Samé of the Revd. T. D. Mazure, Vicar Apostolic of Tibet, in a memorandum on the countries between Tibet, Yunan, and Burma, published in Volume xxx of the Journals of the Asiatic Society, in which he speaks of it as the place where the two priests, Messrs. Krick and Boury, were murdered. The Vicar was, however, under the impression that his Samé was situated in the valley of a river flowing into the Irrawady; but Colonel Yule, in his notes to the Vicar's paper, points out that we know from the reports of the British officers in Upper Assam that the two priests were murdered (about the month of August 1854) at a village called Simé in Wilcox's map, which is situated on the banks of the Brahmakund river—the eastern Brahmaputra—and he goes on to say that "this murder of two missionaries becomes thus, in fact, the basis of a geographical connection between British India and Tibet." This remark is even more apposite at the present time than it was originally; for the murder of the missionaries enables us to identify with certainty the nearest point to the British Frontier which was reached by the explorer on his attempt to return to India *viâ* Assam. Wilcox reconnoitred

the Brahmakund river up as far as the village of Samleh, and he obtained the positions of several of the villages higher up, from native information. Thus it appears that his Simé was about 18 miles beyond Samleh. For this portion of the river we as yet have no route survey; but the distance is so short that we may accept the position assigned to Simé in Wilcox's map without hesitation.

202. This being the case, the fact that the explorer was unable to proceed to India directly through the Mishmi country, but was compelled to make a considerable detour to the north, has been the means of our acquiring much additional geographical information, and more particularly of laying at rest the frequently-mooted question whether the great Sanpo river of Tibet flows into the Irrawady river or into the Brahmaputra. If the former, the explorer must have crossed it three times, first between Batang and Sama, secondly between Sama and Alanto, and finally at Chetang. He maintains that he only crossed it at Chetang, and that to the west of his route, between Sama and Alanto, there is a great range of hills, forming the water parting between the affluents of the Sanpo river and those of the well-known system of parallel Tibetan rivers which he crossed between Batang and Sama. He knows the Sanpo river well, and has crossed it frequently and in various places, and he is satisfied that none of the affluents of the system of parallel rivers which he crossed can possibly be the Sanpo.

203. A full account of his explorations will be got ready for publication, with maps in illustration, as soon as possible, probably within six months. Meanwhile, however, this statement of general outlines will suffice to show that the explorer has worked with great pluck and perseverance, never allowing himself to be turned back by misfortune and disaster, until he had succeeded in accomplishing a highly creditable amount of work, and meanwhile taking service with Mongolians, Lamas, and Chinese Tartars with a view to earn a livelihood for himself and his companion while carrying out the explorations.

TIDAL AND LEVELING OPERATIONS.

XXVIII.—THE TIDAL OPERATIONS.

204. The tidal observations and investigations have been duly continued, as formerly, in accordance with the programme prescribed by the Government of India for obtaining a systematic record of tidal phenomena on Indian coasts, which was published in section XI of the General Report on the operations of the Great Trigonometrical Survey for 1876-77. Major Baird, the officer by whom they were initiated, has been absent in Europe on furlough for the whole of the year under review, where, however, he has employed much of his leisure in promoting the investigation of the Indian tides. His place in charge of the operations has been held during the present year chiefly by Major Rogers, but partly by Major Hill, who, having to pass a military examination, was located at Poona, the head-quarters of the Tidal Party, and placed in charge of the operations, while Major Rogers took the field in charge of the Eastern Frontier Series Party.

Personnel.

Major J. Hill, R.E., Deputy Superintendent, 4th grade, in charge up to 15th April.
Major M. W. Rogers, R.E., Deputy Superintendent, 4th grade, in charge after 15th April.
Mr. W. G. Beverley, Assistant Superintendent, 1st grade.
Mr. G. Belcham, Surveyor, 4th grade.
„ E. J. Connor, Assistant „ 1st „
Sub-Surveyor Dhonda Venayeh.

205. The stations at which observations have been taken this year with the large self-registering tide-gauges of this Department are the following:—

Aden.	Negapatam.	Dublat (Saugor Island).
Kurrachee.	Madras	Rangoon.
Bombay.	Vizagapatam.	Moulmein.
Karwar.	False Point.	Amherst.
Beypore.	Kidderpore.	Port Blair.
Paumben.	Diamond Harbour.	

The tidal station which had been established at Elephant Point, below Rangoon, has been dismantled and moved to another site higher up the river, together with the Telegraph Office and other public buildings, as the original site was being carried away by the river. The tidal station at Bhaunagar,

erected at the cost of His Highness the Thakur of Bhaunagar, has met with an accident, which has prevented the setting up of a tide-gauge. Thus no observations have been taken at either of these stations during the present year.

Account of the Registrations, &c., at each Station.

206. At Aden the tide-gauge has been working very well, with only two stoppages, both unimportant. The observatory was inspected by Mr. Belcham in December 1881, when all the instruments and driving clocks were taken to pieces and cleaned. The self-registering aneroid barometer and anemometer have unfortunately been unserviceable for the greater part of the year, and are being replaced by new instruments. Captain Thyne, the Port Officer, has rendered much assistance in supervising the work of the clerk in charge.

207. At Kurrachee the new large-scale tide-gauge, which was erected in the place of the small-scale gauge set up some years ago by Mr. Parker—in connection with the harbour improvement works—has been working very satisfactorily, the stoppages having been few and unimportant. The aneroid barometer has worked well. The registrations of the direction and velocity of the wind have been taken from an anemometer which is employed in connection with the harbour works.

208. At Bombay the registrations of the tide-gauge have been continuous, and in every way satisfactory; as also have been those of the self-recording meteorological instruments.

209. At Karwar the tide-gauge has worked well, with few and unimportant interruptions; the catgut string carrying the back-lash weight was frequently bitten through by rats, and eventually wire had to be substituted for it. The aneroid barometer has been working satisfactorily, but not the anemometer, which appears to have become worn out, and must be replaced by a new instrument.

210. At Beypore the tidal registrations have been continuous and satisfactory. The meteorological records were frequently interrupted; a fly-catcher was found to have made its nest in the case of the clock of the aneroid barometer; and the anemometer was injured by violent gales during the monsoon of 1881. The observatory was inspected by Mr. Belcham in February 1882, when the instruments were put into working order, and since then they have registered satisfactorily.

211. At Paumben some interruptions in the tidal registrations were caused by the pipe which connects the well of the gauge with the sea becoming corroded A new pipe was substituted and general repairs were effected in February 1882, and since then all has gone on satisfactorily. The aneroid registrations have been fairly continuous. No anemometer registrations have been made, as no instrument was available for the purpose.

212. At Negapatam the site primarily selected had been objected to on the ground that an observatory erected there would interfere with the traffic; a new site was therefore chosen on the western side of the back-water, about 100 yards south of the pier. A substantial structure was erected for the observatory; the instruments were set up, but with some delay, owing to a mistake on the part of the packers in England, who had sent out the barrel of one tide-gauge and the clock of another: thus the two had to be fitted together, which was done at the contiguous railway workshops. The tidal registrations were fairly started by the 1st November 1881; but some time elapsed before the clerk in charge succeeded in mastering the details of the manipulation, and meanwhile there were several breaks of continuity in the record. The anemometer has been working well, but not so the aneroid, the clock of which appears to have been badly constructed originally, and subsequently the registering barrel was let fall by the clerk and so much injured that for some time the instrument was unserviceable.

213. At Madras the tidal registrations have been carried on satisfactorily throughout the year. In February, when the periodical inspection was made, the pipes connecting the well of the gauge with the sea were thoroughly cleaned, and this necessitated a stoppage of the registration for 17 days. The cyclone of the 12th November, which destroyed a large portion of the walls for the protection of the new harbour, did no injury to the gauge; but of course the transfer of the gauge from the present wooden pier to a preferable site on

the new masonry pier has been postponed indefinitely. Captain Taylor, the Master Attendant, has rendered much assistance both here and at other ports on the Madras coast. Barometric and anemometric registrations are not made at the tidal station, as all necessary information regarding these meteorological elements should be obtainable from the Government Astronomer at Madras, being regularly recorded at his observatory.

214. At Vizagapatam the tidal registrations have been satisfactory on the whole, the breaks of continuity being few and unimportant. The anemometer has worked well throughout, and the aneroid for about half the year. The timber piles supporting the observatory have been eaten away to an extent which is reported to have imperilled the safety of the observatory; but steps have been taken to strengthen them sufficiently to last for another year, after which further observations will be unnecessary.

215. At False Point the tidal registrations have been going on more satisfactorily than last year, and there have been no stoppages of more than a few hours. In May 1881 it was detected that a general settlement of the staging on which the observatory was erected had been going on for some time, the bed plate of the gauge having sunk about seven inches since the instrument was first set up; the levels were again tested in December 1881 and May 1882, when further settlements of $1\frac{1}{2}''$ and $1''$ were found to have taken place, showing continuously progressive settlement at the rate of about two-tenths of an inch monthly. This has necessitated the application of corresponding corrections to the tidal registrations in order to reduce them to a fixed datum.

216. At Kidderpore the tidal registrations have been fairly continuous, but with occasional short breaks; these were caused by the stoppage of the pendulum of the driving clock, which is attributed to shocks communicated by boats bumping against the piles on which the observatory is supported, and to vibrations caused by the action of the winds and tides. The barometric and anemometric registrations show several breaks, but these may be filled in with the aid of the records of the meteorological observatory at Alipore.

217. At Diamond Harbour so many breaks of continuity in the tidal registrations were caused by the stoppage of the pendulum of the clock, for the same reasons as at Kidderpore, that an attempt was made to substitute for the usual clock one of the chronometer escapement clocks which had been specially provided for employment on staging unsuited for pendulum clocks. The chronometer escapements were found, however, to be too delicate for the purpose, the hair springs being liable to break on very slight provocation: thus after a time the pendulum clocks had to be reverted to. The aneroid registrations were continuous throughout the year, and those of the anemometer for eleven months.

218. At Dublat the registrations of the tide-gauge were interrupted for 19 days because the bridge connecting the observatory with the shore was carried away in a storm. The staging is not sufficiently substantial and requires to be much strengthened. Here, as at Diamond Harbour, an escapement clock is necessary in place of the pendulum clock. The anemometer registrations have been most satisfactory throughout the year, but the aneroid barometer was frequently out of order.

219. At Rangoon the observations have been carried on satisfactorily, but there have been numerous short stoppages of the clocks of all the instruments, due for the most part to the traffic on the wharf on which the observatory is set up. The immediate charge of the operations has been transferred from the Executive Engineer, Mr. King—who has given much valuable assistance—to an officer of the Port Trust.

220. At Elephant Point the site of the observatory was so nearly cut away by the river that it became necessary to dismantle the instruments and remove them for safety to the Telegraph Offices. The observatory, whilst being removed on a raft, was washed away and lost. A new site was selected by Major Rogers in March 1882, at the mouth of the Pee-li-ka Creek, about two miles from the Point, which, though not quite as open to the sea as the old one, has the advantage of being safe from the erosion of the river; the Port Trust is about to erect an observatory there. Observations had been carried on at the first site for nearly a year, and though their value is impaired by numerous breaks, they have sufficed for the construction of preliminary tide tables.

221. At Moulmein the tidal registrations are reported to have progressed fairly well on the whole; but there have been frequent short stoppages of the pendulum clock, caused by vibrations of the pier on which the observatory is set up. The aneroid and anemometer have worked satisfactorily. A robbery took place here in June 1881, the only one that has occurred anywhere since the commencement of the tidal operations; the thieves took away such small articles as they could lay their hands on, and five of the tidal diagrams, in pure mischief, as the diagrams could not be of any use to them. Fortunately it is the custom every day to transcribe the hourly readings of the diagrams and post them to the office at Poona, in case of mishap to the diagrams: thus the theft was immaterial.

222. At Amherst there has been some erroneous tidal registration, because the pipes connecting the well of the gauge with the sea had become partially clogged with mud, a large amount of which is here held in suspension in the water. In such situations frequent flushing of the pipes is necessary; and when the clerk in charge neglects to do this, so much retardation takes place in the flow of water into and out of the well that the diagrams become inaccurate, and therefore useless. A sufficiency of correct registration has, however, been secured for the construction of tide tables for the coming year. The aneroid and anemometer registrations have been uniformly satisfactory.

223. At Port Blair the tidal registrations continue to be very satisfactory. This is due in great measure to the immediate supervision exercised by Mr. Humfrey, the Port Officer, who takes much interest in the operations. There have been two changes in the clerks in charge during the year: the present clerk is a convict, supplied by the Chief Commissioner, Major Protheroe. The aneroid registrations have been very satisfactory throughout the year. The anemometer was out of order, and had to be sent away for repair.

224. From the preceding description of the performances of the three self-registering instruments at each of the tidal stations, it will be obvious that a few spare clocks with spring escapements are required to be substituted for the pendulum clocks of the tide-gauges at observatories on piers and stagings which are subject to jars and concussions of sufficient force to stop the performance of a pendulum; also that a few spare aneroids and anemometers are needed to replace any instruments which are out of order and under repair, in order to preserve the continuity of the registrations. Application has therefore been made to the Director-General of Stores at the India Office to take early steps to supply four spare clocks with lever escapements, and as many self-registering aneroid barometers and anemometers, for future use.

225. Reference should be made to paragraphs 186 to 190 of last year's report for information regarding the scales of the tidal-curve diagrams—which are adjusted to vary with the amplitudes of the tides between extreme high and low water at different stations—the instrumental adjustments, the references to a fixed datum, the periodical inspections, the duties of the clerks in charge, the despatch of the diagrams to the central office at Poona, the preparation of numerical tables from the curves of the diagrams, and finally the evaluation of the tidal constants. These constants furnish the requisite data for the determination of any past or future tide, either by direct calculation, or with the aid of a tide-predicting machine, such as the one which has recently been constructed for the India Office, and is being employed by Mr. Roberts in the preparation of the tide tables for Indian ports, which are published under the orders of the Secretary of State for India.

226. During the present year large discrepancies were for the first time met with between the tidal predictions and the actual facts of the tides. This arose from the circumstance that it was for the present year that predictions had first been made for stations situated on the banks of great rivers, as the Hooghly and the Irrawaddy, in which the tides are influenced not only by the attractions of the sun and the moon, but by the amount of water brought down by the river from its sources, which varies at different seasons of the year. There are three tidal stations on the Hooghly—Kidderpore, Diamond Harbour, and Dublat; two on the Irrawaddy—Rangoon and Elephant Point; and one on the Salween river—Moulmein. Tide tables were computed for these riverain stations as if they had been purely oceanic stations, and these tables

were found to be erroneous to the extent of occasionally an hour or more in the times, and a foot or more in the heights, of high and low water. Attention was first drawn to the subject on comparing Mr. Roberts' tables for Kidderpore and the other stations on the Hooghly with the tide tables published by the Calcutta Port Commissioners. Mr. Roberts' tables were based on five years' tidal observations taken in connection with the operations of the Department of Public Works, before Major Baird's tidal stations were established; the observations had however been reduced by the modern method of harmonic analysis. The Port tables were based on tidal observations taken in connection with the surveys of the river-bed and channels which have been made from time to time by the Port authorities, and they were reduced by the methods usually followed by the surveyors to the Admiralty. On comparing both sets of tables with the subsequently acquired results of actual observation, it was found that Mr. Roberts' predictions of the times of high and low water were almost invariably too early, while the Port table predictions were generally too late, the errors of the former being greatest; the errors in the predictions of height were pretty equally balanced between excess and defect, and were in no case very material The mean values of the two sets of tables are much more accurate than the values in either set taken singly.

These facts have shown the necessity for supplementing the mathematical formulæ for the harmonic analysis of purely luni-solar tides by formulæ to take cognizance of riverain influences. The subject is a very abstruse and difficult one, but it has been brought to the notice of some of the leading mathematicians in England, and there is much reason to expect that it will soon be satisfactorily disposed of. It is also expected that additions may be made to the India Office tide-predicting machine which will enable the machine to fulfil its functions as satisfactorily for stations situated on the banks of tidal rivers as it has done hitherto for stations situated on sea coasts. Meanwhile Mr. Roberts is adopting a provisional method of predicting tides for riverain ports. which is described below in an extract from his tide tables for Diamond Harbour, in the River Hooghly, for 1883.*

227. In addition to their practical value for the requirements of navigation, the Indian tidal observations are furnishing information which has already been found to be of much scientific value. Thus they have recently thrown light on the question of the degree of the rigidity of the earth, which was mooted about fifteen years ago by Sir William Thomson, who appealed to the universal existence of oceanic tides of considerable height as a proof that the earth, as a whole, possesses a high degree of rigidity, and maintained that the previously received geological hypothesis of a fluid interior was untenable. At the recent meeting of the British Association for the Advancement of Science at Southampton, Mr. G. H. Darwin brought forward a "numerical estimate of the rigidity of the earth," which gives evidence of a tidal yielding of the earth's mass, and further indicates that the effective rigidity of the whole earth is about equal to that of steel. But it is only recently that there has been a

* From a comparison made between the observations and the predictions for 1882, it appears that the number of short-period terms combined by the India Office tide-predicting machine is not nearly sufficient to reproduce the tide-curves for this place, nor Indian riverain ports generally, more especially for the phases of low-water. As it will take time to evaluate by the method of harmonic analysis the proper number of terms requisite to reproduce the tide-curves with the desired accuracy, recourse has been had to the following method of treatment, which, judging from an extended comparison of some months of the year 1882, made between the predictions and actual observations for Kidderpore, promises to yield predictions differing from the facts within narrow limits.

The observed times and heights of high and low-water were tabulated in the ordinary manner to produce the semimenstrual curves for time and height of high and low-water depending on the time of the moon's transit in apparent time, referred, however, to the transit at Greenwich about 40 anterior to the time of observation. The predictions were then obtained directly from the quantities thus found, and were corrected for lunar and solar parallax and declination by the tables contained in Sir John Lubbock's elementary treatise on the tides, which are used in the Nautical Almanac and Admiralty Offices for their tidal predictions. For the corrections to the heights of high and low-water the proportions between the London values of spring and neap tides compared with those of Diamond Harbour have been used. This method of treatment takes thus far into account semidiurnal tides only. In order to correct the predictions for the diurnal tides, the following plan has been adopted. The predictions for time of high and low-water for Dublat have been computed similarly to the above (the semimenstrual curves having been obtained from the actual predictions for 1883), and the differences taken between the times thus obtained and the times as given by the machine-curves. These differences represent fairly the effects of the diurnal tides. A proportionate part of these differences has been used for each high and low-water, and applied to the Diamond Harbour predictions of purely semidiurnal tides. In addition to these corrections, another (which may be termed a seasonal correction) has been applied for the freshets in the river, the general effect of which appears to be to accelerate the times to a considerable extent.

The predictions for the heights have been similarly corrected for the diurnal tides, and the solar annual and semiannual tides, excepting in this case the quantities, have been obtained directly by means of the India Office tide-predicting machine. The values of the diurnal and long-period tides used were those based on the evaluated results given in the tide tables for 1882

sufficient accumulation of tidal observations, properly reduced by harmonic analysis, to test Sir William Thomson's theory; and Mr. Darwin points out that the great advances in knowledge that have now been made are principally due to the adoption of systematic tidal observation at a great number of stations by the Indian Government.

228. Here it may be interesting to mention that the first systematic tidal observations which were made by this survey for reduction by the modern method of harmonic analysis were undertaken with the primary object of furnishing evidence regarding changes which were supposed to be taking place in the relations of the levels of the land and the sea; they were made by Major Baird, at three stations in the Gulf of Cutch, during the years 1873—75, with the intention that similar observations should be taken several years afterwards, when a sufficient interval had elapsed to allow time for a change of level of sufficient magnitude to be determined with certainty, from the first and last observations of the levels to take place. Whether the faith that a future generation would carry out an idea originating in the present generation which was then shown will ever be realised, remains to be seen. It so happens, however, that the recent tidal observations of this survey at another point are comparable with observations taken at the same place upwards of sixty years ago. In 1821 Colonel De Haviland of the Madras Engineers observed the mean-sea level at Madras, and by his determination the mean-sea was about one foot higher then, relatively to a fixed point on the shore, than it appears to be now by our recent determination of the relation between the present mean-sea and the same point—a stone bench-mark built into the wall of Fort St. George. The difference between the two results has hitherto been supposed to be due, possibly, to the circumstance that Colonel De Haviland's operations were restricted to observations of high and low water, and to a period of about $4\frac{1}{2}$ months only; the observations have, however, been recently analysed by Major Rogers, who has found that they agree well with those of the present self-registering gauge in the times of high water relatively to the full and change of moon, and also in the times of spring tides; and further that the mean level of the sea during the months corresponding to those in which Colonel De Haviland's observations were made differs by less than half an inch from the mean value for the whole year, and is therefore a good value. Thus assuming no mistake to have been made in connecting the tidal observations with the bench-mark in Fort St. George—and such a mistake is very improbable—it may be considered established that the mean-sea level at Madras is about one foot lower, relatively to the land, now than it was sixty years ago.*

XXIX.—THE EARTHQUAKE OF THE 31ST DECEMBER 1881.

229. On the morning of the 31st December 1881 an earthquake occurred in the Bay of Bengal, which operated with considerable violence in the neighbourhood of the Andaman and Nicobar Islands, and with more or less violence along the entire length of the west coast of the Bay, from Ceylon to Calcutta, and was also felt, though comparatively slightly, at various points on the east coast. In addition to the ordinary shocks produced by the waves of force acting through the ground, the surface of the ocean was greatly disturbed, and waves were formed which continued to roll against the coast lines for several hours after the cessation of the earth-waves, which lasted for only a few seconds. The clerk in charge of the tidal observatory at Port Blair reported a great disturbance of the surface of the sea to have taken place there, which had violently agitated the pencil of the self-registering tide gauge, causing it to oscillate in the course of a few minutes through spaces nearly equal to the entire normal semi-diurnal oscillation, and after a time to tear the paper of the diagram. This had alarmed him so much that he stopped the clock and did not restart it for some hours, when there was less agitation of the sea-surface. He then found by the diagram that the earthquake waves were still

* Major Rogers reports:—"Mr. Belcham inspected the Indian Tidal Stations and worked in all respects satisfactorily.

"Mr. Connor had charge of the Computing Branch, and to his zeal and hard work the very successful outturn of computations is greatly due."

existing, and were following one another with great regularity; and they continued to do so for about twenty-five hours after the first shock of the earthquake was felt, when they died away. The diagrams at all the other tidal stations, for the same day, were then examined, and evidence of a succession of ocean-waves caused by the great earth-wave was unmistakeable at all the stations on the west coast of the Bay and at Dublat station—at the south end of Saugor Island—as well as at Port Blair. There was evidence of slight disturbance at Diamond Harbour, 38 miles up the Hooghly beyond Saugor Island; but there appeared to have been no disturbance whatever either of river-surface at Rangoon and Moulmein, or of ocean-surface at Amherst, and these are the only points on or near the east coast of the Bay at which tidal registrations were being taken.

230. Diagrams of the disturbed tidal curves, reduced from the original records, are here given to indicate what actually took place at each spot and at the same moment of time. For the latter purpose, all the hour lines of the diagrams have reference to local mean time at Port Blair. The curves from midnight of the 30th December up to the times when the sea-waves began to reach each station—which fall between 8 A.M. at Port Blair and 1 P.M. at Dublat, and possibly was as late as 3 P.M. at Diamond Harbour—are normal in every instance; and thus by comparing them with the curves for the remainder of the twenty-four hours, the influence of the earthquake in disturbing the normal tides is readily seen. For Port Blair and Negapatam the normal curves are drawn below the actual curves. At the former place the diagram was torn by the pencil, and the record is not continuous; at Negapatam the curve from midnight up to the commencement of the sea-waves is vibratory, and not firm, as at all the other stations; but there the curves are normally vibratory, probably because the piping, connecting the well of the gauge with the sea, ends in shallow water and has not been carried out far enough into the sea. The longitudes of the several tidal stations west of Port Blair, in time, are given in the margin.

	H.	M.
Diamond Harbour	0	18
Dublat	0	20
False Point	0	24
Vizagapatam	0	38
Madras	0	50
Negapatam	0	52
Paumben	0	54

231. Both the officers in charge of the tidal operations, first Major Hill and afterwards Major Rogers, have taken much pains to ascertain all the facts of the primary 'Great earth-wave' and the subsequent 'Sea-waves.' It so happened that at the time of the occurrence of the earth-wave Major Rogers was measuring angles with one of the great theodolites of this Survey at a station on the Island of Kisseraing, below Tenasserim, on the east coast of the Bay, as a part of the operations which are described in paragraph 34 of this report. He writes that he "saw the earthquake before feeling it," as he was at the moment observing a signal—distant some 15 miles—which appeared to rise and fall in the field of the telescope. On looking at the levels of his instrument, he found that they were violently agitated. He immediately recorded the time at which the phenomenon occurred. Subsequently he ascertained that the earthquake had been felt, at almost the same moment, at Madras and False Point, on the opposite coast. Thus then Major Rogers, assuming the great earth-wave to have travelled with equal velocity in all directions from the origin or centre of impulse, considers that the origin must have been situated at some point in the Bay nearly equi-distant from Madras, False Point, and Kisseraing,—not in the centre of the triangle joining the three places, but more to the south, towards the line joining Port Blair and Negapatam, which was probably the line of greatest disturbance, as at those places the sea-waves were greatest.

It is remarkable that there should be no indication of any sea-wave at either of the tidal stations at Rangoon, Elephant Point, Moulmein or Amherst. This may be due to the circumstance that the belt of islands and shoals which extends from Cape Negrais down to the Island of Sumatra forms a barrier to waves issuing from an origin near the centre of the Bay; the sea-waves were propelled with great violence against these islands on all sides and over the surrounding shallows, but they seem to have died away very rapidly in the deep sea beyond. Moreover, the great earth-wave must have operated with far greater force towards the west than towards the east of the centre of impulse; for violent shocks were felt all along the west coast of the Bay, and to a considerable distance inland, whereas on the east coast the shocks were very slight and barely perceptible.

To accompany Surveyor General's Report for 1881-82.

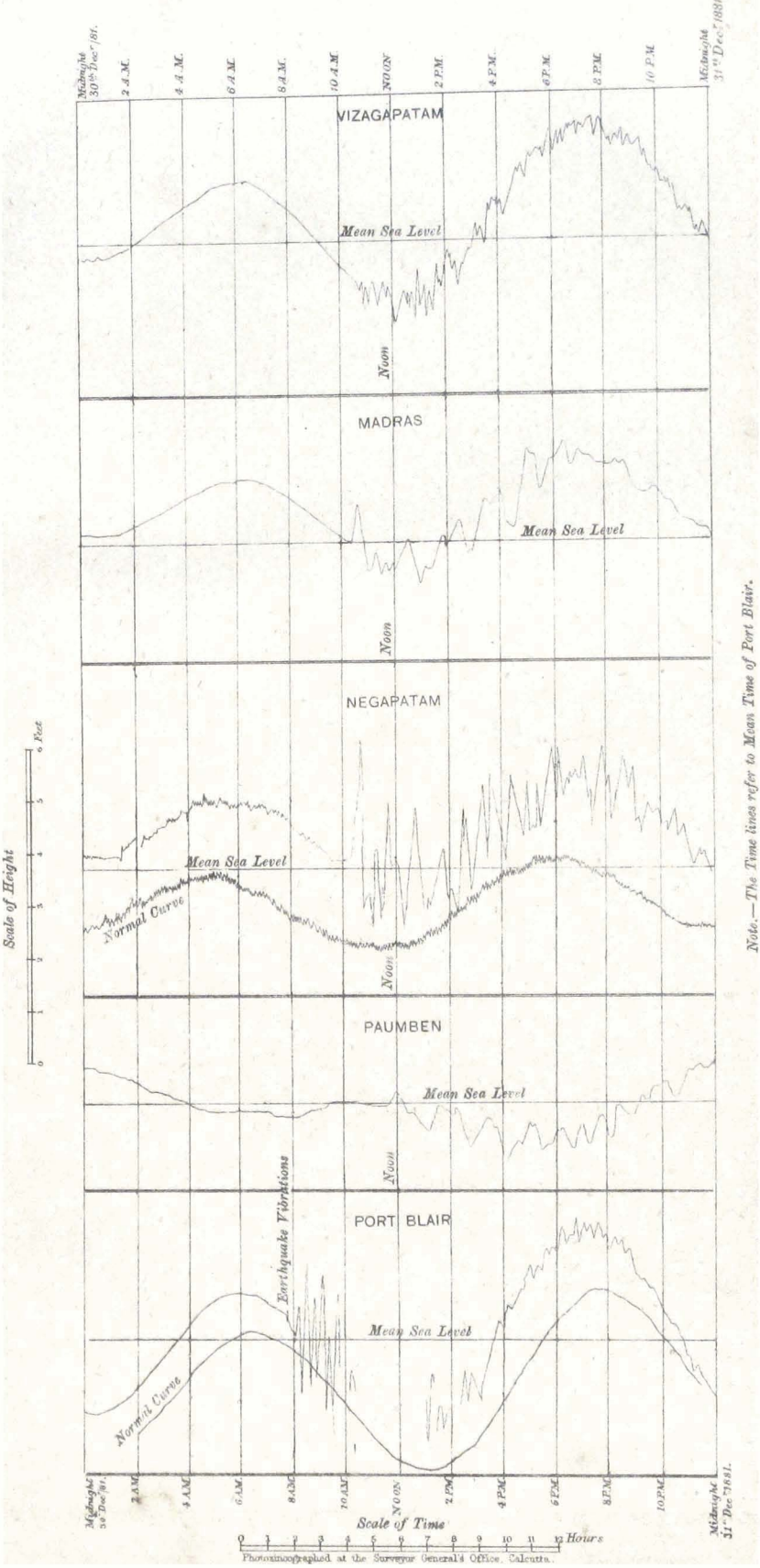
CHART OF BAY OF BENGAL

TO ILLUSTRATE REPORT ON TIDAL WAVES PRODUCED BY EARTH-QUAKE OF 31st DECEMBER 1881

Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, December 1882.

TIDAL CURVES.

To illustrate the effects of the Earthquake of the 31*st December* 1881.



Photozincographed at the Surveyor General's Office, Calcutta.

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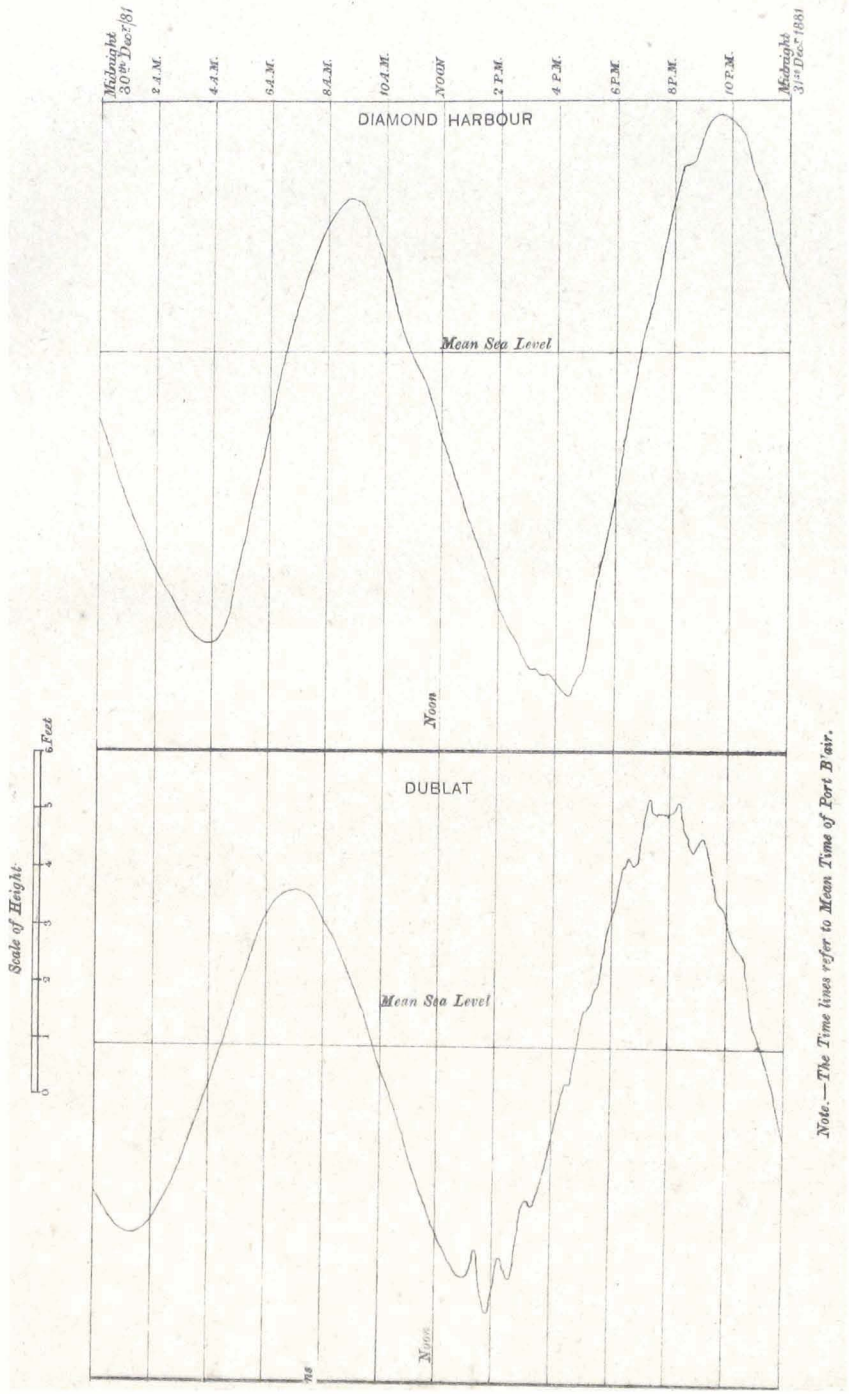


Note.—The Time lines refer to Mean Time of Port B'air.

232. The accompanying Chart of the Bay of Bengal shows the positions of all the tidal stations on both coasts, the trigonometrical station at Kisseraing, and Major Rogers' assumed centre of impulse. It also gives the values of all the soundings in the Bay which are believed to have yet been taken. Major Rogers' report is given *in extenso* in the appendix, and will be found to contain much additional matter of interest, including estimates of the respective velocities of the earth-wave and the primary sea-waves. It is believed that so full an account and such precise details of the phenomena of an earthquake have rarely been acquired hitherto. That they have been obtained in the present instance is mainly due to the existence of the many tidal stations which have been established on Indian coasts.

XXX.—THE SPIRIT-LEVELING OPERATIONS.

1.—THE OPERATIONS EXECUTED IN CONNECTION WITH THE TIDAL OBSERVATIONS.

233. These operations have for their object the connection of the several tidal stations by lines of spirit levels running along the coast lines and across the continent from sea to sea; also the connection of the principal stations of the great triangulation which fall in the neighbourhood of the lines of levels, with a view to the rectification of the differences of height which have already been determined by the less accurate trigonometrical method; and also, collaterally with these operations, the connection of the bench-marks of the Irrigation, Railway, and other branches of the Department of Public Works, with a view to their general combination and reduction to a common datum.

234. During the present year the main line of spirit-leveling was entrusted to Mr. Rendell. His first duty was to revise the western ghât section of the line of levels from Bombay to Madras, with a view to ascertaining whether any accidental error had been committed in leveling up the steep ascent of the ghâts that would account for the discrepancy of three feet which had been met with at Madras on comparing the value of the mean sea determined from the local tidal observations with the value given by the spirit-leveling from Bombay. This has already been fully set forth in section XXVIII of the annual report for last year. The revision giving practically identical results with the first operations, Mr. Rendell proceeded to Calcutta and commenced a main line of levels to connect the tidal stations at Kidderpore, Diamond Harbour, and Dublat in the river Hooghly with the nearest tidal station on the sea coast, viz. the one at False Point on the Cuttack coast line.

Personnel.

Mr. Rendell.
Sub-Surveyor Narsing Dass and two recorders.

235. Operations were commenced at False Point tidal station, whence the line of levels was taken along the coast to the lighthouse, and then across a very difficult network of creeks at the mouth of the Mahanadi river to the banks of Kendrapara canal. There *terra firma* was reached after wading for a distance of about 18 miles through an extensive jungly swamp, which is wholly covered with water at spring tides, and is never entirely free from it. The stands of the instruments had frequently to be set up in water two to three feet deep; and as the soil below was loose and slushy, so that any movement on the part of the observer disturbed the level of the telescope, Mr. Rendell had to summon up his coadjutor, Narsing Dass, from a station in rear to read the level at the moment that he was reading the staves with the telescope, and then to return and perform the same duty for his coadjutor; thus the independent measurement of the double line was maintained throughout in accordance with the long-established procedure for these operations, but with very much more of difficulty and delay. After reaching the banks of the Kendrapara canal the operations were carried on, as usual, across country to Jhajpur, and thence along the Grand Trunk Road to Balasore. From Balasore a branch line was carried to the coast to connect the old tidal station at Balaramgarhi, while the main line was taken *viâ* Contai to the Kakrahati ferry, across the Hooghly river, on the direct road to Calcutta. Various rivers and creeks, ranging from one quarter to three quarters of a mile in breadth, had to be crossed before Kakrahati was reached; but in all instances the crossing was accomplished by direct spirit-leveling, though occasionally staves with broader graduations

than those in ordinary use had to be employed, the distances being so great. To cross the Hooghly river in this manner was, however, found impracticable, the river being considerably over a mile in breadth at its narrowest part. Mr. Rendell therefore set up temporary tide gauges on both banks, at a part where the main channel and the banks were parallel to each other. He and his coadjutor took simultaneous readings of both gauges at the times of high water, rising tide, and falling tide. Upwards of three hundred observations, extending over four days, were taken. A difference of level of nearly two inches was found between rising and falling tides; but the mean of both differed by only 65 of an inch from the level at the top of the tide when the surface of the river was neither rising nor falling. The general mean may be accepted as within half an inch of the truth, and is probably much more exact than any result which might have been obtained by measuring the vertical angles across the river, or by any other process.

236. After crossing the Hooghly river the line of levels was taken down to Diamond Harbour and connected with the tidal station there. It had still to be carried to the Dublat tidal station at the south end of Saugor Island; but the field season was now well advanced, and by the time that the line was brought down to the Baratola river, on the crossing to Saugor Island, strong winds had set in, which could not be faced by native boats; and as the survey party was dependent on these boats for the carriage of water and provisions, and usually resided on board of them, it was necessary to cease working downwards, and to proceed to Dublat by way of the inland creeks and back-waters. Thence the leveling was taken upwards, *viâ* the Saugor Light House, to the Baratola river, where a junction was effected with the down line. The party was now thoroughly exhausted, having undergone great hardships and much exposure. Field operations were therefore suspended. The out-turn of work is very creditable to Mr Rendell; for the length of main line leveled is as much as 380 miles, of which more than half fell on marshes, swamps, and paddy-fields, which had to be operated over very carefully and slowly. The several crossings of rivers and tidal creeks were also very troublesome, and caused much delay, and the exposure generally was excessive.

237. The programme for the next field season includes the completion of the line from False Point by the connection of the tidal station at Diamond Harbour with that at Kidderpore, and a further connection with the main line which was carried in the years 1858–65 from Kurrachee through Sind, the Punjab, the North-Western Provinces, and Western Bengal to Calcutta. Lines of levels will also be carried along both banks of the river Hooghly to furnish data for the elaborate survey of that river and its banks, which is now being carried on conjointly by this Department and the Commissioners of the Port of Calcutta, as described in section XIII of the present report.

238. Subsidiary lines of levels were executed by a detachment from the tidal and leveling party in the districts of Nasik and Ahmednagar with a view to the correction of the heights of the principal stations at the southern ends of the Khanpisura and Singi series of principal triangles. These heights were mostly determined 30 to 50 years ago by the trigonometrical method, and they have been found to be less accurate than is desirable, the observations having in many instances been taken at other times than that of minimum terrestrial refraction, the laws of which were scarcely known then. Thus a revision of these heights was very necessary. It was undertaken by Mr. Beverley, who made a combination of the trigonometrical and spirit-leveling methods of operation, measuring the vertical angles at stations of the auxiliary line of levels to the surrounding trigonometrical stations, which were mostly situated on high hills inaccessible to the spirit-leveler. Mr. W. G. Beverley was prevented from continuing in the field for a full season by ill health, to which he afterwards succumbed, dying at Poona in September. Mr. Beverley entered the Survey Department in the junior or subordinate branch in 1854. He served in that branch for about 17 years, during which he did such good service in the Himalayan surveys, chiefly under the late Lieutenant-Colonel T. G. Montgomerie, R.E., that he was promoted in 1871 to the senior branch.*

* Major Rogers reports:—"Mr. Rendell carried his levels through exceptionally trying and difficult country and showed great energy and intelligence in the prosecution of his work.
"Narsing Dass worked excellently.
"The computers in general gave satisfaction."

2.—THE OPERATIONS IN CONNECTION WITH THE REVENUE SURVEYS.

239. The small party of levelers which has been employed for two previous seasons in the Hanthawaddy district of British Burma has again been organized. At the commencement of the season, the party first measured a line of 20 miles to close a circuit which had been left unfinished the previous year, and thus completed the several series of levels which had been laid out for the Hanthawaddy district.

240. The party then became free to take up new work of a special character, which had been planned in accordance with the wish of the Chief Commissioner that leveling should be done in connection with the survey operations in the Bassein district, as well as in Hanthawaddy. The character of the country where the Bassein cadastral party has been operating, situated as it is in the heart of the Irrawaddy delta, a tract largely intersected with tidal creeks, rendered it unnecessary that the ordinary plan of placing lines of levels at fixed intervals should be adopted; and it was desirable that special lines should be selected, such as would be most useful for practical purposes. This selection could best be made by an officer of the Public Works Department, who would be likely to make practical use of the level data. Accordingly, Mr. R. Gordon, Executive Engineer of the Henzadah Division, an officer whose duties had specially led him to give much attention to the physical character of the valley of the Irrawaddy, was consulted on the subject, and asked to say where he would recommend the lines of levels to be placed. Mr. Gordon's plan is to have lines of levels carried along two main branches of the Irrawaddy—one line from Pagoda Point, at the mouth of the Bassein river, the other from a little below Maoobin, on the China Bakeer river joining a little above Henzadah, and thence a single line northwards following the river up to the frontier. From Henzadah, another line will branch off eastwards to the Prome Railway, following which southwards it will terminate at Rangoon. This scheme was forwarded for the consideration of Mr. Furnival, Chief Engineer at Rangoon, who added traverse sections across the valley in the neighbourhood of Henzadah in addition to Mr. Gordon's river lines.

241. A commencement has been made of this plan of leveling by taking a line from a bench-mark of the Hanthawaddy levels to the eastern branch of the Irrawaddy near Maoobin, and thence following the river up to Henzadah. From this point, Major McCullagh, who has superintended the operations, had intended to have had a line taken eastwards to the railway, and thus to have completed a circuit through the railway series of levels and the Hanthawaddy levels, but the setting in of the rains prevented the programme from being carried out. The line of levels measured is 128 miles in length and double throughout. The number of bench-marks is 129, some of them being specially fixed marks, and some of them existing permanent objects. In carrying out the river line, the levelers had many difficulties to overcome, with many miles of high grass and jungle to cut through, and numerous streams, large and small, to cross. The levelers and the establishment suffered much from fever.

GEODETIC.

XXXI.—ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

242. The electro-telegraphic operations for the determination of the differential longitudes of certain stations of the principal triangulation were resumed last year, after remaining in abeyance since the season of 1876-77, as already intimated in the last report. They have been continued during the current year by Major George Strahan and Major Heaviside, Major Strahan taking the place of Lieutenant-Colonel Campbell, who went on leave at the commencement of the field season, and returning at its end relieved Major Heaviside and thus enabled him to take leave during the recess.

Personnel.

(No. 1 Astronomical Party.)

Major W. J. Heaviside, R.E. (field season), Deputy Superintendent, 3rd grade.
Lieutenant-Colonel W. M. Campbell, R.E., (recess) Deputy Superintendent, 2nd grade.
Mr. D. Atkinson, (recess) Surveyor, 2nd grade.
Sub-Surveyor Dhondo Balwant Joshi.

(No. 2 Astronomical Party.)

Major George Strahan, R.E., Deputy Superintendent, 2nd grade.
Mr. J. Bond, Assistant Surveyor, 1st grade.
Sub-Surveyor Baboo Harsukhai.

243. During the present year seven arcs have been measured, as follows:—

Fyzabad–Agra.	Hazaribagh–Calcutta.
Fyzabad–Jubbulpur.	Hazaribagh–Julpaigori.
Fyzabad–Hazaribagh.	Julpaigori–Calcutta.
Jubbulpur–Hazaribagh.	

An eighth arc, Fyzabad–Julpaigori, had been included in the programme for the field season; but before it could be commenced cloudy weather had set in at Julpaigori, and this made it impossible to carry on the system of simultaneous star observations at both stations, which is imperatively necessary to secure very precise results in differential longitude determinations.

244. The seven arcs of the current year, combined with the arc Agra–Jubbulpur, which was measured last year, present three verificatory circuits, as follows:—

		m.	*s.*
Fyzabad–Agra ...	... ...	16	27·932
Fyzabad–Jubbulpur	... ...	8	44·629
Agra–Jubbulpur	... deduced ...	7	43 303
	... measured ...	7	42·993
	Circuit error ...	...	0·310
Hazaribagh–Fyzabad	... ...	12	55·194
Hazaribagh–Jubbulpur	... ...	21	40·908
Fyzabad–Jubbulpur	... deduced ...	8	45·194
	... measured ...	8	44·629
	Circuit error ...	...	0·565
Julpaigori–Hazaribagh	... ...	13	27·071
Julpaigori–Calcutta	... ...	1	30 402
Calcutta–Hazaribagh	... deduced ...	11	56·669
	... measured ...	11	56·724
	Circuit error ...	...	·055

245. The magnitudes of the two first circuit errors are largely in excess of the theoretical probable errors of the operations, and of any errors actually met with hitherto; they clearly indicate the presence either of defects in the instrumental equipment, or of mistakes in the calculations, which are somewhat intricate and troublesome. The performances of the transit instruments had not been nearly so satisfactory as during the preceding years, so that before the calculations of this year's operations were completed and the amounts of the circuit errors were known, these instruments had been sent to the Mathematical Instrument Department in Calcutta for examination. Afterwards, when the circuit errors were known, the observations and calculations were carefully scrutinised, with a view to tracing home all possible causes of sensible error. The analysis of the observations, however, revealed nothing. On the contrary, the results furnished by each arc, *per se*, were on the whole remarkably satisfactory. For instance, as a check on the work, the operations had been executed so as to give results by two distinct methods of procedure: one in which the transits of any star over both meridians are observed by both observers and are recorded on chronographs governed by one and the same clock, the clock at the distant station being telegraphically connected with the chronograph at the observing station for the purpose; the other in which the transits of a star are also observed at both stations, but at each station the transit is recorded in terms of local time, and clock comparisons are made periodically to enable the two sets of observations to be combined. The two methods were independent of each other, excepting as regards the observers and the instruments, which of course were common to both; and this necessitated the application to both of corrections for personal equation and instrumental adjustment, which were based on the same constants, a single set of constants being employed for the whole

of the observations taken on each night. The results by the two methods were in all cases so closely identical, that there would have been no suspicion of error but for the subsequent tests which were afforded on completing and closing the circuits; and then the presence of material latent error became only too apparent.

246. Now it so happened that in the field season of 1872-73, when the electro-telegraphic operations were commenced in India, very discordant results were met with. The officers then conducting the operations were Major Herschel, R.E., and Lieutenant-Colonel Campbell, and they eventually discovered, after long and careful investigation, that the construction of one of the transit telescopes, No. 2, was defective, in that the attachment of the telescope tube to the transit axis was infirm and unstable. The instrument was placed in the hands of the Mathematical Instrument-maker at Madras and rectified, and from that time until now excellent results have been obtained, seven circuits having been completed, of which the average closing error is only 0".032. Naturally, therefore, the operations of the present year were commenced without any suspicion of instrumental defects. While they were being carried on, however, some misgivings were felt; and it was therefore decided to send the instruments for thorough examination to the Mathematical Instrument Department at Calcutta as soon as they could be spared, after the conclusion of the field season. It was then found that the instrument, which had originally given trouble, was again in fault, as will now be explained

247. In order to facilitate transport, the transit telescopes have been constructed in three pieces, the object-end tube, the eye-end tube, and the transit axis, which travel in separate cases. Before being set up for observation, the tubes of the telescope are fixed on the transit axis, for which purpose each tube carries a flange at one end, which can be bolted to the cube of the transit axis. As originally constructed by the makers in England, the tubes were simply soldered to the flange,—a very reprehensible arrangement, seeing that the joint is subject to great strain, arising from the weight of the tube and its appurtenances, which acts with considerable leverage. At Madras the soldering of the object-end tube of No. 2 was found to be giving way, and this was the cause of the bad performance of the instrument, for it introduced instability in the relations between the visual axis and the axis of rotation of the telescope. Here permanence is essentially necessary to satisfactory instrumental performance, because the value of the constants for collimation and level error are only obtained on the assumption of stability at all the joints and constancy in all directions to which the telescope is pointed—whether to stars in the zenith, to the collimators in the horizon, or to the mercury in the nadir. In order to strengthen the instrument, a metal collar was introduced inside the object-end tube and screwed to the flange. The screws passed through the tube, and thus attached it very firmly to the flange. For several years the attachment answered perfectly; but now on examination it has been found to betray signs of weakness, and to an extent that is sufficient to cause the errors which have been met with.

248. The question may naturally be put—why was not the defective state of this instrument found out sooner? The answer is that as yet no means have been invented of readily testing the relations between the visual and the rotatory axes in every position of a transit telescope, with a view to examination from time to time, whenever desirable, and more particularly *pari passu* with the observations that are being taken with the telescope. It is invariably the custom in all the great astronomical observatories, and wherever such instruments are employed, to assume that the axial relations are either absolutely constant, or that they vary systematically by known laws—as of flexure, inequality of pivots, &c.—for which due allowance can be made in reducing the observations. Thus when they happen to be unstable and inconstant, as in the present instance, the discovery of their condition is only made after the conclusion of the observations; and even then it is only made when the operations have been purposely carried out in such a manner as to show up all error, as in the present instance, by the application of the circuit test. It seems, however, to be just possible to provide a means of examining the relations between the visual and rotatory axes, whenever desirable, by fixing a small apparatus outside the object glass to reflect an image of

the wires for comparison with the wires themselves; then, by measuring the distance between the wires and their image, in different positions of the telescope, any inconstancy will at once be shown up. Experiments are being made by Lieutenant-Colonel Campbell with a view to constructing such an apparatus; and though as yet they have not been successful in surmounting the numerous difficulties which have to be overcome, success is still hoped for. If attained, it will far more than outweigh the loss even of all the operations of the present year.

249. It is probable, however, that three or four arcs of this year may, on further testing after the rectification of the defective instrument, be found free from error. It will be noticed that the last circuit of the season exhibits a far smaller error than the two first circuits. The two first lie chiefly in the North-West Provinces. They were measured during the coldest season of the year, when the daily range of temperature from extreme cold to extreme heat was much greater than it was afterwards found to be in Bengal, where the last circuit was measured as the hot season was commencing. Thus the relations between the visual and the rotatory axes of the defective transit telescope, which were probably unstable under the varying temperatures at the commencement of the field season, may have become fairly stable during the warmer and more equable temperature which prevailed towards the close of the season. This would account for the smaller errors latterly met with. Moreover, latterly the observer with No. 2 introduced a method of continuity of direction in the motion of the telescope in passing from the collimation and level observations to the stars, which probably also tended to cancel the evils caused by the defective condition of the telescope.

250. It only remains to state that, on the recent examination in the Mathematical Instrument Department at Calcutta, the attachment of the object-end tube of No. 2 to its flange was strengthened by the application of a more substantial collar than the one introduced at Madras, which has been attached to the flange by numerous screws as well as solder. Similar collars have been applied to the eye-end tube and to both tubes of the sister instrument, in all which the attachments to their respective flanges had hitherto remained in their original condition of dependence on solder alone, and were showing signs of weakness. It is to be hoped that the precautions which have now been taken will prove to be permanently effectual, and that the instruments will be found to be in as serviceable condition hereafter as they proved to be during all but the first and last years of their employment in India.

251. In the coming field season arcs will be measured to furnish an additional check on the operations of last year, and extend them eastwards to Chittagong. Later on, the first arcs of last year will be revised. This arrangement is necessary to permit of the observations at the stations in Bengal and the North-West Provinces being carried on at the times which give best promise of cloudless skies in each locality. As a preliminary to the operations of 1883-84,* pillars will be constructed for the instruments at Akyab, Prome, and Moulmein.

Mr. Bond was employed during the season under report in building the transit pillars in advance at Fyzabad, Hazaribagh, and Julpaigori, and connecting their sites with the main triangulation, and in revising the connecting triangulation at Agra, which did not contain sufficient checks within itself to be quite satisfactory. The revision showed, however, that the error in the previous determination was insignificant. Mr. Bond's work and conduct were perfectly satisfactory in all points during the season.

Mr. Keelan joined the party towards the beginning of the recess in place of Mr. Bond, who was transferred to the head-quarters office in Dehra. He was employed in reading off the chronographic sheets and in various computations, and discharged these duties satisfactorily.

Mr. Atkinson was employed under Lieutenant-Colonel Campbell, in No. 1 Astronomical Party, during the recess on computation of the previous season's work, in which he gave satisfaction.

PART II.

THE OPERATIONS AT THE SEVERAL HEAD-QUARTERS OFFICES.

These offices comprise—

(1) The Surveyor General's Office.
(2) The Revenue Survey Office.
(3) The Lithographic Office.
(4) The Photographic Office.
(5) The Mathematical Instrument Office. } All in Calcutta.
(6) The Trigonometrical Survey Office, Dehra Dun.

252. New buildings have been designed for the three other offices in Calcutta in the neighbourhood of the present building. They have not yet been commenced, and will probably not be completed for three years. But what has already been done is of very great value and importance. It has brought the administrative offices together under one roof, which will be of great help in furthering the general amalgamation of the three branches of the department—the trigonometrical, topographical, and revenue—which was commenced in the year 1878, and has as yet been only partially carried out.

Personnel.

Major R. V. Riddell, R.E., Deputy Superintendent, 2nd grade.
J. O. N. James, Esq., Deputy Superintendent, 3rd grade
H. Duhan, Esq., Personal Assistant.

DRAWING BRANCH.

Drawing and Compiling Section.

Mr. W. H. Patterson, Chief Draftsman.
„ J. A. May, Surveyor, 3rd grade.
„ W. Green, Draftsman.
„ J. R Adels „
Munshi Sonaullah „
„ Nabi Buksh „
Mr. A. J. Musgrove, Apprentice.
„ R. C. Sinclair „
„ W. P. Smith „

Geographical Examining Section.

Mr. A. Chamarett, Surveyor, 1st grade.
„ W. Todd „ 2nd „
„ A. J. Wilson „ 2nd „
„ F. Adams „ 3rd „
Baboo Mohesh Chunder Shaw and 2 others.

ENGRAVING BRANCH.

Mr. C. W. Coard, Superintendent.
„ W. Donaldson.
„ G. G. Palmer.
Mr D. L. Mitchell.
„ J. Fulford.
„ T. B. Rogers.
„ A. G. Palmer.
„ S. M. Coard.
„ A. W. N. James.
„ A. R. Coard.
„ A. D. M. Chamarett.
„ E. A. Ollenbach.
25 Native Engravers and 1 Clerk.

Copperplate Printing Section.

Mr. W T. Collins, Copperplate Printer.
14 Native Printers and Pressmen, &c

CORRESPONDENCE BRANCH.

Mr. T. W. Babonau, Registrar and Accountant.
Mr. M. Francis.
„ F. A. D'Rozario.
„ T. E. Ware.
„ E. D. Algar.
Baboo Bance Madhub Banerjee.
Mr. J. A. Vallis.
Baboo Bheecum Singh, and 9 others.

Map Record and Issue Section.

Mr. R. A. Gibson
„ H. R. Vallis.
„ W. P. Abro and 1 Native Clerk.

253. A few weeks before the close of the year under review the Department of Public Works in Bengal announced that the new building to accommodate the Surveyor-General's and the Revenue Survey offices, which had been under construction for about two and a half years, was ready to be occupied; and within a month after the close of the year the houses in Park Street and Middleton Street, in which the offices had previously been located, were vacated, and the entire stock of maps and records—the collection of nearly a century—copperplates, and plant of all descriptions, was transferred to the new building. This was an undertaking of great labour, extending over about three months, which unfortunately happened to fall in the hot season, and necessitating much forethought and careful arrangements to enable it to be carried on so as to interfere as little as possible with the current work of the office. The supervision of the arrangements for the transfer of the Surveyor-General's office—which was very much the larger of the two, and had long grown beyond the limits of the accommodation afforded by the house in Park Street, in which it had been located for half a century—devolved on Major Riddell and Mr. James; the transfer of the Revenue Survey office

devolved on Major Coddington. The whole of the arrangements were carried out most satisfactorily. The new building has been well designed and admirably constructed. It is commodious and airy; gives sufficient space for all the members of the office, excellent accommodation and lighting for the engravers and draftsmen—the former benefiting more particularly—as they had long been very inconveniently restricted in space, and for the most part were badly lighted.

1.—THE SURVEYOR-GENERAL'S OFFICE.

254. The duties connected with this office are supervised by Major R. V. Riddell, R.E., and Mr. J. O. N. James. Major Riddell conducts the work connected with the management of the topographical parties and their accounts,* and has charge of the Lithographic and the Mathematical Instrument Offices, and Mr. James has the management of the Drawing, Engraving, and Map Despatch Offices.

255. The *Drawing Branch* has been employed on work of the usual kind, viz. compilations on various scales, of maps of India, provincial and district maps, and revisions of old maps from the results of recent surveys. The large demand for the map of India, scale 1 inch = 32 miles, necessitated the issue of a second edition revised up to July 1882. Considerable progress has been made towards completing a series of outline maps of India on the scales of 1 inch = 64 miles, 80 miles, and 96 miles. As these are in great demand to illustrate reports, engraved standards are under preparation, from which prints may be taken for transfer to stone at any time. At the request of the Quartermaster-General in India, a map of Lower Egypt was drawn and published for the use of the troops proceeding from India to Egypt. Maps of the Suez Canal, Cairo, and Alexandria were also printed for the same purpose. All these were in great demand, and large numbers were sold to the public.

256. A new map of Bengal, Behar, and Orissa, with hills, scale 1 inch = 16 miles, has just been printed. Owing to the constant alterations of the boundaries of districts in Bengal, the completion of this map was long delayed; and it was eventually necessary to prepare it for publication by double printing, the boundaries and district names being drawn on one stone, the topographical details and names of towns and villages on another; thus alterations of the frequently varying details may now be carried out without injury to the permanent details, which was impossible when both were drawn on the same stone; and in future new editions of the map may be readily published soon after further changes of boundaries.

Several district maps on the $\frac{1}{4}$-inch scale were prepared for publication; also maps for the North-Western Provinces Gazetteer and drawings for the engravers for new sheets of the Indian atlas. Full details connected with all the work in progress and completed will be found in the usual statement given in the appendix.†

257. The *Examining Branch* continues to render good service in the examination and scrutiny of the mapping rendered each year by field parties of the topographical survey, also of the compilations and drawings prepared in the Drawing Branch, and of all the proofs of prints received from the Engraving, Lithographic, and Photographic branches of the office, which is a very laborious undertaking. Fifty-eight standard sheets of the topographical surveys, 25 original compilations, proofs of 138 engraved maps and of 469 lithographed and photozincographed maps, were examined in addition to other miscellaneous work.‡

258. *Engraving Office.*—The Bengal sheet (No. 4) of the standard map of India has been completed in outline, and the hill-etching will now be taken up; on sheet 5 (Madras presidency) the hills have nearly been completed; the outlines for sheet 6 (Burma and Tenasserim) are complete; sheets 1 and 3 are

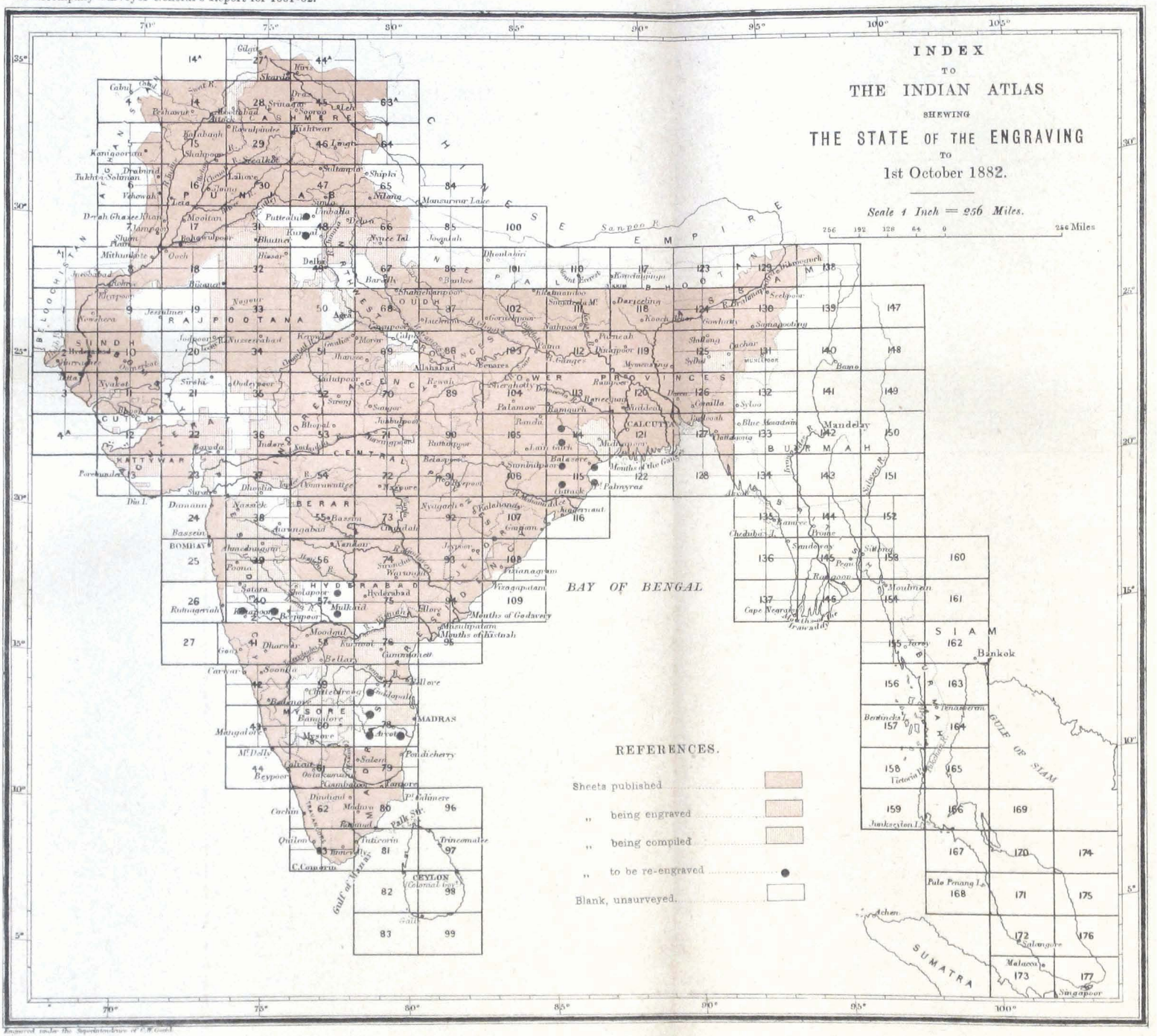
* In the Correspondence Branch Mr. Babonau has performed his multifarious duties as Registrar and Accountant very satisfactorily; Messrs. Francis, D'Rozario, and Ware, and Baboos Banee Madhub Banerjee and Bheecum Singh, have also given entire satisfaction.

† Mr. J. F. Baness, Chief Draftsman in the Drawing Branch, was transferred in March 1882 to the office of the Director-General of Statistics, and Mr. A. Chamarett officiated for him till relieved by Mr. W. H. Patterson on the 8th August. Mr. James reports that both Messrs. Chamarett and Patterson have conducted their duties ably.

Mr. W. Green and Baboo Mohes Chunder Shaw have given satisfaction.

‡ Messrs. Wilson and Adams, and Baboo Purna Chandra Sen, continue to render good aid in the Examining Branch.

To accompany Surveyor General's Report for 1881-82.



Engraved under the Superintendence of C.H. Goad.

Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,

Surveyor General's Office, Calcutta. December 1882.

as yet incomplete as regards portions of Afghanistan, Rajputana, and Central India. Great progress has been made on the hill-etching of the map of India, scale 1 inch = 64 miles, only Afghanistan and a portion of the hills on the Eastern frontier remaining to be finished. The map is expected to be ready for issue by next July or August. The map of the Central Provinces, scale 1 inch = 16 miles, has been completed, with hills. Nine quarter sheets of the Indian Atlas as per margin have been completed during the year. Forty-two others are in different stages of progress; 23 of the old large size full plates have been repaired in part, and have had additions made on them for railways and changes of boundary. Small additions and corrections have been made to other plates. Various other maps of a useful character are in hand, the details connected with the progress of which are given in the statement of work in the appendix. The total out-turn of engraving work is as follows:—2,069 square inches of hill-etching; 362 square inches of minor details, such as forest and sand hills; 3,792 square inches of outline; and 225,576 letters engraved. The hill-etching of the map of India on the scale of 1 inch = 64 miles, and on the new quarter plates of the Himalayan sheets of the Indian Atlas, is highly artistic and effective, and very creditable to the European engravers by whom it has been executed. The steel facing of the copperplates continues to be carried on successfully, and 99 plates have been thus treated before being printed from during the year. The young engravers trained in the office are now by turns employed on this work. In the Copperplate Printing Branch 7,573 impressions of maps were printed, 1,053 proofs were pulled, and 341 transfers prepared for transfer to zinc or stone.*

31 N.-W.	77 N.-E.
32 S.-W.	129 S.-E.
53 N.-W.	130 S.-E.
66 N.-W.	138 N.-W.
67 S.-E.	

259. The work in the *Map Record and Issue section* continues to increase; the map issues and work connected therewith are briefly as follows:—

	Maps.	Value.
		Rs.
To Government officials	45,029	47,120
„ India Office, London	3,015	3,954
„ Agents for sale	10,119	13,392
Total ...	58,163	64,466

Applications received for maps by letters, indents, and telegraphic messages	3,418
Letters issued in reply and as advice of despatch	1,072
Invoices and receipts issued	3,091
Packets, parcels, and packages despatched	3,115

In addition to the above 23,236 sheet maps were coloured by contract for sale and issue, and 7,375 for other departments. The amount realized by map sales through agents and deposited in the Government treasury was Rs. 10,211-10-9.†

260. The work of rearranging, classifying, and cataloguing the original maps is proceeding steadily, and will probably take another year to complete. This work was much needed, not merely as a matter of convenience, to facilitate ready access to any map that might be wanted and to indicate the maps to which reference should be made for specific facts, but because the numerous changes in territorial limits which have taken place in India during the past century caused some difficulty in identifying the portions of country to which they actually refer under the existing territorial divisions of British and Native districts and States. Moreover, the old register volumes in manuscript, which have been in use for the past 60 or 70 years, have become almost illegible from constant use and the fading of the ink. Steps are being taken to print the new register or catalogue in the same form as the catalogue of manuscript and printed reports, field-books, and maps, &c., in the India Office, London.

* In the Engraving Branch the Superintendent, Mr. C. W. Coard, and his European assistants, have worked ably and well, and the native engravers under their tuition are making good progress.

† Mr. R. A. Gibson, Map Curator, is a most useful assistant, and performs his duties ably.

2.—THE REVENUE SURVEY OFFICE.

261. The Revenue Survey Office receives and examines all maps and other professional records executed by the 10 field parties at present constituting the Revenue Survey Branch of the department. This office also has charge of the records of all previous surveys executed by the Revenue Branch, and replies to references connected with these completed surveys. The office likewise supervises the expenditure in the Revenue Branch, and keeps its accounts. A summary of the out-turn of the field work in the several parties of this Branch, with statement of cost and rates, is given at pages 78 and 79. The Statements A and B (pages 85 to 91 of the appendix) exhibit the maps and other records prepared in the field offices and head-quarters office respectively, and Table C (page 92 of the appendix) gives a detailed statement of the number of cadastral maps printed since the commencement of cadastral survey operations, as well as the number printed during the past year.

Personnel.

Lieutenant-Colonel J. Sconce, Deputy Surveyor-General and Superintendent, Revenue Branch.
Major F. Coddington, Deputy Superintendent, 2nd grade.

DRAWING AND COMPUTING BRANCH.

Drawing and Compiling.

Mr. F. W. Kelly, Surveyor on duty.
„ J. Connor, Assistant Surveyor and Draftsman.
Baboo Hari Hur Sen, Head Computer.
„ Tincowry Sen, Computer.
Sheikh Mehir Ali, Draftsman.
„ Golam Mohumud „
„ Abdul Azeez „
„ Robim Bux „
and 14 others.

Map-examining.

Mr. T. W. Reilly, Surveyor and Draftsman.
Mr. R. C. D. Ewing, Assistant Surveyor and Draftsman.
Sheikh Abdur Rozak, Draftsman.
„ Wahed Bux.

Cadastral Map-examining.

Mr. W. Sinclair, Surveyor and Draftsman, on furlough from 21st April 1882.
Mr. J. H. O'Donel, Surveyor and Draftsman.
Sheikh Kodrut Ally, Draftsman, and six others.

Records and Map issue.

Mr. W. J. Lane, Assistant Surveyor (died on 11th October 1882).
Baboo Ashootosh Ker and one other.

CORRESPONDENCE AND ACCOUNTS BRANCH.

Correspondence.

Mr. A. E. Byrn, Registrar.
„ A. C. Cunningham, Head Clerk.
Baboo Kally Pudo Banerjee, Clerk.
„ Doorga Narain Ghose, do.
„ Ramkisto Chunder, do.
„ Shama Churn Chuckerbutty, Clerk.
Baboo Raj Coomar Dutt, Clerk.
„ Kally Kisto Chunder, Despatcher, and three others.

Accounts.

Mr. Gopal Chunder Laha, Head Accountant.
Baboo Bama Churn Chuckerbutty, Accountant, and two others.

262. The following is a brief review of the summary of the field work as shown in the table at page 78. A column has been added to the table showing the rate of the cadastral surveys per field, besides the usual rate per acre. The general rate for the cadastral surveys in the North-West Provinces is Rs. 138-13-3 per square mile (Re. 0-3-6 per acre), which bears a favourable comparison with Rs. 159-4-11 per square mile (Re. 0-4-0 per acre), the rate for last year. The diminution in the total area surveyed cadastrally in these provinces is accounted for by the withdrawal of one of the three parties hitherto employed. The three cadastral parties in British Burma have surveyed 231 square miles more than last year, and have worked at a cheaper rate, the general rate for the year being Rs. 232-4-9 per square mile (Re. 0-5-10 per acre), against Rs. 250-8-7 per square mile (Re. 0-6-3 per acre) of last year. The rates for the 4-inch surveys in the Punjab are slightly higher on account of the areas—all that remained for survey—being less than last year. The low rate of Rs. 53-6-2 for the 4-inch survey, done for forest purposes in the Bombay presidency, has been obtained by reason of the extent of open country which has been surveyed with the forest lands. A small area of forest reserves in British Burma has been surveyed at a high cost, occasioned by the extremely intricate nature of the country. The topograpical surveys on the 2-inch scale have been accomplished at very similar rates as in previous years. The very low rate of the survey in the southern collectorates of the Deccan is due to the greater part of the country being open and easy for survey. The new topographical survey of the banks of the Hooghly river in the neighbourhood of Calcutta has proved a very tedious and costly undertaking; the intricate village sites lying along the river, and forming the greater part of the area surveyed, have rendered the work more minute than the survey of many a town would be.

263. The following maps, drawn in executive offices, have been examined and published during the year, viz.—

District Rawalpindi, Kala Chitta Pahar	13 sheets on 4-inch scale.
Meerut Division, Topographical Survey	64 sheets on 2-inch scale, for reproduction to scale.
Ditto ditto	76 sections on 2-inch scale, for reduction to 1-inch scale and publication in 19 sheets.
British Burma, district Hanthawaddy	16 sheets on 2-inch scale, for reproduction to scale.
Deccan and Konkan Topographical Survey	36 sheets on 2-inch scale, for reproduction to scale, and the same for reduction to 9 sheets on 1-inch scale.
District Pooree, Killa Khorda	40 sheets on 4-inch scale.
Patna City and Bankipore civil station	2 sheets on 10-inch scale.
Cadastral maps of single villages, in districts in North-West Provinces	2,540 sheets on 16-inch scale.
„ „ in districts in British Burma	2,430 ditto 16-inch do.
„ „ in district Pooree (Bengal)	104 ditto 32-inch do.
„ „ in district Sylhet (Assam)	16 ditto 16-inch do.

264. The following maps, drawn in the Revenue Survey Office, have also been examined and published, viz.—

Dera Ismail Khan	9 sheets on 1-inch scale (drawn in 36 sections on 2-inch scale).
Midnapore	1 sheet on 1-inch scale (drawn in 4 sections on 2-inch scale).
Moradabad and Budaun districts and Rampur State	1 sheet on 1-inch scale (drawn in 4 sections on 2-inch scale).
Oudh districts (new edition)	6 sheets on 1-inch scale.
Noakholly district	11 sheets on 1-inch scale.

265. Besides the examination and drawing of maps as shown above, the time of the draftsmen has been largely occupied, as will be seen from Table B, in supplying copies of miscellaneous maps and records to Government officials. Attention to the demands of private individuals for copies of village plans has engaged a large part of the time of a section of the office. The actual copying of the plans is done at the expense of the applicants, but the labour of identifying the plans according to the descriptions sent falls upon the office draftsmen, and the draftsmen also supervise the copying. Applications for copies of plans come almost exclusively from Bengal.

266. All the records received have been examined and brought on the register of the office, the usual final check on the computations having been carried out for three districts.*

267. The Deputy Surveyor-General acknowledges the very valuable assistance he has received from Major F. Coddington in all matters connected with the administration of the Revenue Branch.

3.—LITHOGRAPHIC BRANCH.

268. The number of maps, plans, and drawings published during the year amounts to 421, of which 267 were undertaken to meet the requirements of other departments, and only 154 for the requirements of the Survey Department.

Personnel.

Major R. V. Riddell, R.E., in charge.
Mr. H. L. Lepage, Head Assistant.
Babu Boloram Nath,
Munshi Mahomed Azim,
„ Sobhan Buksh,
and 22 others,
} Draftsmen.
Mr. H. Niven, Chromo-Litho Printer, on leave.
„ J. Watson, „ „ officiating.
1 Press Assistant and 60 others.
Mr. E. D'Pyvah, Type Printer, and 22 others.
Three native clerks.

269. It has been found necessary to commence a reprint of the one-inch scale sheets of Oudh; two sheets have been printed, and several are now in hand; 11 sheets of the one-inch maps of Noakholly have been published.

* Mr. F. W. Kelly, Surveyor, 1st grade, as head of the drawing section of the office, has continued to render excellent service.

Mr. W. Sinclair, Surveyor, 2nd grade, in charge of the cadastral map examination, continued to give entire satisfaction up to the time of his going on furlough. Mr. J. H. O'Donel, Surveyor 4th grade, who took over Mr. Sinclair's duties, has also done very well. Messrs. J. Connor and R. C. D. Ewing, Assistant Surveyors and Draftsmen, have done good and approved work. The office has to regret the loss of Mr. W. J. Lane, Assistant Surveyor and Draftsman, a useful and intelligent officer, who died on the 11th October 1882.

Mr. A. E. Byrn, Mr. A. C. Cunningham, Mr. Gopal Chunder Laha, Baboos Harri Hur Sen, Kally Pudo Banerjee, Doorga Narain Ghose, Ram Kisto Chunder, Bama Churn Chuckerbutty, Tincouri Sen, Sheikhs Meher Ali, Abdul Azeez, and Rohim Bux, together with the rest of the establishment, have all given satisfaction.

The new maps of Bengal with hills, scale 1 inch = 16 miles, which has already been referred to in paragraph 256, was printed on two stones—the topographical and other permanent details in black, the varying district boundaries in red. A preliminary map of the Central Provinces, scale 1 inch = 16 miles, obtained by a transfer to stone from the incomplete engraved plates and the hills in part drawn on stone, has been issued. Six sheets of the Indian Atlas (Nos. 30, 40, 48, 67, 112, and 119), the copperplates of which were in a damaged condition and unfit to repair, were transferred to stone and printed with large additions and corrections. The following district maps were completed:—Seebsaugor, Goalpara, Khulna, Dacca, Sylhet, Beerbhoom, Balaghat, Sonthal Pergunnahs, Kamroop, and Raepore, scale 1 inch = 4 miles; Hoshiarpore, scale 1 inch = 2 miles in four sheets.

270. From other departments 337 subjects comprised in 346 sheets were received for publication, and the value of the work performed amounts to Rs. 20,111.*

4.—THE PHOTOGRAPHIC OFFICE.

271. Major Waterhouse returned from furlough and resumed charge from Major Cowan on the 26th December 1881.

Personnel.

Major J. Waterhouse, B.S.C., Assistant Surveyor-General, in charge.

NEGATIVE BRANCH.

Normal Establishment.

Mr. J. Mackenzie, Photographer.
„ C. DeCruze, Asst. „
Ismail Khan „ „
2 negative retouchers, 2 glass-cleaners, and 1 bhisti.

Cadastral Establishment.

Mr. C. Marshall, Photographer.
„ L. Lognier „
„ T. Lloyd, Asst. „
4 Assistant Photographers, 3 negative retouchers, 4 glass-cleaners, and 1 bhisti.

PHOTO-TRANSFER PRINTING.

Normal Establishment.

Mr. J. Harrold, Photographer.
Habibul Hossain, Asst. „
2 labourers.

Cadastral Establishment.

Mr. R. George, Photographer.
2 Assistant Photographers and 4 labourers.

SILVER-PRINTING BRANCH.

Normal Establishment.

Mr. G G. Dempster, Photographer.
2 Assistant Photographers and 2 labourers.

ZINC-PRINTING BRANCH.

Normal Establishment.

Mr. B. Mackenzie, Zincographer.
1 writer, 4 zinc correctors, 5 printers, 4 spongemen, 16 pressmen, and 3 grainers.

Cadastral Establishment.

Mr. J. Watson, Zincographer (on deputation) to Litho Branch from 10th April 1882.
Mr. E. A. LeFranc, Zincographer.
1 writer, 8 zinc correctors, 7 printers, 4 spongemen, 15 pressmen, and 6 grainers.

GENERAL OFFICE ESTABLISHMENT.

Normal Establishment.

Baboo Kanny Lall Sen, Store-keeper and Accountant, and 2 clerks.

Cadastral Establishment

Head Assistant (vacant), and one clerk.

272. The out-turn of the office during the year is given in the annexed abstract, and shows a considerable increase in the number of original subjects reproduced, though with a decrease in the number of printed copies, as fewer prints were demanded. Statements showing the comparative out-turn of the present year and the year before, of expenditure and value of work done, and of work done for other departments, are given in the Appendix.

273. The value of the printed maps and other subjects issued during the year has been—

	Rs.
Departmental	28,428
Extra departmental	16,531
Cadastral	69,836
Total ...	1,14,795

The direct expenditure for establishment and stores has been Rs. 93,146, so that the profit to credit of the department amounts to Rs. 21,649.

274. The subjects received for reproduction during the year have been of the usual miscellaneous character. A large number of maps of Egypt and charts of the Red Sea, Suez Canal, Alexandria, Port Said, and Suez were reproduced for the use of the Indian contingent, the military authorities, and the general public. Happily, provision had been made of the best available maps of Egypt and the Suez Canal, chiefly French; and from single copies of these we were able to meet demands till better maps were received from England. The way in which these sudden calls for war maps can be met by photozincography is the best exemplification of its practical value. Of the War Office map in 4 sheets only two copies were received in this country, but by reproducing one

* Mr. H. L. Lepage, Head Assistant, has performed his duties satisfactorily with the aid of Mr. Watson, who has been temporarily transferred from the Photographic Office to supervise the chromo-lithographic printing, *vice* Mr. Niven, absent on leave. Mr. D'Pyvah, type printer, and the native draftsmen and clerks, have worked well.

we were able to supply 400 copies, in 1,600 sheets, of this very useful map in a very short time ; besides redrawing it on blue prints and reproducing it on half scale, so as to bring it into one sheet.

275. The number of sheets of cadastral maps printed off and issued during the year was 4,856, which is 311 sheets more than last year, though the number of copies printed is less, owing to the North-Western Provinces Government only requiring 10 copies of each sheet.

276. An improvement has been introduced into the process of intensifying negatives, by which the use of hydrosulphate of ammonia is dispensed with, thus avoiding the very unpleasant smell of this chemical and effecting a very considerable saving in expense. Improvements have also been made in the photo-transfer process by the use of enamelled transfer paper, which gives much sharper prints than the paper ordinarily in use.

277. Some progress has been made in the introduction of heliogravure ; an improvement in the method of graining the gelatine reliefs by means of waxed sand, which was effected by Major Waterhouse recently while on furlough, has put the process on a very practical footing for half-tone work. The system of electrotyping adopted at Vienna is found to answer very well, being exceedingly simple and regular in action. There are still some difficulties to overcome in the application of the process to large map work, which have formed the subject of considerable experiment during the year. Two plates of very delicate shaded drawings of basalt crystals have been reproduced, and 800 copies of each printed for the Geological Survey ; four more plates of the same kind are in hand. The advantages of the process over lithography for this kind of work are the fidelity with which every touch of the artist is reproduced and the evenness of the printing ; the plate, when once steel-faced, yields an almost unlimited number of equally good impressions. The process has been very fully described with all late improvements in Major Waterhouse's report, given in the appendix, in which will also be found further details of the working of the Photographic Office during the year.*

Abstract of Work performed in the Photographic Office from 1*st October* 1881 *to* 30*th September* 1882.

	Original sections or sheets.	Negative plates.	Photographic transfer prints.	Number of plates.	Number of pulls.	Number of printed sheets of each subject.		Silver and other prints.	Cost.
						Single.	Combined.		Rs. A. P.
Topographical maps	162	273	240	71	8,495	8,505	8,503	104	7,189 10 3
Revenue survey maps	300	506	627	80	17,272	17,272	17,272	.....	13,810 7 3
District maps	2	6	.....	2	400	400	400	.....	185 4 9
General maps	4	9	.....	37	6,050	3,350	3,150	27	1,336 0 9
City and cantonment plans	18	59	68	34	4,845	4,865	2,725	.....	2,375 10 7
Miscellaneous, departmental	354	476	320	209	15,805	32,921	27,712	310	10,056 2 11
Ditto extra departmental	420	519	557	367	43,725	57,905	47,565	92	17,908 11 6
Transfers and proofs	.....	.....	.....	.....	2,455	.....	.....	.....	.....
Total ...	1,250	1,848	1,813	800	99,047	125,218	107,329	533	52,922 0 0
Cadastral, North-Western Provinces.									
Photozincographs	1,920	1,920	1,930	1,931	19,410	19,410	13,310	.....	29,807 9 0
Zincographs	594	.....	.....	594	5,940	5,940	5,630	.....	6,128 2 0
Total ...	2,514	1,920	1,930	2,525	25,350	25,350	18,940	.....	35,935 11 0
Cadastral, British Burma.									
Photozincographs	1,584	1,584	1,605	1,592	54,160	54,160	20,265	.....	25,870 14 6
Zincographs	762	.....	.....	762	26,248	26,248	9,044	.....	8,578 13 0
Total ...	2,346	1,584	1,605	2,354	80,408	80,408	29,309	.....	34,449 11 0
Cadastral, Bengal.									
Photozincographs	104	104	104	104	3,782	3,782	955	.....	1,086 8 0
Zincographs	1	.....	.....	1	50	50	50	.....	13 4 0
Total ...	105	104	104	105	3,832	3,832	1,005	.....	1,099 12 0
Cadastral, Assam.									
Photozincographs	16	16	16	16	400	400	325	.....	244 0 0
Transfers and proofs for cadastral maps ...	.....	.....	.....	.....	6,075	.....	.....	.....	.....
GRAND TOTAL ...	6,241	5,472	5,473	5,797	218,712	235,208	156,908	533	1,25,260 2 0

* Major Waterhouse reports favourably of his European assistants, Messrs. J. and B. Mackenzie, Harrold Marshall, George, Lagnier, Le Franc, and Dempster, who all continue to work with their usual zeal and steadiness, and of the head clerk, Baboo Kunnya Lal Sen.

5.—THE MATHEMATICAL INSTRUMENT DEPARTMENT.

278. The financial year 1881-82 was a busy period for this Department, especially during the last five months of the year, when the demands, due chiefly to the requirements of railway extension surveys, taxed its resources very heavily.

Personnel.

Major R. V. Riddell, R.E., Superintendent.
Major S. H. Cowan, S.C., Officiating Superintendent, from 3rd July to 2nd October.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument-maker.
Mr. F. Marshall, Assistant Mathematical Instrument-maker.
64 artificers on the permanent establishment.
75 (on an average) artificers on the temporary establishment.

Store Branch.

Mr. G. R. Alderman, Store-keeper.
Baboo Womesh Chunder Chowdhry, Material Store-keeper.
1 Packing sircar.
2 Packers.

Office Branch.

Mr. M. O'Brien, Head Clerk.
„ J. W. Collins, Second Clerk.
6 other permanent clerks.
1 extra clerk.

279. The total number of instruments, &c., received amounted to 26,220. These were valued at Rs. 1,70,080, and the result was derived from the following detail:—4,970 instruments, in value about Rs. 28,130, were received from England; 4,685 were locally purchased at a cost of Rs. 23,390; about 9,010, were manufactured in the workshop at a cost of about Rs. 17,720; about 7,560, valued at Rs. 1,00,850, were received by inter-departmental exchange; of these about 22 per cent were serviceable, and the remainder repairable. The serviceable stock was further increased by the repair on the premises of more than 2,850 instruments (part of the repairable stock), at a cost of a little over Rs. 12,300, which, after repair, were valued at about Rs. 32,120.

280. More than 20,800 instruments, in value very nearly Rs. 1,74,100, were issued during the year, viz.—

	Approximate Number.	Approximate Value.
		Rs.
To the Survey of India Department	7,240	31,620
„ Marine „	320	6,000
„ Telegraph „	190	1,310
„ Military „	400	6,940
„ Public Works „	7,590	1,02,390
„ Educational „	60	490
„ Miscellaneous „	4,250	20,690
„ Road Cess Committees, District Engineers, &c., entitled to receive instruments on payment when they can be spared ...	540	3,820
„ Workshop to complete repairs of instrument	240	820
Total ...	20,830	1,74,080

About 1,570 instruments were repaired for various departments, at a cost of about Rs. 14,100.

281. The total number of instruments issued was very little greater than the number issued during the previous year, but the proportion of expensive instruments having been much greater during the latter year, the total value of the instruments issued was about 50 per cent in excess of the issues of the previous years. This result was caused by the largely increased requirements of the Public Works Department (due, as before stated, to Railway Extension Surveys), to which the average number of instruments issued in the years 1878-79-80-81 was 4,160, at a value of Rs. 35,200; while in the year under report 7,590 instruments were supplied to that Department, at a value of Rs. 1,02,390.

282. The average number of theodolites and levels issued annually during the three years 1878 to 1881 was 88 for the former and 78 for the latter instruments. During the year under report the numbers were 118 and 198 respectively, and more could have been used if they had been available.

283. The stock of instruments locally purchased was exceptionally great; and as it was purchased under very unusual conditions, no comparison can be made with the supply procured from this source in any other year. In the month of August a requisition was received from Burma for a large supply

of instruments for Railway Extension Surveys. Similar demands soon followed from other quarters, and before the end of the calendar year the stock of instruments used in those operations had been completely exhausted; while at the same time a large number of these instruments were still required for immediate use. It is found that the demand could be met to a great extent by local purchases. Consequently, at the end of the month of January application was made to the Government of India, in the Public Works Department, for an extra grant of Rs. 35,000 for the purchase of instruments for that Department. Sanction to this measure was granted in letter No. 538, dated 15th February 1882, from the Under-Secretary to the Government of India to the address of the Surveyor-General; and although by that time the number procurable in the local market was somewhat lower than what had been ascertained to exist in the month of January, purchases to the extent of nearly Rs. 23,800 were made, and the instruments issued before the end of the financial year.

284. The number, class, and cost of the principal instruments purchased are as follows, viz.—

Designation of Instruments.	Number.	Cost.
		Rs.
Chronographs	2	100
Compasses, prismatic	8	715
Glasses, binocular	6	300
Instruments, drawing, in cases, 1st and 2nd sort ...	65	3,730
Ditto, ditto, miscellaneous, single ...	65	727
Lenses, reading	10	41
Levels, dumpy	15	3,950
Pins for maps	3,552	252
Rules, carpenters'	72	147
Do., parallel, of all sorts and sizes	93	1,221
Scales, in sets	68	1,622
Do., single	62	199
Set squares in sets	18	145
Staves, leveling	116	2,463
Tapes, measuring	333	2,195
Theodolites	12	4,272

285. The articles which form the bulk of the manufactures in the workshop, and the cost of their manufactures, are as follows:—

Names of Instruments.	Number.	Cost of manufacture.
		Rs.
Boards, drawing	89	1,182
Chains, measuring	219	2,145
Clinometers, wooden	36	504
Compasses, magnetic, for plane-tables	38	456
Glasses, tracing	6	289
Machines, map-printing	13	696
Pins, for measuring chains	6,000	1,000
Plane-tables	164	1,622
Pluviometers	35	833
Rules, flat	610	328
Do., sight, for plane-tables	247	1,235
Scales, metal	81	850
Squares, optical	12	78
Stands for various instruments	177	1,914
Staves, leveling	25	375
Cases, packing	584	2,784

286. A new lens-polishing machine has been constructed in the workshop. This machine supplies a want which has long been felt. Lenses which would formerly have been condemned as useless can now be restored and be made perfectly serviceable.

287. The total number of instruments repaired in the workshop was a little over 4,400, and the cost of the repairs was Rs. 26,400 very nearly. The principal instruments repaired were as follows, viz.—

Names of Instruments.	Number repaired.
Anemometers	16
Arithmometers	6
Barometers	53
Chains	326
Compasses, magnetic	30
Ditto, prismatic	54
Ditto, surveying	84
Glasses, binocular	17
Instruments, drawing, miscellaneous	965
Instruments, drawing, cases of 1st, 2nd, and 3rd sort	91
Levels, dumpy	171
Rules, flat and parallel	178
Scales	46
Sextants	15
Stands for various instruments.	257
Staves, leveling	218
Tapes	35
Telescopes	31
Theodolites	103

The number of instruments repaired was about 20 per cent less than that repaired during the previous year, but the defect in number is made up in quality; for the number of levels and theodolites (which are among the more intricate class of instruments passing through the workshop) repaired during the year under report was 274, exceeding by 69 the average number of corresponding instruments repaired during the previous three years, although one of them, viz. the year 1878-79, was productive of an exceptionally large out-turn of work.

288. As stated in paragraph 241 of last year's report, three classes of articles in constant demand, in the manufacture of which no great amount of skill is necessary, had been manufactured by artisans in the town, at a cost of about Rs. 845, and endeavours were being made to extend the system. Two more articles, viz. frames for level staves and frames for optical squares, were added to the list of component parts which can be procured in this manner; and although a sum of Rs. 860 only was spent on this class of work, more could have been spent if this Department could have received timely notice of the unusual demands which were made on it during the last half of the financial year 1881-82.

289. The space available at present for the storage of instruments does not admit of a greater stock being kept than is sufficient to meet average demands; and as when an extra large supply of certain classes of instruments is wanted it is generally wanted urgently, it is very desirable that the stock kept ready for issue should be greater than is at present possible. A project for a new building has been sanctioned by Government, and it is believed that the new building is now being designed. When completed, some of the difficulties with which this Department has to contend should be removed; and the sooner it is ready for occupation the better, for it is clear that the work of the Department is increasing.

290. The profit and loss account of the workshop showed a profit of a little over Rs. 300, the charges having amounted to Rs. 45,914, whereas the value of the work done was calculated at Rs. 46,227. Last year, as stated in

paragraph 242 of the annual report, this account showed a loss of about Rs. 1,800. In the year 1879-80 a profit of Rs. 13 was shown, and as the loss in 1880-81 was probably attributed by Major Riddell to the proper source, the results of the three years appear to show that the rates charged by the workshop are as nearly correct as is possible. The cost of the remaining portion of the establishment, including supervision, packing expenses, office accommodation, &c., was about Rs. 19,320, which may be considered to represent the expenses connected with the receipt and issue of about 53,500 instruments, valued at about Rs. 4,24,000.*

6.—THE TRIGONOMETRICAL SURVEY OFFICE.

291. The principal work of this office is the final reduction and publication of the triangulation of all parts of India, and the reproduction of the topographical surveys executed in the Trigonometrical Branch of the Department. The office being located at Dehar Dun, at a considerable distance from Calcutta, has a drawing, a photozincographic, and a printing branch of its own. It is thus independent of all extraneous assistance in the matter of publication, excepting as regards the binding of its printed matter, which has to be done elsewhere, usually at Calcutta. The office has also a depôt of instruments and stores attached to it, chiefly containing the higher class of instruments appertaining to the Great Trigonometrical Survey, of which it has long been the head-quarters office. It is now, and has for many years been, under the immediate and able superintendence of Mr. Hennessey, M.A., F.R.S., aided by Mr. Cole, M.A.

Personnel.

J. B. N. Hennessey, Esq., M.A., F.R.S., Deputy Superintendent, 1st grade, in charge.
W. H. Cole, Esq., M.A., Deputy Superintendent, 4th grade.

Computing Branch.

Mr. C. Wood, Surveyor, 2nd grade.
„ H. W. Peychers, Surveyor, 4th grade.
Baboo Gunga Purshad, Computer.
„ Kally Mohun Ghose, do.
„ Kally Coomar Chatterjee, Computer.
10 other Computers, &c.

Printing Branch.

Mr. B. V. Hughes, Printer.
13 compositors and apprentices.

Correspondence, Stores, &c.

Mr. H. E. T. Keelan, Surveyor, 2nd grade (to 1st July).
Mr. J. Bond, Assistant Surveyor, 1st grade (*from 1st July*).
2 native writers.

Photozincographic Branch.

Mr. C. G. Ollenbach, Zincographer.
„ C. Dyson, Photographer.
2 Native Draftsmen.
1 Assistant Draftsman.
1 Map-keeper.

Drawing Branch.

Mr. G. W. E. Atkinson, Surveyor, 2nd grade.
Jafer Khan and 6 other Draftsmen.
19 Assistant Draftsmen and Map colourists.

Solar Photography.

Mr. L. H. Clarke, Surveyor, 2nd grade, and Solar Photographer.
Mr. C. F. Guthrie, Assistant to ditto.

292. The more important calculations of the year were those in connection with—(1) the Southern Trigon, which comprises the whole of the principal triangulation south of $18\frac{1}{2}^{\circ}$; (2) the observed latitudes; (3) the Assam Longitudinal Series and Assam Valley triangulation. Much assistance was also rendered in bringing up the field computations of the Eastern Frontier Series, including the principal triangulation, the Mergui base-line, the astronomical observations at Mergui and Moulmein, and the Burma secondary operations, all which were carried on with a view to facilitate the final reductions to be made hereafter. The Gilghit triangulation by Colonel Tanner was also computed, various tables were prepared for the details of the North-East Quadrilateral, which are given in Volume VII of the final account of the principal triangulation, and some secondary operations were finally adjusted and reduced.

293. The reduction of the Southern Trigon by the simultaneous method adopted for the three preceding Quadrilaterals was commenced last year, and has been completed this year, very satisfactorily, as appears from the values of the residual errors which are given in the appendix. The auxiliary figures now alone remain for adjustment.

294. The final reduction of all the Astronomical latitudes observed up to date in connection with the geodetic operations of this survey is reported to have made good progress, "in keeping with the fact that under pressure to meet immediate wants only one pair of computers could be employed on the work, and that for little over half the year. The reduction, moreover, presents a considerable undertaking, involving, as it does, observations to

* Major Riddell reports that he is well satisfied with the work of Mr. T. Bolton, the Instrument-maker, and with that of Mr. T. Marshall, the Assistant Mathematical Instrument-maker, who is a very useful acquisition to the workshop. The store-keeper and office clerks have worked assiduously and as successfully as can be expected

large groups out of 906 stars at 117 stations, so that more rapid progress under the circumstances was not practicable. Contributions towards the volume of latitudes, to be printed, have been secured to the extent of description by Lieutenant-Colonel Campbell of Strange's zenith sector, with drawings of the same instrument by Major G. Strahan." The final reductions depend on an elaborate analysis by Mr. Hennessey of the several values of the places of the observed stars, which are given in the various published catalogues of stars' places, sometimes with material differences between different catalogues.

295. Volume VII of the Account of the Operations of the Great Trigonometrical Survey was completed and placed in the hands of the book-binders by the close of the year under review. Volumes VII and VIII are devoted to the several chains of triangles—sixteen in number—comprised in the North-East Quadrilateral, the great geodetic figure, which—speaking broadly—covers the area included, from north to south, between the Himalayan mountains and the parallel of Calcutta, and from west to east, between the Central Indian meridian and the Eastern frontier. Volume VII gives full details of the simultaneous reduction of all the chains of triangles, an operation which was performed under the immediate direction of Major Herschel, R.E., F.R.S., during the absence of Mr. Hennessey in Europe, and the details of five out of sixteen of the included chains of triangles. Volume VIII gives the details of the remaining eleven chains. It was completed and placed in the hands of the book-binders by Christmas 1882. While these pages are being passed through the press, both volumes are being distributed to the principal scientific libraries and geodesists in all quarters of the globe.

296. It had been intended that Volume IX, the next for publication, should be devoted to the details of the astronomical observations for latitude and their final reduction; but delays occurred to prevent this intention from being carried out. Meanwhile considerable progress had been made by Lieutenant-Colonel Campbell in the preparation of the volume which is to give an account of the electro-telegraphic determinations of differences of longitude. The printing of this volume has therefore been pressed forward. 290 additional pages have been printed, and the volume will probably be ready for issue by April 1883. It will be published as Volume IX of the series.

297. Of the Synoptical Volumes, which give a *précis* of the results of the whole of the triangulation, both principal and secondary, for the requirements of topographers and geographers, Volumes VII, X, XI, XII, and XIII have been distributed, and progress has been made with the volumes of the Assam Longitudinal Series and Assam Valley triangulation, and of the Gurwani Series.

298. In the report for last year it was pointed out that the lines of spirit levels in the Bombay and Madras presidencies, which connect the tidal stations at Okha—near the entrance to the Gulf of Cutch—Bombay, Karwar, and Madras, present the anomaly of raising the southern points relatively to the northern, and that this is probably due to an accumulation of minute errors caused by oblique illumination of the bubbles of the spirit levels. It was also stated that the mean-sea level, as determined at each tidal station, would be assumed to be the datum to which the spirit levels should be referred in each instance, and that any discrepancy which might be met with on closing a line of levels at a tidal station (purely oceanic and not riverain) would be dispersed over the line and treated as an error generated in the leveling operations. In accordance with this arrangement, the lines of levels connecting Bombay, Karwar, and Madras have been adjusted simultaneously by the method of least squares; pamphlet No. 4 of Heights in Southern India from the Spirit-leveling operations has been prepared and is in press, and suitably amended issues will be made of the pamphlets previously published.

299. The sheets 75 and 82 of the charts of spirit levels, which were drawn in 1880-81, have been printed and distributed, and four other sheets are in hand. Additional data have also been collected from several districts in Bengal, and will serve to illustrate the sheets of that province, not issued hitherto from want of material. It is hoped that several additional sheets will be ready for publication next year.

300. A new edition, the sixth, of the map of Turkestan is under compilation, in communication with the Foreign Department, to which proofs of the

map have already been submitted. It is intended to include all the geographical information received up to date from officers and explorers of the Survey Department, notably from the recent operations in Afghanistan, Colonel Tanner's surveys around Gilghit, and the work of explorer M— S— in and around Badakhshán, and from all other available sources—as Regel's (part of) Darwaz 1882; Schindler's Routes, Persia, 1880; Floyer's Beluchistan, 1882; Turkestan Military Circuit (Russian Topographical Department), 1880-81, &c.

301. All the maps of the current year's work of the Guzerat and Cutch parties have been examined and published; a few preliminary charts of triangulation have been compiled and published, but of course this work has been materially diminishing of late years, as the field operations have been gradually coming to an end; but a large amount of miscellaneous work has been executed, as detailed in the appendix. For the Forest Survey Department 17 maps and 1 chart were passed to press and published. The money paid to this office for maps and charts during the year was Rs. 743.

302. The Colby apparatus of compensation bars and microscopes and its appurtenances—including standard bar A, with which comparisons of length have been made at all the base-lines—is always lodged for protection in the office at Dehra when not actually in use. Fourteen years having elapsed since the measurement of the Cape Camorin base-line, when it was last employed, it had to be carefully examined and put into good working order before being sent to Mergui for the base-line, which was measured there this year. This was done by Mr. Hennessey conjointly with Colonel Branfill.

303. The important duty of watching over the protection of the principal stations of the Great Trigonometrical Survey continues to be carried on. In all there are 3,472 stations in 338 districts, involving correspondence and accounts with each district officer. During the year 764 stations were specially protected or repaired, at an average cost of Rs. 4-8 per station. Of the district officers who should have sent annual reports, about one-sixth failed to comply.

304. Mr. Hennessey reports that "various scientific duties continue to present themselves for discharge, with a growing tendency." Meteorological observations at Dehra and Mussooree are of long standing. These were taken during the year, as usual, and a daily weather-telegram was sent from Mussooree to the Meteorological Reporter to the Government of India during the months of April to November. Earth temperatures have been observed daily, and the mean monthly results for about a year and a half will be found in the appendix. Actinometry was commenced in 1869 by Mr. Hennessey, who has subsequently also availed himself of favourable opportunities when at Mussooree to observe: occasional measurements were made last year: four of the assistants, two being natives, are now able to use the instrument. Mr. Hennessey's results have been published and discussed in various numbers of the proceedings of the Royal Society, and the subject having attracted attention of the Solar Physics Committee, South Kensington, the Secretary of State has sent out Sergeant Rowland, R.E., to act under the Meteorological Reporter to the Government of India in taking a series of observations at Leh, extending over two years or more. Mr. Blanford has placed the Serjeant temporarily under Mr. Hennessey, who is instructing him and arranging for the required work. As one of the miscellaneous items may be mentioned an appeal from Professor Schuster, Secretary to the Meteoric Committee, presided over by Sir William Thomson, for collecting evidence as to the presence of well-known meteoric components deposited as dust on the earth's surface, for assistance in procuring *desert* sand and condensed water from *unbrodden* snow—a request which has already been complied with in respect to sand, but has not yet been found practicable as regards snow.

305. The explorer M— S— having returned after nearly four years' absence from India with valuable traverses in and around Badakhshán, his journal and itinerary have been translated; and the illustrating sketch map prepared, which is given in section XXVI of Part I of the present report.

306. Solar photographs for the Solar Physics Committee, South Kensington, were taken on every day of the year when the sun was visible: invisibility occurred only to the extent of 10 per cent, against 15 in the year previous. Solar features appeared on every day of visibility, besides that a remarkable exhibit of large spots occurred in April. The spots were

depicted in a daily series of negatives, fortunately without any break. The photoheliograph in use is the old instrument, giving 4-inch images of the sun: for a short time the instrument was employed with an enlarging apparatus giving 8-inch images; but intimation being received from General Strachey that the Astronomer Royal requires 4-inch negatives for the measuring apparatus at Greenwich, a reversion has been made to the smaller sized pictures. The new large photoheliograph for taking 12-inch negatives has been received safely. The observatory for its accommodation is now well advanced, and it is expected that the instrument will shortly be in working order.*

* Mr. Hennessey acknowledges the valuable and efficient aid he has received from Mr. Cole in direction as well as in execution, more particularly in regard to the completion of Volume VII.

Mr. Wood is commended for the willingness and ability with which he has discharged a great variety of duties.

The work of Mr. Peychers, Baboos Gunga Pershad and Cally Mohun Ghose, in the Computing Branch, is reported on very favourably.

Messrs. Keelan, Atkinson, Clarke, Ollenbach, Hughes, and Dyson, are also commended.

Summary of Out-turn of Work executed by the TRIGONOMETRICAL PARTIES *during the survey year* 1881-82.

Description of Details.	Bombay Party, 24″ theodolite.	Eastern Frontier Series, 24″ theodolite.	Spirit-leveling operations.*	Total.
Number of principal stations newly fixed	8	7	.....	15
„ „ triangles completed	7	8	.....	15
Length of principal series in miles	15	94	.....	109
Area of principal triangulation in square miles ...	21	1,667	.....	1,688
Average triangular error in seconds	0·47	0·73	.....	.....
„ probable error of angles in seconds ...	·03	·06	.....	.....
Astronomical azimuths of verification	3	1	.....	4
„ latitude	4	3	.....	7
Number of principal stations selected in advance ...	.....	10	.....	10
„ of platforms constructed for principal stations	.....	7	.....	7
Number of principal stations placed under official protection and protected	.....	11	.....	11
Number of principal stations the elements of which have been computed	.....	17	.....	17
Number of secondary triangles of which all three angles have been observed	8	.....	.....	8
Area embraced by triangulation to prominent points exterior to principal triangulation and in square miles	282	3,062	.....	3,344
Number of points fixed by intersection but not visited	11	37	.....	48
Number of stations and points, the heights of which have been determined	9	35	9	53
Number of miles of rays and pathways cleared ...	.....	23	.....	23
„ of preliminary charts of triangulation ...	1	.....	.....	1
„ of hill tops cleared of forest or jungle ...	.....	7	.....	7
„ of miles leveled over	23	.....	448	471
„ of permanent bench-mark stones embedded	2	.....	24	26
Number of trigonometrical stations connected with lines of levels	4	.....	11	15
Number of other permanent points fixed as bench-marks	6	.....	286	292

* In addition to the above, 128 miles of leveling were executed by the Hanthawaddy Revenue Branch Party in British Burma, fixing the heights of 129 bench-marks, of which 57 were on posts specially embedded, the remainder being on trees and other previously existing objects.

Summary of Out-turn of the TOPOGRAPHICAL

Scale of survey.	Topographical Survey.	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.	TRIANGULATION. 1ST CLASS TRIANGULATION, IN WHICH EACH ANGLE IS USUALLY OBSERVED ON FOUR ZEROS, OR MORE. Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	2ND CLASS TRIANGULATION, IN WHICH EACH ANGLE IS USUALLY OBSERVED ON TWO ZEROS. Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	3RD CLASS OR TERTIARY TRIANGULATION, IN WHICH TWO ANGLES ONLY OF EACH TRIANGLE ARE OBSERVED. Number of intersected points.	Number of triangles.	Error per mile in feet.	Number of heights.	Number of extra heights determined by barometrical observations or otherwise.
1 inch = 2 miles.	No. 7 Party, Rajputana ...	12″	3,500	36	10·7	13·7	...	...	...	...	...	8	25	7·1	0·35	21	202	450	0·84	220	...
1 inch = 1 mile.	No. 1 Gwalior and Central India.	12	1,624	34	6·3	8·3	...	...	...	...	...	21	104	5·1	0·11	21	243	440	0·69	100	6
	No. 5 Bhopal and Malwa ..	14	1,091	19	8	10·	...	...	...	...	...	11	32	2·7	0·19	11	112	227	0·91	84	...
	No. 6 Party, Mysore ...	.....	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1,323
	Kohat Survey	6	1,000	24	12·5	0·8	...	...	...	...	...	17	27	24	0·5	17	65	141	1·3	128	18
2 inches = 1 mile.	No. 2 Party, Khandesh and Bombay Native States.	10	490	26	3·8	4·6	21	68	9·0	0·63	23	...	...	...	...	...	102	155	2·0	69	...
	Guzerat	10″ and 6″	1,705	70	3·0	5·4	...	...	...	...	...	53	116	7·9	0·25	53	348	475	1·5	151	133
	Cutch	7	1,377	78	1·8	...	...	...	...	...	...	73	159	8·6	0·3	63	691	1,209	0·8	551	14
6 inches.	No. 5 Bhopal and Malwa ..	6	10	8	7	4·3	...	...	...	...	...	7	10	13·1	0·41	7	69	133	...	30	...

PARTIES between the 1st October 1881 *and 30th September* 1882.

Scale of Survey.	Topographical Survey.	Traverse. Instrument used.	Traverse. Number of stations at which the Theodolite was set up.	Traverse. Linear miles, simple traversing.	Traverse. Linear miles, Boundary survey.	Traverse. Average angular error per station in seconds.	Traverse. Average error per 1,000 links in links.	Traverse. Number of village tri-junctions fixed.	Traverse. Number of plane-table points fixed.	Topography. Final topography completed during the season, in square miles.	Topography. Average number of plane-table fixings per square mile.	Topography. Number of linear miles of test lines by which each man's work has been tested.	Names of districts, &c., through which the season's operations have been carried.	Area of triangulation in advance of topography, square miles.
1 inch = 2 miles.	No. 6 Party, North-Eastern Frontier Survey.	.....	...	...	...	...	...	...	...	222	0·25	.....	Hill Tipperah	...
	No. 7 Party, Rajputana ...	.....	...	...	...	...	...	...	...	5611·3	1·2	.....	Jodhpur, Maifani, and a small portion of Jeysulmere.	5,800
	Cutch	.....	...	...	...	...	...	...	...	598	.....	.....	Cutch	...
										6431·3				
1 inch = 1 mile.	No. 1 Party, Gwalior and Central India.	.....	...	...	...	...	...	...	...	2440	7·5	90	Marwar, Serohi, and Mewar	3,420
	No. 5 Party, Bhopal and Malwa.	.....	...	...	...	...	...	...	...	1071·5	7·1	16·5	Banswara, Rutlam, Sailana, Gwalior, Khando, Kusalgarh, Partabgarh, Jaora, Piplanda, Udeypur, and Dongarpur.	1,640
	No. 8 Party, Mysore	.....	...	...	...	...	...	...	...	4,226	10·3	423·2	Shimoga, Kadur, Hasan, Chittaldroog, and Tumkur.	9,091
	Kohat Survey	.....	...	...	...	...	...	...	...	1343·8	4·2	51	Kohat	1,300
										9081·3				
2 inches = 1 mile.	No. 2 Party, Khandesh and Bombay Native States.	5″	1,805	1,025	...	3·5	2·8	1,034	...	1552·5	20	276	Khandesh and boundary of Nizam's dominions.	1,400
	No. 6 Party, North-Eastern Frontier.	.....	...	...	1,040	...	...	...	...	244	2·5	.....	South Sylhet	...
	Guzerat	7,″ 6,″ and 5″	934	91·8	78·4	12·49	2·7	...	...	1237·4	23·7	563·2	Parts of Chikli, Balsar, and Pardi, Taluks of the Surat district and Baroda and Bansda States.	3,468
	Cutch	5″	686	622	...	11·8	1·7	...	...	1,019	7·8	621·9	Cutch	1,377
										4702·9				
4″	Guzerat	.....	...	...	...	...	...	...	...	152·3	50·1	7·5	Dang Forest	195
6″	No. 5, Bhopal and Malwa ...	6	21	12·18	...	6	0·80	...	...	20·2	.....	6·7	Banswara, Jaora, cities ...	...
12″	Guzerat	.....	..	...	...	...	...	...	...	24·90	112·3	6·25	Chaorasi taluka, Surat district, and Sachin state.	...

Summary of the Outturn of the Field Work of the REVENUE BRANCH

Designation of Survey Party.	Scale of Survey.	Where Employed. Province.	District.	Number of villages.	Area Completed. Topography and detail.	Traverse. In advance.	Triangulation. In advance.
					Cadastral Surveys. Sq. miles.	Sq. miles.	Sq. miles.
No. 4 party	16 inches = 1 mile	North-Western Provinces	Ghazipur	664	226	.....	.....
	Ditto	Ditto	Ballia	1,177	410(b)	102	.....
	Ditto	Ditto	Benares	.....	.....	170	.....
,, 5 ,,	Ditto	Ditto	Mirzapur	645	734	329	.....
	Ditto	Ditto	Tarai	19	16	.....	.....
,, 6 ,,	Ditto	British Burma	Hanthawaddy	418	744	458	.....
	Ditto	Ditto	Rangoon Town	.....	10	.....	.....
,, 7 ,,	Ditto	Ditto	Tharrawaddy	230	526	270	.....
	Ditto	Ditto	Prome	.....	.....		.....
,, 8 ,,	Ditto	Ditto	Bassein	519	613(g)	350	.....
Sylhet test survey.	Ditto	Assam	Sylhet	60	26	.....	.....
		Total of Cadastral Surveys		3,722	3,513	1,754	.....
					Mauzawar, Riverain, and Forest Surveys.		
No. 1 party	4 inches = 1 mile	Punjab	Dera Ismail Khan	23	689	.....	.....
	Ditto	Ditto	Muzaffargarh	43	785	.....	.....
	Ditto	Ditto	Rawalpindi	.....	190	.....	.....
	Ditto	Ditto	Sialkot (Chenab river)	.....	11	.....	.....
,, 3 ,,	Ditto	North-Western Provinces	Bulandshahr (adjoining Ganges and Jumna rivers).	.....	157	.....	.....
,, 4 ,,	Ditto	Bengal	Shahabad (adjoining Ganges river)	66	31	.....	.....
,, 7 ,,	Ditto	British Burma	Tharrawaddy	.....	43	25	.....
,, 10 ,,	Ditto	Bombay	Thana	.....	940	450	.....
		Total of Mauzawar, Riverain, and Forest Surveys		.....	3,045	475	.....
					Topographical Surveys.		
No. 9 party	2 inches = 1 mile	North-Western Provinces	Meerut	.....	323	.....	.....
	Ditto	Ditto	Bulandshahr	.....	1,173	.....	.....
	Ditto	Ditto	Aligarh	.....	.....	1,395	.....
,, 11 ,,	Ditto	Bombay	Southern Collectorates of Deccan	.....	2,074	2,016	2,880
,, 6 ,,	16 Ditto	Bengal	Hooghly and 24-Perguunahs	.....	33	63	.....
	6 Ditto	Ditto	Ditto ditto	.....	14		.....
,, 2 ,,	2 Ditto	British Burma	Hanthawaddy	.....	92	42	.....
,, 7 ,,	Ditto	Ditto	Tharrawaddy	.....	107	.....	.....
,, 8 ,,	Ditto	North-Western Provinces	Mirzapur	.....	.....	.....	1,790
		Total of Topographical Surveys		.....	3,816	3,566	4,670
No. 11 party	80 inches = 1 mile	Sholapur City	.....	.....	1(o)	.....	.....
			Grand Total	.....	10,375	5,735	4,670

Abstract according to Jurisdictions.

Province.	Scale of Survey.	Area surveyed in square miles.	Cost.	Average rate per square mile.	Remarks.
			Rs. A. P.	Rs. A. P.	
North-Western Provinces	2-inches = 1 mile	1,196	47,720 0 3	29 6 1	Rate is exclusive of Rs. 3,769-1-9, the cost of Mirzapur triangulation in advance.
	4 do. = 1 do.	157	6,905 10 4	44 5 10	
	16 do. = 1 do.	1,385	1,92,277 0 7	138 13 3	Cadastral.
Punjab	4 do. = 1 do.	1,875	56,558 13 5	29 10 11	
Bengal	4 do. = 1 do.	31	1,693 0 0	54 9 10	
	6 do. = 1 do.	14	4,330 0 0	300 4 7	This work is equivalent to a city survey.
	10 do. = 1 do.	31	40,764 11 4	1,295 6 8	
Assam	16 do. = 1 do.	26	18,067 0 11	694 14 2	Cadastral special test survey.
British Burma	2 do. = 1 do.	199	11,545 11 2	58 0 3	
	4 do. = 1 do.	42	18,775 10 8	447 0 8	
	16 do. = 1 do.	2,102	4,88,291 1 0	232 4 0	Cadastral.
Bombay	2 do. = 1 do.	2,074	47,458 5 0	22 14 1	
	4 do. = 1 do.	949	59,180 12 2	63 6 2	
	80 do. = 1 do.	1	.....	.....	Cost = Rs. 5,016, paid by Sholapur Municipality.
	Total	10,375	9,83,731 13 4	.....	

Deputy Surveyor-General's Office,

Calcutta, the 1st October 1882.

PARTIES between 1st October 1881 to 30th September 1882.

Designation of Survey Party.	Cost.	Rate. Per acre.	Rate. Per field.	Number of fields.	Average size of fields.	Remarks.
	Rs. A. P.	Rs. A. P.	Rs. A. P.		Acre.	
No. 4 party ...	93,093 2 6(*a*)	0 3 5	0 1 6	988,157	0·41	(*a*) The cost is exclusive of Rs. 325 spent in surveying 12·5 square miles of overlap on 2″ scale on district Azamgarh.
,, 5 ,, ...	96,537 13 5(*c*)	0 3 3	0 4 5	346,110	0·67(*h*)	(*b*) Of this area 4 square miles were surveyed on the 32″ scale.
	2,646 0 8	0 4 2	0 5 3	8,035	1·27	(*c*) Exclusive of Rs. 3,450 expended on theodolite mark-stones.
,, 2 ,, ...	1,72,344 10 1(*d*)	0 5 8	0 5 5	509,763	0·93(*a*)	(*d*) Exclusive of Rs. 6,869-2-9 expended on demarcation.
,, 7 ,, ...	1,36,175 4 11(*e*)	0 0 5	0 4 4	495,000	0·30(*h*)	(*e*) Exclusive of Rs. 1,701-6-9 expended on demarcation and Rs. 13,342-3-2 paid by Forest Department.
,, 8 ,, ...	1,79,771 2 0(*f*)	0 5 6	0 8 2	349,790	0·44(*h*)	(*f*) Exclusive of Rs. 4,434-2-3 expended on demarcation.
Sylhet test survey.	18,067 0 11	1 1 6	0 5 9	49,825	0·33	(*g*) The topography of 32 square miles was surveyed on the 2″ scale.
	6,98,635 3 0					(*h*) The average size of fields is on the cultivated portion only.
		Per square mile.				(*i*) Of this amount Rs. 18,624 have been debited against the Forest Department.
		Rs. A. P.				(*j*) Special survey by a selected European officer.
No. 1 party ...	20,479 10 7	77 0 0				(*k*) Very intricate forest-clad country.
	24,703 2 10	130 0 3				(*l*) Exclusive of charge for October 1881, which was included in the Return of 1880-81.
	1,476 0 0	134 2 11(*j*)				(*m*) The numerous village sites on the banks of the Hooghly river rendered the work equivalent to a city survey.
,, 3 ,, ...	6,965 10 4	44 5 10				(*n*) The average size of fields is on the gross area.
,, 4 ,, ...	1,003 0 0	54 0 10				(*o*) The intermediate lands lying between the city and detached bazars have also been mapped, adding 1,371 acres to the area of the survey. Total area mapped = 3 square miles nearly. Actual city area = 524 acres.
,, 7 ,, ...	18,775 10 8	447 0 8(*k*)				
,, 10 ,, ...	60,180 12 2(*i*)	53 0 2				*Note.*—The rates in the 5th, 6th, 7th, and 8th divisions are exclusive of the following :—
	1,33,273 14 7					Rs. A. P.
						No. 5 party ... 1,099 12 9 Leave and furlough allowance of European assistants.
						,, 6 ,, ... 2,092 11 4 Leave and travelling allowance.
						,, 7 ,, ... 660 0 0 *Furlough allowance.*
						,, 8 ,, ... 1,170 0 0 Ditto ditto.
No. 3 party ...	43,950 14 6	29 0 1				
,, 11 party ...	47,458 5 0	22 14 1				
		Per acre.				
,, 6 ,, ...	40,708 11 4 (*l*)	1 12 11	(*m*)			
	4,330 0 0 (*l*)	0 7 7	(*m*)			
		Per sqr. mile.				
,, 2 ,, ...	3,300 0 0	35 13 11				
,, 7 ,, ...	6,245 11 2	77 1 0				
,, 5 ,, ...	3,769 1 0	2 1 8				
	1,51,822 11 0					
	..... (*p*)					(*p*) Cost = Rs. 5,016, paid by Sholapur Municipality. Average rate = Rs. 3-1-11 per acre.
	9,83,731 13 4					

Districts completed since last Report.

District.	Number of villages.	Number of fields.	Area in square miles.	Cost inclusive of all expenditure.	Final rate per square mile.	Nature of survey: by whom and when surveyed.	Remarks.
				Rs.	Rs. A. P.		
Ghazipur	3,774	1,092,382 (average size of the fields = 0·48 of an acre.)	1,499	2,55,343	102 11 1	*Surveyed cadastrally on the scale* of 16 inches to a mile by Major W. Barron: commenced, 1878-79; finished, 1881-82.	
Dera Ismail Khan ...	911	.....	2,351	2,99,756	31 6 2	Surveyed Munzawar on the scale of 4 inches to a mile by Colonel H. C. Johnstone, Captain H. L. Smith, and Lieutenant-Colonel D. Macdonald: commenced, 1873-74; finished, 1881-82.	Includes 112 square miles of country lying between settlement boundary and base of hills.
Meerut	.....	... ,,	2,366	79,209	33 3 2	Surveyed topographically on the scale of 2 inches to a mile by Major W. H. Wilkins and Mr. E. T. S. Johnson: commenced, 1879-80; finished, 1881-82. A line of villages, in area 174 square miles, along the Jumna river, has been surveyed on the scale of 4 inches to a mile.	Excluding the 4-inch survey, the cost rate of the 2-inch survey is Rs. 31-11-3 per square mile.

J. E. SANDEMAN, *Major*,
for Deputy Surveyor-General.

APPENDIX.

EXTRACTS

FROM

THE NARRATIVE REPORTS OF THE EXECUTIVE OFFICERS

IN CHARGE OF

THE SURVEY PARTIES AND OPERATIONS.

Extract from the Narrative Report, dated 27th October 1882, *of* LIEUTENANT-COLONEL B. R. BRANFILL, B.C., *Deputy Superintendent, Survey of India, in charge Bombay Party.*

Preliminary.

THE Eastern Sind series having been completed by the Bombay party during last field season, and the computations connected with it very nearly so during the recess, I received instructions to examine and prepare the base-line measuring apparatus for the Mergui base, which it was determined to measure during the field season of 1881-82.

In carrying out this duty at Dehra, I received every assistance from Mr. Hennessey, who placed the workshop resources of the Dehra office at my disposal and gave me all the information and instructions requisite. The apparatus was found to be worn and shaky, but was put into efficient working order, cleaned and adjusted throughout by the middle of October, when it was packed up and despatched by rail to Calcutta.

Government steamer *Celerity*.

The Indian Government steamer *Celerity* had been provided to aid in pushing on the triangulation to the southward of the base-line in the Mergui Archipelago, and the whole of the Bombay party, with its ordinary camp equipage and triangulating instruments, proceeded in this vessel from Calcutta to Rangoon on the 5th November.

As there was no stowage room for it in the *Celerity*, the whole of the base-line apparatus had to be despatched by the ordinary coasting steamer of the British India Steam Navigation Company, which left on the 4th November bound for Mergui, accompanied by Mr. Atkinson and two natives to look after the measuring bars and instruments.

A steam-launch found to be very desirable.

In view of the shallows and sunken rocks with which the Mergui Archipelago abounds, and the great draught of water of the *Celerity* (nearly 12 feet), which would preclude any near approach to the shore generally, and prevent her entirely from traversing many of the channels, Captain Searle, Superintendent of Marine, strongly urged that we should obtain the use of the steam-launch *Moulmein*, which was being sent in tow of the *Celerity* from Calcutta to Rangoon for the use of the port of Moulmein. He also urged this course as a matter of great economy in the expenditure of coal, inasmuch as the *Celerity* could carry comparatively little fuel for her own relatively large consumption, and the party would be deprived of the aid of steam power entirely whilst she was proceeding to and fro to recoal, whereas the steam-launch only consumed about one-tenth the amount of fuel, and was actually more suitable for the many coasting trips that were necessary in visiting the survey stations. Moreover, the steam-launch could be manned and worked by the crew of the *Celerity* without any extra expense.

Steam-launch obtained at Rangoon.

On the 10th the *Celerity* put into Rangoon, the last port where there was a depôt of fuel to recoal, and whilst there, with your sanction, I applied for and obtained the use of the steam-launch for the ensuing two months at the rate of Rs. 500 a month. I am glad to state that this arrangement, in the opinion of those engaged in the operations, proved eminently convenient and economical.

The party reaches Mergui.

On the 12th November the *Celerity* left Rangoon, and reached Mergui on the 14th, the day before the arrival of Major Rogers and the Eastern Frontier and Burma parties, with which the Bombay party was to co-operate.

Plan of operations.

No time was lost in making the necessary disposition of the party for commencing the triangulation. The plan of operations decided on was that the Bombay party should complete the triangulation near the base-line, including its connection with the Eastern Frontier series, and any verificatory and secondary triangulation that might be requisite before taking up the necessary astronomical observations, whilst Major Rogers with the Burma parties extended the triangulation to the southwards as far as possible until the middle of January, when both parties were to assemble and proceed with the measurement of the base.

Triangulation commenced.

The signal-men were sent off to their stations by boat on the 18th of November, and a complete observing party with Troughton and Simms' two-foot theodolite No. 1 on the 19th to King's Island for the hill station of Kapa Taung, where final observations were commenced on the 24th and finished on the 27th.

Arrival of base-line apparatus.

Mr. Atkinson meanwhile having arrived with the base-line apparatus at Mergui on the 23rd, I sailed back thither to ascertain that the equipment was all right, to see it properly stowed, and to organize, instruct, and start the leveling party, all which was accomplished by the 5th of December, when I resumed the final observing at Pawo (island) station, whither the main party had been transported in the interval. I may remark here that all the travelling had to be done in open, country sailing boats, and that it was a continual source of inconvenience, delay, and anxiety, progress depending entirely on fair weather with favouring wind and tide.

Leveling party started.

Completion of the principal triangulation.

The final observations were carried on henceforward without any noteworthy occurrence until their completion, as follows:—

At Kapa Taung H. S., between 24th and 27th November 1881. (Leveling party organized and started in this interval.)

At Pawo H. S., between 5th and 7th December 1881.

At Toung pilá or west end of base-line T. S., between 9th and 11th December.

At Natlaintaung H. S., between 13th and 18th December. An azimuth was observed at Natlaintaung to a pair of circumpolar stars.

At Minthantaung H. S., between 21st and 27th December. An azimuth was observed at Minthantaung to α Ursœ Minoris (Polaris).

At Tatoung H. S., between 28th and 29th December.

At Tauribiye or east end base T. S., between 30th and 31st December. A set of circum-meridian star observations for latitude was taken on the nights of the 1st, 2nd, and 3rd January 1882 to eleven pairs of stars.

At Sandawat H. S., between 5th and 8th January. A set of circum-meridian star observations was taken at Sandawat on the nights of the 5th, 6th, and 7th January to thirteen pairs of stars.

The west end of the base-line was again visited and a set of circum-meridian star observations taken for latitude to fifteen pairs of stars, on the nights of the 10th, 11th, and 12th of January, and also a set of circumpolar star observations to α Ursœ Minoris for azimuth, between the 11th and 15th January, after which Minthantaung was revisited and circum-meridian star observations for latitude taken on the 16th, 17th, and 18th January to fourteen pairs of stars.

Finally a set of circumpolar star observations for azimuth was observed at the east end of the base-line, between 23rd and 30th January, by Major Rogers, whilst the measurement of the base-line was being begun.

The above statement includes all the observations taken with Troughton and Simms' two-foot theodolite No. 1.

Progress of the triangulation to the southward under Major Rogers.

Meanwhile Major Rogers, with the Eastern Frontier and Burma parties immediately under him, was engaged in prosecuting the triangulation to the southward of Mergui through the archipelago.

No principal stations having been prepared or definitely selected during the previous season, his first object was to lay out the series, build the stations, and clear the rays, &c. He accordingly, as soon as possible, after reaching Mergui, embarked in the *Celerity* with the whole of his establishment in tow, and, dropping parties at the stations to be built first, proceeded to reconnoitre the archipelago, laying out the series of principal triangles as he went.

With the aid of the steamers, he visited 16 islands and selected as many stations, extending the approximate series 170 miles, as far south as latitude 9° 20′, and returned to Yajeo, the first station for observing at, within a month after starting, by the 15th December.

The final observations were carried on rapidly, overtaking the building and clearing parties by the 15th January, when the usual hazy weather had begun, and all had been done that could be accomplished in the time with the means available. Seven new principal stations were built and observed at, embracing an area of 1,667 square miles, extending the series 94 miles to the southward.

Detail of Triangulation under Major Rogers.

The final observations were completed at the undermentioned stations as follows:—

With Waugh's two-foot theodolite No. 1.

At Yajeo H. S.,	between	15th	December	1881	and	18th	December 1881.
Tai-ai-pin-zouk H. S.	,,	21st	,,	,,		22nd	,, ,,
Linya H. S	,,	24th	,,	,,		26th	,, ,,
Kisseraing H. S.	,,	29th	,,	,,		31st	,, ,,
Alaymhán H. S.	,,	3rd	January	1882		5th	January 1882.
Hsaeekyun H. S.	,,	7th	,,	,,		8th	,, ,,
Kau-Yay H. S.	,,	11th	,,	,,		12th	,, ,,

With 12*-inch theodolite by Troughton and Simms.*

At West Lampee H. S., between 13th January 1882 and 14th January 1882.

With 12*-inch theodolite No.* 181, *Troughton and Simms.*

At East Lampee H. S., between 14th January and 15th January 1882.

The observations at this last station were taken by Mr. L. Pocock, all the rest by Major Rogers.

A great number of observations were taken to fix the islands and hill peaks of the archipelago; many of the peaks, however, were so densely overgrown with forest as to be hardly distinguishable, but the objects fixed will be of value, as geographical points.

Assembly of entire party for the base-line.

Whilst the last series of latitude observations was still in progress, Major Rogers with the whole of his triangulating party returned from the southward to take part in the measurement of the base-line. The star observations were somewhat hurriedly brought to a

close on the 19th of January, and the whole party assembled at the east end of the base on the 22nd.

The steamer *Celerity* and the steam-launch, together with all the country boats that were not absolutely required, were now dismissed, and all the hands that could be spared were discharged and sent in the discarded boats to Moulmein.

Preparatory arrangements for the base-line.

During the month of December the base-line apparatus had been conveyed by degrees, whenever boats had been available for the purpose, to the east end of the base, where there was a landing place and the most convenient spot for encamping on. The carpenter, smith, and two or three skilled khalasies meanwhile had been well employed in putting together the trestles, tent frames, &c., &c., so that everything was just ready in good time. The ground over which the base-line runs had been marked out and roughly leveled during the previous season, but beyond clearing the side drains little or nothing could be done to it before the middle of this January, owing to its being under water or too wet to be dealt with. The work, however, was now pushed on rapidly, and no inconvenience was experienced from the delay. The measuring apparatus was put into working order, and the members instructed and practised in the manipulation of the instruments as soon as possible. The comparisons of the compensation bars with the 10-foot standard (A), those of the 6-inch microscopes with their scales and those of the runs of the micrometers of the comparing microscopes, *k* and *l*, with the standard foot (1/*f*), were taken on the 25th and 26th of January.

The measurement of the base-line.

The actual measurement of the base was commenced on the 27th and went on slowly, but steadily, in the usual manner without any mishap. The measurement proceeded from east to west, *i.e.* from right to left of the observers, who were south of the bars, facing north, the tongues of the bars pointing also in that direction.

Distribution of work.

After the second day's work, the observers and instruments were arranged as follows, and this order was maintained to the end :—

No. 1 β Major M. W. Rogers, R.E., at the boning instrument 21 feet in rear of the set of bars;

„ 2 α Lieutenant the Hon'ble M. G. Talbot, R.E., at the W. microscope on the rear end of compound bar A, origin of the set;

„ 3	A	Mr. C. P. Torrens	at the	R.	microscope on the	advanced end of compound bar A.
„ 4	B	„ L. J. Pocock	„	S	„	„ B.
„ 5	C	„ R. W. Senior	„	T	„	„ C.
„ 6	D	„ D. Atkinson	„	P	„	„ D.
„ 7	E	„ C. D. Potter	„	U	„	„ E.
„ 8	H	„ Lt.-Col. B. R. Branfill	„	V	„	„ H.

the terminus of the set.

„ 9 Moung Shoay Gyoke, with a second boning instrument, laying the trestles in advance.

No. 2 had charge of the last fixed register from the beginning of the set until he had seen it safely covered up by a register box without being touched. It was his duty also to hand the '*director*' in passing down the final alignment. The temperature of the two components of compound bar B. and of the air was registered by No. 3 ; Nos. 4, 5, and 6 kept up the field-book in triplicate, making all the entries independently as they were called out, set by set, by the various observers : thus, immediately after the final alignment and before the final length was passed down, whilst the advanced register was being adjusted and the three recorders (4, 5, and 6) last named were otherwise unemployed, No. 3 gave out the temperatures which he had just recorded, and No. 2, the height of the rear and advanced ends of the set above the registers, which had been entered in a note-book by himself and No. 8, who finally proclaimed the completion of the set and the particulars of the (⊙) mark defining the terminus of the set. The spare time of No. 7 was spent in looking after and correcting the length and alignment of the chain-men and trestle layers in advance. No. 8 was fully occupied in directing and aiding the approximate focus and the approximate alignment—besides the laying and observing the register at the terminus of each set.

Two days' bar-comparisons taken at centre of the base.

On the 7th of February, the 9th day of the measurement, the centre of the base was reached, and the two following days were spent in comparing the compensation bars with the standard.

Completion of the measurement.

The measurement was resumed on the 10th and brought to a conclusion in 5 days (at the rate of over 28 sets per day) on the 15th of February, the 14th day of the measurement. On the 14th February 36 sets were done in 9 working hours, at the rate of a quarter of an hour per set : the quickest having occupied only 12 minutes, the slowest 19.

Rapid progress.

It is believed that this is the largest day's work ever done with the same apparatus.

The 258th set and a half fell 3·22 feet short of the (⊙) mark defining the west end of the base, which quantity was measured off on Cary's 3-foot brass scale.

Remark upon the soil.

The first (eastern) half of the base was over comparatively good firm ground, but the last (western) half was for the most part over a clayey flat that was much cracked by the heat, and very shaky. It was found necessary to fill the crevices round the registers with pure dry sand, and to place the registers in pits filled up to ground level or higher, with sand; and every precaution was taken to preserve them intact and unmoved from set to set.

Two days bar-comparisons at close of the measurement.

The 16th and 17th February were spent in a third series of bar-comparisons at the west end of the base.

Conclusion of the operations and return to Calcutta.

The triangulation and the line of levels having both been completed and arrangements made for closing and protecting the station buildings in the vicinity, and for delivering them to the local officials, the majority of the party proceeded to Mergui and took passage by the first steamer for Calcutta, where it arrived on the 7th of March.

Disposal of the instruments, &c.

The theodolites and trigonometrical instruments were returned into store in the Mathematical Instrument Department; the camp equipage was stored with that of the astronomical parties at Chinsurah; and the base-line instruments and apparatus were sent to the Great Trigonometrical Survey Office at Dehra Dun.

Entire out-turn of work.

The entire out-turn of trigonometrical work accomplished by the combined parties engaged in the work comprises 15 triangles, fixing 15 new stations, covering an area of 1,688 square miles, and extending the series 109 miles southward of the point reached the previous season, with a very considerable number of secondary (topographical and geographical) points in an area of 3,344 square miles exterior to the principal triangles.

In addition to the above, and besides the measurement of the base-line, four determinations of the astronomical azimuth were obtained near Mergui, and seven astronomical latitudes—four of the latter about Mergui and three about Moulmein.

A line of levels was executed 23 miles in length between the base-line and Mergui, where it is intended to establish an observatory for tidal investigations. In the course of this work ten permanent bench-marks were connected, four of which are trigonometrical stations.

I am glad to report that the conduct of each and all the assistants was unexceptionally good throughout.

Health of party.

The health and working capacity of the natives was on the whole very good, but a few of those who had remained at Moulmein during the preceding recess were so debilitated as to be unfit for work. Several of the Bombay men succumbed to the enervating effects of the climate and food, and have since died.

Note on the Astronomical Azimuth and Latitude Observations about the Mergui Base-line.

The astronomical observations.

Astronomical observations for the determination of the azimuth and the latitude were required at both ends of the base-line, and also at other principal stations of the series in the neighbourhood, in order to obtain a good mean value of these elements, that should be as free as possible from the disturbing effect of any abnormal local attraction upon the plumb line at any one station.

The azimuth stations.

31. The hill stations of Natlaintaung and Minthantaung were selected for the extra azimuth observations, on the north and south sides of the base-line respectively, as being apparently less likely to be affected by any irregularities of local attraction in an east or west direction than the other stations in the immediate neighbourhood.

The observation of one circum-polar star at both elongations was found to be impracticable. It was therefore intended to observe a pair of stars at their opposite elongations. Owing to cloudy and hazy weather this was also found to be impracticable after the first azimuth, and we were obliged to be content subsequently with observations to α Ursæ Minoris (Polaris) at one (the western) elongation only; taking double the usual number of observations with two observers, one of them at the telescope and the other at the levels and microscopes; this was found to be quite feasible.

Circum-meridian Latitude Observations.

Circum-meridian star observations for latitude.

Circum-meridian star observations for latitude were taken at the same stations as azimuth observations, with the exception of Natlaintaung, at which it was surmised that there might probably be an abnormal excess of local deviation of the plumb line in a northerly direction, and the principal station next to the northward, Sandawat H. S., was preferred as being less objectionably situated on that score.

The principal share of these observations, as far as the setting the telescope and making the intersection of the star was undertaken by myself, and, in the case of the Minthantaung observations, I took them alone as Lieutenant Talbot was engaged on other duties, preparing the base-line, &c.

Observatory tent.

The observations were taken throughout in the ordinary observatory tent belonging to the party, the frame and top of which had been divided in two in the centre, and the halves separated so as to leave a complete meridional aperture 8 or 10 inches wide from horizon to horizon through the zenith. The junction of the two halves was made by thin cross pieces of iron at the peak of the tent frame, and at intervals down the fly. The aperture was covered by a separate strip of cloth (or *purdah*) which could be attached or removed at will, and this arrangement proved sufficiently convenient without adding appreciably to the weight or portability of the tent.

Stars used.

Forty-seven stars were selected from the Nautical Almanac and from the Greenwich seven-year Catalogue for 1864, in pairs of nearly equal north and south zenith distance ranging between 9° and 38°, and in right ascension all between 1 hour and 8 hours, so as to be suitable for observing about the meridian between sunset and one o'clock after midnight, during the month of January. My instructions were to observe ten pairs of stars on three nights each; but as I was uncertain of the value of some of the stars' places selected from the old Greenwich seven-year Catalogue, I endeavoured to secure twelve or more pairs, and succeeded in obtaining 11 pairs at the east end, 13 pairs at Sandawat, 15 pairs at west end, and 14 pairs at Minthantaung. We had no experience or previous practice, but after a little while the routine became easy and tolerably quick: it was as follows:—

Modus operandi.

The 24-inch theodolite having been adjusted during the day, was examined and leveled about sunset, when the transit of a high star was observed on the meridian, to determine the error and rate of the Sidereal chronometer. The recorder was provided with a table of the selected stars showing their aspect, altitude and zenith distance, the chronometer time of their culmination or transit, and the maximum interval therefrom, within which it was requisite to observe them, so as to avoid, if possible, the necessity of using the second term in the formula of reduction. The intention was to observe the star as near to its culmination as practicable.

Marks were made upon the circular lamp-table by which the telescope was very readily laid approximately in the meridian with either a north or south aspect, and it was then set to the altitude of the star about to be observed. A few seconds before the proper time for the first observation the telescope, set to the proper altitude, was moved in azimuth from the meridian to meet the star, and the instant of completing the intersection at the proper part of the horizontal wire of the telescope was called out by the observer and noted by the recorder, who was watching the chronometer, and who read out the time registered, which was then checked by the observer looking at the chronometer. The level was then read and recorded, and lastly, the readings of the vertical limb, either the altitude or zenith distance, directly, by means of the two vertical microscopes (G and H).

The telescope was now turned over 180° in altitude and the same in azimuth, so as to change the face of the instrument from east to west, or *vice versâ*. The telescope being again set to the zenith distance or altitude of the star on the meridian, the second observation was made as near as might be to the time of its culmination, the time, level, and vertical microscope readings being recorded. A repetition of this observation followed as quickly as possible, after which the setting of the instrument was again reversed and a repetition of the first observation taken. This completed the set of four observations to a star for the night, and the instrument was immediately set ready for the next star, barometer and thermometer readings being taken frequently in the intervals.

The even and steady illumination of the limb by the hand lamp was found to be a difficult and dilatory process, and a fixed light upon the graduations to be read was a great desideratum.

Time occupied by a set of observations.

With two observers the average time occupied in observing an entire set was nearly 5½ minutes, between a minimum of five minutes and a maximum of 7 minutes; but with only one observer, an average of 6½ (between 6 and 7 minutes) for each set.

Towards the conclusion of the night's work another transit was taken for error and rate of the clock.

After some little practice it was found easy enough to observe 30 stars with all the requisite subsidiary observations in half a night, between sunset and midnight, and if an ordinary two-foot theodolite were specially adapted for this kind of work by a more suitable level, steady illumination and other improvements, a greater number might be obtained, under ordinarily favourable circumstances, without difficulty.

Estimate of progress for one season.

I estimate that seven groups of latitude stations, one degree apart, and three stations near to one another in each group, might be observed in a season. Or if only one station were observed in a single locality, twelve latitudes might be determined extending over an arc of as many degrees of the meridian.

Collimation and index error determined.

During the observations on each night the horizontal collimation error was determined by means of a good referring-mark lamp signal, and the zero or index error of the vertical microscopes likewise.

Run of level.

The value in arc of a division of the level scales was determined by observations for the purpose, taken several times during the operations; that of the vertical axis level was found to be almost identical with the value in ordinary use, previously determined.

Barometer. The barometer readings were taken by an aneroid which was compared with a George's portable mercurial barometer at both the highest and lowest stations visited, and corrections applied accordingly. The corrected barometer readings were projected and a curve for each night drawn, whence the correct pressure corresponding to the mean time of observing each star was taken and entered in the angle book.

Thermometer. The corresponding temperature was interpolated directly from the original observations.

Refraction. From these interpolated values a mean refraction was computed for each star on each night from Bessel's refraction tables in use in the Great Trigonometrical Survey computing office.

Extract from the Narrative Report, dated 4th October 1882, *of* MAJOR M. W. ROGERS, R.E., *Deputy Superintendent, Survey of India, in charge Eastern Frontier and Burma Parties.*

I TOOK over charge at Bangalore on the 20th September, and on the 26th the party left recess quarters for Burma and reached the field head-quarters at Moulmein on the 12th October.

As it was your intention to have a base-line measured at Mergui during the season, it became necessary for me to arrange for labour, supplies, and boats, not only for my own establishment, but for that of the base-line party under Lieutenant-Colonel Branfill, which was to go direct from Calcutta to Mergui.

The rains had not ceased in Burma on my arrival there, so I had ample time to make all arrangements, and the party left for Mergui on the 12th November, arriving on the 15th.

Colonel Branfill in the Indian Government steamer *Celerity* had arrived the day before; so having handed over his men and boats to him, and arranged for the storage of the Government property, I was then ready to carry out my part of the season's programme, which was to extend the triangulation as far south as possible before the weather became too misty for observations, when it was arranged that the party should return to Mergui and aid in the measurement of the base-line.

You had obtained the Indian Government steamer *Celerity* for the use of the triangulation, and Colonel Branfill had also obtained the loan of the steam-launch *Moulmein;* in addition to these, I had two open cargo-boats and a decked schooner for the carriage of men and stores.

No stations had been selected or built in advance, so the first thing to be done was to push on this part of the work: I therefore landed Messrs. Pocock and Potter on the two islands where I proposed placing the first stations in advance, and I then proceeded in the *Celerity* to make a thorough inspection of the Mergui Archipelago with a view to selecting stations for the triangulation as far south as the end of British territories.

I visited sixteen islands during my expedition, landing on several of them at more than one place in order to find water and the best place from which to commence the ascent of the hills.

Sixteen stations were selected, extending the series from latitude 11°40′ to 9°20′, or about 170 miles. Two stations fixed upon were not visited, and two islands visited were rejected.

Having completed this part of the work, I returned to Yajeo H. S., and commenced the principal observations there on the 15th December.

During the time I was observing, the building of stations and cutting of roads were pushed on vigorously by Messrs. Pocock and Potter.

By means of heliotropes and the ordinary Morse Code, I was able to communicate with them and the steamer, and they with each other, so that we were always acquainted with the progress of each party's work, and I was able to utilize the steam power, not only for my own observing party, but to transfer the assistants and their men from one island to another, whenever they required it.

The steam-launch was most useful in taking me to several stations which the steamer could not have come near owing to the shallowness of the water, and I used her on this work whilst the *Celerity* went to Mergui for coal.

There was nothing particular to note in the observations themselves, save that on the morning of the 31st December, whilst observing at Kisseraing H. S., an earthquake occurred which, though hardly perceptible to a by-stander, was at once detected by the movement of the levels of the great theodolite and by the heliotrope (to which I happened to be observing at the moment), rising and falling in the field of the telescope.

The observations were carried on until the 15th January, when it became necessary to close work in order to reach the base-line at the time agreed on: even before this the haze, which last year had so impeded Captain Hill's observations, began to give trouble; and under any circumstances I doubt if observing could have been carried on beyond the end of the month, and as it was the recognition of intersected points was most difficult during the last ten days.

The observing season here may be said to commence on the 15th November and end on the 15th January, and even this brief time is liable to be curtailed by heavy rains at the commencement and premature setting in of the haze at the close.

It is therefore most necessary that no hindrance should occur through delays in travelling, and I can only wonder how any work at all was done in the previous season, when days were spent in drifting from station to station in open boats. Thanks, however, to the power of steam, we were able, in the very brief time we spent on the triangulation, to accomplish the following work.

Observations were taken with the 24″ theodolite at seven principal stations, and with the 12″ at two more, advancing the series 94 miles, and fixing seven new stations embracing an area of 1,667 square miles.

Seven new stations were built on the islands. To reach these stations, whose heights above the sea ranged from 500 to 1,500 feet, 23 miles of pathway had to be cut through most dense forest jungle, a portion in one case having to be made over mangrove swamps, by felling trees and making a causeway. The hill tops had to be cleared of forest, and in some cases rays had to be cut to enable the adjacent stations to be seen.

With this large amount of work to be done at each station, it was only to be expected that the observations should catch up the preliminary operations, and consequently no stations have been built in advance.

In future operations, to ensure that there may be no delay from this cause, there should be two building parties; and in addition, during the latter part of the season, when the haze prevents observing or selecting, the whole of the party should be employed in building and clearing.

The party returned to Mergui on the 18th January, and after having paid off and dismissed such men and boats as were no longer required, it was moved to the base-line and placed at the disposal of Lieutenant-Colonel Branfill for the measurement.

During the measurement, arrangements were made for covering and protecting all the stations of the series, which was done; and although no stations, save those on the Mergui island, could be placed under official protection, the inaccessibility and deserted nature of the country is such that I do not consider the stations to be in any danger except from natural causes. After the completion of the base-line the party left for Moulmein, where they arrived on the 25th February.

I then received your instructions to observe astronomical latitudes at Moulmein, and I therefore selected three stations of the triangulation near Moulmein and proceeded to observe for latitude at the first of them—Moulmein H.S.

As I foresaw that owing to my tidal inspection work I could not arrange to observe at all the stations myself, I carefully instructed Messrs. Pocock and Potter in the use of the 24″ theodolite and the method of observing circum-meridian altitudes, and also in all the necessary computations for selecting suitable pairs, &c., and worked with them for two nights, until I was satisfied that they might be trusted alone. They observed for latitude at Martaban H.S. and Toung-zun H.S., whilst I left Moulmein for Rangoon and Port Blair.

On completion of the latitudes the party left Moulmein for Mussoorie, under the charge of Mr. Potter; Mr. Pocock having been ordered to join the Mysore party at Bangalore.

I received every assistance in his power from Captain Butler, Deputy Commissioner of Mergui.

Captain Hotham of the Indian Navy and the officers of the Indian Government steamer *Celerity* did everything in their power to aid me in my work, and to their cordial co-operation I am greatly indebted for the good progress which I made in my observations.

The triangulation this year was entirely on the islands of the Mergui Archipelago.

The islands may all be described as high and precipitous, the smaller ones rising sheer out of the sea, the larger ones having steep valleys between their various peaks, but no flat ground of any extent.

Towards the north, the islands are fringed with a belt of mangroves, some two or three miles in width, the only access to the mainland being up the larger creeks at high tide (the tide here rises from 16 to 18 feet). Such as this is the large island of Kisseraing and the eastern side of Domel: wherever there is a small valley with fresh water there are nearly sure to be mangroves at its mouth.

The islands south of 11°20′ have stretches of fine sandy beach, and in many cases good water coming out of the hills and flowing over the sand into the sea.

In Davis Island, latitude 9°50′, there is almost a small river coming down from the hills with a fine waterfall, and in the interior of Kisseraing another was found. The peaks on many of the islands are of a considerable height, many being over 1,000 feet and several over 2,000.

With no exception, the islands are covered with dense forest, with thick undergrowth and creepers in every direction, a thorny kind of cane being one of the most common. This makes it very difficult to penetrate to any distance, as every step of the way has to be cut through the undergrowth.

The soil is very rich, consisting chiefly of leaf mould, and it remains moist all the year round, as it receives an immense amount of rain, and the thick foliage prevents the sun penetrating during the hot weather.

The density of the forest may account for the few beasts and birds which are seen. Monkeys are plentiful, coming down to the beach at every low tide to catch crabs and shell fish in the mud.

I saw tracks of wild pig, deer or tapir, leopards or some animal of that description, and on Forbes' Island, what seemed to be the footsteps of a rhinoceros.

Jungle fowl, imperial pigeon, curlew, horn-bills, king-fishers, and on Davis Island one pair of snipe, were the only birds I saw; but it must be remembered that I have only penetrated, at the most, half a mile into any of the islands except along the paths cut to the stations.

The trees are in many cases very large and high, having a great length of trunk without any branches, apparently devoting all their strength to reaching the upper air and sun-light as soon as possible. One tree, which had been blown down on the island of Kisseraing, measured 116 feet from the ground to the beginning of branches, and 227 feet in all.

Fish are very plentiful, and during the cold weather there are many temporary fishing villages established on the northern islands by men from Mergui and around, who dry the fish for export to Rangoon.

Turtle are met with on most of the islands, but all I saw of them were the remains of two very fine ones, which had served overnight as the meal of some of the wild men of the islands.

The archipelago is uninhabited save by the fishermen above mentioned and the roving tribes of Selungs or sea-gypsies mentioned by Captain Hill in his last report. Of these I met several, and as a rule found them by no means averse to communication, rowing up to the steamer or steam-launch and getting on board the latter when asked. These were in the southern islands, where they mostly live. The only ones I saw on the northern islands fled in such haste that they left most of their boats and property behind.

At Lord Loughborough's Island, in latitude 10°25′, they took us to their temporary village, where we were received by the whole community in a very friendly way. The village was on the beach, just above high tide, and under the shade of the trees; it consisted of a few platforms of light wood floored with split bamboos and roofed with the leaves of the neepá palm.

The men were as a rule a fine set, and extremely ugly, not at all like the Burmese; the women were small and also ugly. They were all dressed decently, but not superabundantly, and many of the men wore necklaces of glass beads.

They had a little rice and paddy, and a large quantity of evilly smelling shell fish and sea slugs drying in the sun. These latter they collect for sale, and also a large shell, which takes a beautiful polish and sells at Mergui for Rs. 8 per 100. It is used in England, I believe, for button-making.

Their boats are very light and fast; the lower portion is a single tree, the sides being heightened by bamboos or some kind of fibrous palm, which are woven in and out on uprights, projecting from the two upper edges of the boat.

Their oars are beautifully made, and they use them with great skill, making their boats fly through the water. They have also masts and a sail of palm leaves. They are very clever in weaving mats, bags, &c., but I could hardly get any, as when I visited them it was not the mat-making season, which is the monsoon, when they can do but little fishing. They have some fine dogs, which they employ in hunting the wild pig in the islands, the weapons they use being the ordinary hog-spear.

There was a Malay trader living at the village I visited, who traded with them for their shells, &c., giving them cloth, rice, and beads. He said that he came from Penang; he had a house a little larger than the rest, in which, besides his stock in trade, were such out-of-place articles as a violin and a bottle of lavender water.

A few of the Selungs speak a little Burmese, and thus we were enabled to talk to them and get a few of their words, which I give below spelt phonetically:—

Sea ..	.. Okel.
Shell ..	.. Keniyak.
Boat ..	.. Káking.
Tree ..	.. Káyá.
Mountain	.. Delai.
Rice ..	.. Pêlee.
Oyster.	.. Geetap.
Fresh water	.. Oyem.
Village	.. Alamplan.
Paddy	.. Par.
Malay	.. Ba-tak.
Dog ..	.. Oyee.
Coral ..	.. Kalong.

At present there is no communication between Mergui and any of the islands, none being necessary, as they are nearly uninhabited and produce nothing. The coasting steamer from Rangoon to Penang passes through a portion of them in going between Mergui and Maloywoon or Renoung.

I visited this latter place, which is on the Siamese side of the mouth of the Pakchan river, and may become a place of importance if the canal through the isthmus of Krau is ever carried out. At present it is a prosperous village, inhabited entirely by Chinese with Malay coolies, and owned by a so-called Rája, who is a fine looking Chinaman, holding the mines under the Siamese Government. The mines, which produce rich tin ore, in appearance like dark gravel, are a few miles off; the smelting works are close to the village and the Raja's house, which is a fine one of the Indo-English style. The smelting is carried on in rather

primitive fashion ; the blast is produced by huge bellows like a syringe, with a man working the piston-rod forward and back.

The Chinese seem to be well-to-do, and have good gardens. The day I was there was their mail day, the coasting steamer from Penang communicating with China having just arrived, and many households seemed to have received a box from China, which they were opening in front of their doors with great pleasure and excitement.

Extract from the Narrative Report of MAJOR CHARLES STRAHAN, R E., *Deputy Superintendent, Survey of India, in charge No.* 1 *Topographical Party, Gwalior and Central India Survey.—Season* 1881-82.

Description of country triangulated.

THE following description of the country under triangulation I have compiled from notes furnished me by Mr. Doran. As already stated, it comprised three standard sheets between the parallels of 24°15′ and 25°0′ north latitude and the meridians of 72°30′ to 73°0′ east longitude. From the north-east corner of this portion of country, and not far from the small cantonment of Erinpura, rises a range of hills known as Sarnau, which runs about south-south-west for 20 miles, and rises up to a maximum height of 2,773 feet at Makrora H. S. near its southern extremity. Below the western face of this range, some 12 miles from its northern end, lies the town of Sirohee, the capital of the State of the same name. Here there is a branch post-office, a dâk bungalow, and another bungalow used occasionally by the political officers. At the foot of the southern extremity of the Sarnau range flows from west to east a branch of the Chota or Western Banas, and separates that range from Mount Abu. This mountain extends in a south-westerly direction for another 19 miles, the culminating point, known as Guru Sikkar, being 5,650 feet above the sea ; about 5 miles south-west of Guru Sikkar is the small sanitarium of Abu. In continuation of the Abu range, but only connected by a very low watershed, is the Jairaj mountain, the highest point of which is 3,575 feet, and the length about 12 or 14 miles. Beyond Jairaj, again, but bending more to the westward, is the Lukha mountain, which is not more than 5 miles long, and is only 1,946 feet high. This brings us to very nearly the south-western corner of the country under description, so that this chain of mountains, of which Guru Sikkar is about the centre and the culminating point, divides the ground diagonally into two portions. More or less along the meridian of 72°30′ or the western limit lie the Nadona and Dohirra hills. The highest point of this last range is known as Sunda, and is 3,252 feet in height.

The triangular space (about 700 square miles in area) included between these hills is low, and more or less covered with jungle ; but dotted about it are small hills 200 or 300 feet above the general level. The general drainage is from the centre: one stream, rising in the northern slopes of Abu, flows north-north-west ; whilst another, rising from the same part of the country, flows south-west and out between the Lukha and Nadona hills. They are both called the Sukri, which merely implies that the river dries up. This name seems to be so commonly given to river courses hereabout that it ceases to distinguish one river from another, and is very apt to lead to confusion. A made road runs through this valley in a south-westerly direction from Erinpura *viâ* Sirohee to Deesa. Immediately below the Abu, Jairaj, and Lukha mountains on the opposite side, *i.e.* to the south-east, is the Western Banas valley, down which runs the Rájputána State Railway from Ajmere to Ahmedabad ; its course is, roughly speaking, parallel to the river on its left bank. To the south-east, again, of this valley are rugged masses of hills inhabited by Bhils and Girassias, some of whom proved to be decidedly hostile and much averse to allowing Mr. Doran even to enter their pals. The highest point is that known as Mard, which is 3,080 feet.

General level of the country.

The general level of the Banas valley may be taken at 1,050 near Rohera in the north-east, and 630 where the river leaves the work. This shows a fall of 420 feet in a little over 40 miles, or just about 10 feet per mile. To the west of the Abu ranges the height of the centre of the valley is 1,020 feet, and 25 miles to the south-west of that is 710 feet, giving 12 feet per mile, or much the same slope. To the north and north-west the fall appears to be about 15 or 16 feet per mile. These values must not be taken as strictly accurate, but are sufficiently so to give a general idea of the fall of the ground. The Western Banas was the only river bed in which there was any running water, and even this disappeared before it left the ground under description.

Cultivation.

Of cultivation there is not much anywhere ; the best part is along the course of the Banas river, but even here there is no great extent of cultivated country, whilst on the other side of Abu by far the greater part of the land is covered with brushwood and grass. No doubt, parts of it may be poor, stony soil, and in other parts there may be a lack of water, but the real reason of the scarcity of cultivation is the unsettled state of the country and lawless character of the inhabitants. When reconnoitring with Mr. Doran we passed over large tracts of land in Sirohee which in my opinion only required clearing and tilling to produce excellent crops, but which are now densely covered with bush-jungle. Water was not outwardly visible, it is true, but there was no reason to suppose that there would be any lack of it if wells were sunk, more particularly near the beds of the streams. As you approach Palanpur cultivation increases, and very good rice is grown, more particularly at a small village called Palkhari, which is noted for the excellence of its rice, known as kamod.

Places of note.

The largest native town met with was Sirohee, already mentioned as lying at the foot of the western slopes of the Sarnau range. Although the capital of a State and the residence of a Rájá, it is but a small and uninteresting town. The sanitarium and small cantonment of Abu is situated on the top of the mountain of that name, as also are the celebrated temples of Dilwara and the small temple of Guru Sikkar, which occupies the extreme summit of the mountain. The Dilwara temples are nearly 1½ miles north-east of the residency; these temples are very far from imposing from the outside, but the interior is beautifully carved, more particularly the inside of some of the domes, which are the best of their kind that I have ever seen. All the plateaux of Mount Abu have been already surveyed on the 6-inch scale by Major G. Strahan, and in his report of 1870-71 he gives a short account of the sanitarium and the places of interest to be found there. Since that date another road to the top has been made up the eastern side of the hill; it connects the Rájputána-Malwa Railway with the cantonment. The distance is 15 miles, and the total ascent is 3,000 feet, nearly all of which is surmounted in about 9 miles, the first three and the last three miles being comparatively level. In the valley to the south of Mount Abu are numerous ruins, the remains of Chandal Nagri or Chandrawati, which is said to have been a very large and populous city. Mr. Doran reports that all over the valleys in that neighbourhood he met with ruins indicating that at one time this part of the country must have been far more prosperous than it is now. To the south-east, again, of Chandrawati are the five temples of Ámbá Málá on the road to Dántá. Of these, only one is kept up, and the others are left to crumble away; it is dedicated to Ámbá Diváni and is noted far and wide, pilgrims going to it daily in considerable numbers to make their offerings; the revenue derived from this source, after deducting the expenses connected with the temple itself and its priests, goes to the Rao of Dántá. A mile or so to the south-east of the Ámbá temple is the small village of Kumária, occupying the site of what was once a large and flourishing town called Kandalpur. The following tradition was related to Mr. Doran by the priest in charge of the temple. During the reign of Rája Bhimak, who resided at Kandalpur and was noted for his virtues, Ámbá Devi descended on the earth. She selected Bhimal Sáj, mahajan, one of the numerous good and religious men then living in the country, as her *protegé*, and on him she poured down wealth, enabling him to double his charities and to build temples. He built 360 holy places, and his fame was at its height when the goddess condescended to converse with him personally. She spoke thus to him—"Tell me, my son, to whose assistance and constant care do you owe your present good name and prosperity, for your reputation is world-wide on account of your munificent charities and the numerous temples you have erected." His answer was "To Gorji" (a Jain god). Thrice did she ask him the same question, and thrice did the ungrateful man make the same answer. Enraged at his ingratitude, the goddess cursed him and decreed that all the temples should be burned to the ground. The destruction of the temples at once commenced. Bhimal Sáj, seeing this, fell at her feet and begged that in consideration of his charity and the numerous temples built by him his good deeds should not be buried in oblivion, but that his name might be handed down to posterity. The goddess, taking compassion on him, ordained that five out of the 360 temples should be spared; the remains of the others are still to be seen all round about. In reality I believe the Mohamadans are responsible for their destruction.

States in which the work fell.

The country under description belonged to the three states of Sirohee, Pálanpur, and Dántá, of which Sirohee occupied about three-fourths, the remainder being nearly equally divided between the other two.

Country plane-tabled.

Part of the ground surveyed in detail was extremely easy, and part very difficult; the whole of standard sheet 85 was bad and was undertaken by Messrs. Kitchen and Tate and sub-surveyor Abdul Gufar, assisted by Mr. Doran for a few days. Of this standard sheet the eastern portion is a high plateau, averaging about 2,600 feet above the sea; it forms the highest part of the extreme western edge of the great Rájputána and Central India plateau. From this, again, rise the highest ranges and peaks of the Aravalli mountains with the exception of Mount Abu, which overtops them by no less than 1,000 feet. Unlike Abu, they are mere ridges or peaks. This high country is open, undulating, and fairly covered with villages: there is a good deal of cultivation, but from the nature of the ground it runs in long lines following the small valleys, almost every one of which is, where practicable, dammed up at intervals, forming a series of steps on which rice is grown. Where the valleys are wide and the slopes of the hills can be cultivated, wheat is sown. The inhabitants are Brahmins and Rajputs, principally the former; a few Bhils may be found in the outskirits of each village, but there are no Bhil páls at all. It forms part of the watershed of India; for from the north and to the east flow the sources of the Banas, which eventually flows into the Ganges; to the south are the sources of the Sábarmati, which flows into the Gulf of Cambay, whilst to the north-west rise two or three branches of the Luni river, which loses itself in the Rann of Cutch. The fall from this plateau to the west is abrupt, the first three miles of the Goria Sembal pass taking you down 1,200 feet. After that the slope is gradual, but the road is difficult, from jungle and rocks, for another eight miles, after which the open country is reached. The scenery is rather fine all along this western limit of the Aravalli, the mountains throwing out bold spurs towards the plains, forming a most intricate piece of country covered with heavy jungle. When once clear of the belt of forest below, nothing is visible but a great open plain with isolated hills or short ranges of hills rising abruptly from it. As you go north-west these hills become fewer, and in 50 or 60 miles you

may say you are in the desert. Due west there are more hills, some of them reaching an elevation of about 1,500 feet above the plains, or even more; but they only form comparatively small groups, and in no way seriously interfere with a traveller's progress abou the country. At the same time they are somewhat more troublesome to the surveyor, for they are most awkward hills to climb and to get about on; and as the heat of the sun is always great, and after January rapidly increases until in the end of March it becomes scorching, it is no slight task scrambling over the big rocks of which these hills are composed. There never being shade for the tents, makes it very trying even under their shelter. On the 12th March I registered a maximum in my tent, 99°, on the 21st it was 103°, and on the 25th it reached 107°, and did not go below 100° till past 5 in the afternoon. After that I marched towards the hills, where I found it really quite pleasant compared to what I had left. The change from the burning heat and glare from the sand without a drop of water to the narrow valleys with small streams trickling between green trees was very striking. By the 3rd April I was very nearly on the plateau, and at 5 P.M. the thermometer was only 78°, whilst at 6 A.M. of the 4th the thermometer on the grass read only 45°. This was, however, in an exceptionally cool place, at the bottom of a narrow valley just below the plateau and close to a running stream.

Forts, towns, &c.

The fort of Jalor fell into the season's work; it may be called a first class fort from its size and position, but I cannot give any detailed account of it, as no one is allowed to enter it. It is situated on a high hill standing 1,200 feet above the plain at the north-west end, and 1,500 towards the south-east end of it. On the north, east, and south the hill rises abruptly from a sandy plain; the city, which is enclosed by a wall, lying at the foot of the hill to the north. At a distance of 3,000 yards to the west is the Roza hill, which rises 320 feet above the highest point in the fort, and commands nearly all the interior. It is, however, a difficult hill to get up, and the top is nothing but a mass of huge rocks, piled one on top of the other. From here I got an extremely good view of the whole position, and was enabled to make a tolerably complete sketch on the one-inch scale for the standard sheet. I could also see enough to show me that it was not kept in repair, and it had all the appearance of being perfectly deserted. I observed some half dozen guns on the bastions, but not a sepoy nor a living soul was to be seen anywhere. The Roza hill is connected by a small range with the north-western portion of the fort hill, but there is a good pass for animals, though impassable for carts, through it.

Extract from the Narrative Report of Major T. T. CARTER, R.E., *Deputy Superintendent, Survey of India, in charge No. 2 Topographical Party, Khandesh and Bombay Native States Survey.—Season* 1881-82.

Description of country triangulated.

THE country triangulated consists of certain outlying villages in Khandesh and Nasik, lying in the Aurangabad district of the Nizam's dominions, extending over an area of about 500 square miles, lying between latitudes $\frac{20°-0'}{20}=\frac{18}{}$ North and longitudes $\frac{74°\,52'}{75\,20}$ East. This ground lies to the south of the Satmala range of hills, above the Ghâts, and at an average height of 1,900 feet above the level of the sea. The northern portion is hilly, the hills being covered with heavy jungle. To the east and south the country is more undulating, but is still woody; while to the west and south-west the country is tolerably open, having a few trees just round the villages.

Description of country plane-tabled.—Sheet No. 21.

This sheet consists of three low ranges of hills—one to the west, one very nearly in the centre, and one to the east of the sheet. They run in a north and south direction, and naturally form two valleys. The one to the west is drained by the Bori river, which runs direct into the Tapti; the one to the east is drained by the Anjani, a smaller river, which enters the Girna, a tributary of the Tapti. Both these valleys are very fertile and well wooded with fine mango topes. The Bori river, which enters this sheet at an elevation above sea level of 850 feet, falls to a height of 650 feet, where it leaves the sheet; the hills on either side rising gradually to a height of about 250 feet above the level of the rivers. The eastern range rises to about the same height above the valley of the Anjani, but the character of the range is different, the summits of the hills forming considerable plateaux, on the top of one of which is built a temple and *paka* tank called Padmala, by which name the range is known. All the hills in this sheet are covered with low scrub and grass, but no heavy jungle: consequently the country is much cut up with ravines and small streams, the tracing of which on the ground is always a tedious work to the detail surveyors. A portion of the Châlisgaon and Páchora talukas consists nearly entirely of the valley of the Girna river, running through the sheet from south-west to north-east, with its tributaries, the Titur, Hinra, and Bohla, which take their rise at the foot of the Satmala hills. The north-west corner of the sheet is hilly, the ground rising to an elevation of close on 1,300 feet above the level of the sea. A portion of this ground consists of the Jawardi reserve forest, of 5,000 acres. The Khandesh Government farm at Rokra, of about 1,250 acres, enters the sheets. It is chiefly a cattle farm with breeding stock. There is no very heavy forest in this sheet, the Jawardi reserve forest being newly planted out. The hills to the west are covered with grass and scrub jungle, while the valley of Girna is open and well cultivated, and, except the

Sheet 23.

western quarter of the sheet, is studded with fine mango topes. At the village of Jamdha a *pakka* masonry dam is thrown across the river, and is the head work of two small canals, one of which is taken north of the river and is 25 miles in length, and the other, south of the river, is about 10 miles in length. The sheet is much cut up by numerous small *nalas* and ravines. The boundary between the Khandesh and the Nizam's territory extends along the southern portion of this sheet, and the detail survey has been carried into the Nizam's country for a distance of 1½ miles. The Great Indian Peninsula Railway passes through the sheet from east to west.

Sheet No. 24.

Sheet No. 24 comprises 142 square miles of the Chálisgaon taluka, with an overlap of 50 square miles into the Nizam's territory. This country lies immediately below and north of the Satmala hills, which here rise up abruptly some 1,800 feet above the level of the plain country, which is about 1,150 feet above the sea. The country immediately below the Ghâts, at the foot of the hills, is rugged and raviny, and covered with low scrub; but the mountain sides facing the north are, comparatively speaking, bare. On reaching the top of the Ghâts (Nizam's territory) the country is fairly level, with a gentle fall to the south, and is well covered with fine forest trees. A portion of the Patna reserve forest enters into this sheet, but the forest is not very densely wooded. The rest of the country towards the north is open, very fertile, and studded with fine mango topes, and is well watered by the Titur, Utaoli, Bakra, and Garad nalas, tributaries of the Girna river. These become considerable streams during the monsoons; their banks are steep and they retain their water all the year round. The Great Indian Peninsula Railway passes through the north-west corner of the sheet.

Sheet No. 34.

The country plane-tabled this year in sheet No. 34 comprises part of the Nandurbar taluka. About half of this sheet had been completed during the field seasons 1878-80, leaving the western portion of the sheet and one plane-table (64 south-east) at the south-east corner to be completed. The country in plane-table 64 south-east is hilly. The hills (rising to a height of about 950 feet above the level of the sea) consist of narrow ridges of trap running in a north-east and south-east direction, and here and there intersecting each other The hills are bare, and the country is well adapted for plane-tabling. Mr. Graham says "a remarkable feature in these ridges is that every alternate ridge is very stony, the tops being scattered over with huge boulders." The western portion of the sheet is of a different nature: the ground is more undulating, and for the most part covered with thick forest; the inhabitants are chiefly Bhils, who have made considerable clearings in the forest; the country is very unhealthy, the only time in the year when it is safe to work being from the beginning of April to the beginning of June, and even in these months fever is very prevalent. Part of the Deomogra reserve forest (about 33 square miles) enters into plane-tables 65 north-west and south-west of this sheet. Fortunately, most of the forest trees are deciduous, otherwise the whole of this tract would have been very difficult to survey. There is generally an undergrowth of tall grass, which adds to the surveyors' difficulties. A few wild beasts inhabit the Deomogra forest and the other forest tracts on the banks of the Tapti. Mr. George, while surveying the Deomogra forest, killed a she-bear and her two cubs. She had been the terror of the Bhils in those parts, having mauled no less than 13 men, killing 5 out of the number. Mr. George had some difficulty in getting men to enter the forest, so he thought the best thing he could do was to bag the bear first.

Towns—Sheet 21.—Parola.

Parola, $\frac{\text{Lat. } 20^\circ 53'}{\text{Long. } 75^\circ 10'}$, population 13,204, the head-quarters of the Mahalkari, is a large straggling municipal town It gives its name to the peta of Parola, a subdivision of the Amalner taluka. The chief object of interest is the fort, built 150 years ago by Jaghirdar Hari Sadashir Damodar. It is built of stone and mortar, is about 525 feet long by 435 feet broad, and surrounded by a ditch The fort was dismantled in 1857: nothing now remains except the walls. There are several fine stone Hindu temples inside the town, and outside, several old mosques. The chief trade is in "lugdas" (women's robes) and in cattle, cotton, and grain. The town contains a Mahalkari's court, three schools, a post-office, and a dispensary.

Erandol.

Erandol, $\frac{\text{Lat. } 20^\circ 55'}{\text{Long. } 75^\circ 22'}$, a municipal town, head-quarters of the Erandol subdivision; population 11,295. It rises with high battlemented walls from the bank of the Anjani river, and is connected by metalled roads with Dharangaon, Parola, and Mhasawad railway-station. It was ravaged by Shivaji in 1630. It has a considerable trade in cotton, indigo, and grain, and has a manufactory, where a coarse kind of paper is made. It has a Mamlutdar's court, a large school-house, dispensary, and post-office. In the Pandao Vada (a ruined stone mansion) there is some beautiful and varied scroll work.

Bahadurpur.

Bahadurpur, Amalner taluka, $\frac{\text{Lat. } 20^\circ 55'}{\text{Long. } 76^\circ 5'}$, population 3,586, built in 1596 by Bahadar-khan, was pillaged by Sambhaji in 1685. At that time it was a place of much importance, with many bankers and merchants. It is now a squalid place of no particular note. There are the remains of the old fort.

Tamaswari.

Tamaswari, in peta Parola, Amalner taluka, $\frac{\text{Lat. } 20^\circ 47'}{\text{Long. } 76^\circ 6'}$, population 858. It is situated on the Bori river, and has the remains of a handsome temple built 125 years back.

Páchora, Lat. 20° 40′, Long. 75° 24′, population 3,682, the head-quarters of the Páchora taluka. I stands on the railway 35 miles south-east of Dhulia and 231 from Bombay, and is the nearest station to the Ajanta caves, distant 25 miles. There are the traces of a wall and old fort. Páchora contains a Mamlutdar's court, travellers' bungalow, post-office, and school.

Sheet No. 23.—Páchora.

Bhadgaon, Lat. 20° 40′, Long. 75° 10′, population 6,152, a municipal town, the head-quarters of the Bhadgaon peta of the Páchora taluka. The town is built on an island formed by two branches of the Girna river. The towns, battlements, and four main gates of what was once a strong town wall, remain. Inside the wall some of the buildings are said to be 400 years old. Its trade chiefly consists in cotton, indigo, linseed, &c. It contains a Mahalkari's court, school, post-office, and dispensary. The Khandesh Government farm, the only Government farm in the Bombay presidency, lies two miles to the north of Bhadgaon.

Bhadgaon.

Bahal, Chalisgaon taluka, Lat. 20° 30′, Long. 75° 5′, population 1,848, a large village situated on the Girna river. It has the remains of an old *paka* fort and some old temples on the rising ground, showing that at one time it was a place of importance.

Bahal.

Kajgaon, Páchora taluka. At the railway-station, half a mile north-west of the village, are two cotton-presses—the New Indian Press Company and Messrs. Hormarjee Brothers.

Kajgaon.

Nagardeola, Lat. 20° 34′, Long. 75° 15′, population 4,416. A large village about five miles east of Kajgaon railway-station. There is a ruined Hamadpanti temple of Mahadeo to the west of the village.

Nagardeola.

Chalisgaon, Lat. 20° 27′, Long. 75° 3′, population 5,603, the chief town of the Chálisgaon taluka, stands on the Great Indian Peninsula Railway, 34 miles south of Dhulia. The old fort has fallen into complete decay. It is a place of no great importance, except that it lies on the main road to Kanad, in the Nizam's territory, *viâ* the Outram Ghât. The town is situated on the left bank of the Titur river. The Mamlutdar's court and post-office lie between the river and the railway-station, which is on the right bank of the river and distant about half a mile north-west of the town. Within the town is a school, where English and the vernacular are taught.

Sheet No. 24.—Chalisgaon.

Ranala, Lat. 20° 21′, Long. 74° 26′, population 3,030, is situated in the Nandurbar taluka. It is next in size and importance to the town of Nandurbar. It is an *inami* or alienated village. The first inamdar is said to have been a grandson of the Mahratta Shivaji. It was once the seat of an independent chief ruling over the greater part of Western Khandesh, and in A.D. 1750 was said to have had a population of 20,000 people. There is a large settlement of Bohoras at Ranala, who keep up two schools for their children. The town contains over 200 *paka* houses. In addition to the abovementioned schools, there is a vernacular school and a school connected with the Scotch mission.

Sheet No. 34.—Ranala.

Of forts, properly so called, there are none, though there still remain the old walls round the towns of Parola, Erandol, and Bhadgaon. At Bahadurpur, Bahal, Pachora, Chálisgaon, and Narainpur (sheet No. 34), there are remains of what were at one time Keeps, consisting of four walls with round towers at their corners.

Forts.

The Satmala range is crossed at the Outram (more generally known by the name of the Ranjangaon) Ghât. A well laid out metalled road of about five miles in length, which was opened in 1872, leading from the foot of the hills on the British side to Kanad, the chief town of the Kanad taluka, Dowlatabad Circar of His Highness the Nizam's territory and the outlying British villages, is taken to the top of the ghât. The road is practicable for traffic of all descriptions.

Hills and passes.—Outram Ghât.

Farther east there is a disused pass called the Gortalao Ghât, leading from the village of Wagli in British territory *viâ* Saigowhan to Kanad. It is now impracticable for any one but a man on foot.

Gortalao Ghât.

Padmala hills, three miles east of Erandol. Abrupt hills with flat tops or plateaux covered with grass and scrub.

Sheet No 21.—Padmala Hills.

Two small passes, leading from the large village of Ranala, in the valley of the Amrawati, crossing a narrow ridge of hills that separate it from the Tapti valley, and leading to the large village of Koparli. At present they are impracticable for laden carts, but with a little labour might be made serviceable and of much use as short cuts between the villages mentioned.

Sheet No. 34.

Principal roads.—Sheet No. 21.

(1) Metalled road with masonry bridges and mile-stones leading from Dhulia *viâ* Parola and Erandol to Bhusawal railway-station.

(2) Metalled road 22 miles in length from Parola to Kajgaon railway-station, on the Great Indian Peninsula Railway, with masonry bridges and mile-stones. Nine miles of this road enter this sheet.

(3) Metalled road, Erandol to Dharangaon, masonry bridges and mile-stones. It branches off about one mile east of Erandol from the main road to Dhulia.

(4) Road from Erandol to Maheji railway-station, metalled between the village of Maheji and the railway-station. In course of being metalled throughout.

(1) Metalled road from Pachora to Bhadgaon, with mile-stones; length 8 miles. It continues past the Government farm at Rokra toTalwara, but the latter portion is unmetalled.

Sheet No. 23.

(2) Thirteen miles of the metalled road from Parola to Kajgaon-railway station previously mentioned.

(3) A laid out, but unmetalled, though partially bridged, road from Pachora *vid* Kajgaon and Waghli to Chalisgaon, and ultimately Nandgaon to Nasik Collectorate.

Sheet No. 24.

(1) Metalled road from Dhulia to Chálisgaon, and thence to Kanad, crossing the Outram Ghât.

(2) Unmetalled road from Pachora *vid* Chálisgaon to Nandgaon, Nasik, in continuation of sheet No. 23.

Sheet No. 34.

Main road from Dhulia *vid* Songir, Dondaicha, and Ranala, to Nandurbar. The portion entering this sheet is unmetalled, but it is proposed to metal it throughout between Dhulia and Nandurbar. This road continues *vid* Visarwari and Navapur to Surat, and is much used.

Railway.

The Great Indian Peninsula Railway enters at its 201st mile from Bombay, crosses through the north-west corner of sheet No. 24, through the whole of sheet No. 23 in a north-easterly direction, and through the north-east corner of sheet No. 21, which it leaves at the 248th mile from Bombay.

Rivers.

The Tapti (sheet No. 24), and its tributaries the Girna and Bori (sheets 23 and 24), the Amrawati, Shivnad, and Nasu (sheet No. 34), are the principal rivers met with in this year's work. The Girna and Bori take their rise in the Sahyadri mountain range in the Nasik district; the Shivnad, Nasu, and Amrawati, in the low hills in the Nandurbar taluka.

Tapti.

The Tapti in sheet No. 34 runs through a country of thick forest, inhabited by wild beasts, and, except for small clusters of Bhil huts, with no sign of inhabitants.

The Tapti is neither used for watering fields nor for boat traffic.

Girna.

The Girna, in Khandesh, flows through a well-cultivated valley. At the village of Bahal (sheet No. 23) the Jamdha canals stretch east about 27 miles on the left and 12 on the right bank.

Bori.

The Bori river and its tributaries are much used for irrigation. Neither the Girna nor Bori are navigable, and in the dry season there is little water left in their beds.

Inhabitants.

In the talukas of Khandesh, viz., Amalner, Erandol, Chálisgaon, and Pachora, which are comprised in sheets 21, 23, and 24, the population is chiefly Hindu, being in a proportion of nine to one of the Mahomedan population.

The Hindu population is chiefly composed of cultivators, comprising Kunbis, Bhils, Banjaras, and Kolis, in the proportion, roughly speaking, of 5, 1, ¼, ½ out of a unit of population of 10, the remaining 3 being composed 1 of Mussulmans and 2 of Hindus of other castes and trades. In the Nandurbar taluka the Bhil population came first in number in proportion of 3 Bhils to 1 Kunbi. The Banjaras are in the same proportion as in the other talukas. There are very few Kolis; but their place seems to be taken by a caste of cultivators called Konkanis. The Hindu population is about the same in proportion to the Mahomedan as in the other talukas, viz. 9 to 1.

Kunbis.

Of the people above mentioned, the Kunbis are supposed to have settled in Khandesh about the eleventh century, being forced to leave Guzerat by the encroachment of the Rajput tribes. They are hard-working and most skilful husbandmen. Some of them are well to do, but most are poor.

Bhils.

The Bhils come next in number. In the talukas of Amalner, Erandol, Chálisgaon, and Pachora they are for the most part in service as labourers with Kunbis and other cultivators, or work fields on a joint system, where the landowner provides the land and grain, the Bhils the labour. In the Nandurbar taluka the Bhils are of a less civilized stamp; they form the greater part of the population. The landholders are chiefly Gujar capitalists, and the Bhils are content to work for their food, a little clothing, and liquor distilled from the flowers of the mowa tree (*Bassia longifolia*).

Banjaras.

The Banjaras may be divided into those who keep to their old trade of carriers and those who have begun to settle as husbandmen. They are strong, well-made, and as a rule good-looking, both men and women; but they are by no means clean. Since cart-roads have been opened and they have to compete with railways, they have had to give up to a great extent their wandering ways. There are several divisions of the tribes. The largest is that of the Charan Banjaras, who form about one-half of the whole Banjara population. The Banjara settlements are usually distinguished from those of the Kunbis, or ordinary cultivators, by each family having a distinct hut as a dwelling place.

Kolis.

Kolis are either fishermen or village labourers. They are the same caste as what are called "coolies" in the north-west. In point of numbers they come next to the Banjaras.

Konkanis.

Konkanis, chiefly in the Nandurbar taluka, are sometimes confounded with the Bhils. Their ancestors are supposed to have come from the Konkan, or low country immediately below the Ghâts. They are cultivators.

Amalner taluka.

Soil, products, &c.—The soil is either black, brown, or red; the former is a rich loam, the second coarse and gravelly, and the red an alluvial clay. Bajri, jowari, pulse (kulith), a small quantity of wheat. There is a considerable cotton cultivation, equal to about one-half of the cereal crop.

Erandol taluka.

Soil, products, &c.—Except in some very poor tracts near the hills south-east, the soil is the same as in Amalner. The chief crops are jowari, bajri, wheat (a little), pulses (chiefly gram), and a cotton cultivation, equal to about one-third of the cereal.

Pachora taluka.

Soil and products.—Good black soil in the valley of the Girna; in other parts a red clay soil, which near the hills is light and friable. The chief crops are jowari and bajri, and a small quantity of wheat and oil-seeds. A considerable quantity of *til* is grown, and the cotton cultivation is nearly two-thirds of the cereal.

Châlisgaon taluka.

Soil and products.—The soil is not so good as in the other talukas mentioned; much of it to the south being hard and stony, and the black soil of the Girna valley rests on a subsoil of gravel and sheet rock: consequently bajri is the chief cereal crop, nearly double that of the jowari. Very little wheat is grown, but a larger quantity of oil-seed (til). The cotton cultivation is about one-third of the cereal.

Nandurbar taluka.

Soil and products.—The prevailing soil is a rich black loam. Crops: bajri, jowari, rice, and a considerable quantity of wheat, are grown. Of pulses, gram is the largest crop. There is not much cotton grown, the cotton cultivation being about one-twelfth of the cereal.

Irrigation works.

Jamdha canal.—The Jamdha canal (sheet No. 23), left branch 27 miles long, right branch 12 miles long. The works consist of a masonry weir across the Girna river at the village of Jamdha. Both canals are completely bridged and regulated, and command an area of about 45,000 acres for irrigation.

Mhaswa lake.

The Mhaswa lake, 2¾ miles east of Parola (sheet No. 21), about 4 miles in circumference, but the water-supply varies very much. During the season under review there was very little water in it, but a considerable extent of marsh. The water is retained by a mud and a stone dam 500 yards long. Two small canals are taken out, commanding an arable area of about 4,000 acres.

Wells.

Over most of the country water is found from within 20 to 40 feet of the surface, and the country is well studded with irrigation wells.

Antiquarian remains, objects of interest, &c.

At Diggi village (sheet No. 23), 8 miles south-west of Kajgaon railway-station, on the right bank of the Garad nadi, there is an old but small Jain temple in very good preservation, probably some 600 years old. There are some well-carved figures inside the building, representing a party of dancing-girls and their attendant musicians.

At Patna (deserted village), sheet No. 24, at the foot of the Satmala range and 10 miles south-east of Châlisgaon, there are some Brahmin caves, dating probably from the twelfth century, and of interest as being probably one of the oldest settlements in Khandesh.

Extract from the Narrative Report of Major J. R. Wilmer, S.C., *Deputy Superintendent, Survey of India, in charge No. 5 Topographical Party, Rájputána and Malwa Survey.—Season* 1881-82.

Country triangulated.

The country triangulated consisted chiefly of hills and undulating and intricate country, easy enough to throw points over, but tedious and troublesome for plane-tablers. The greater portion of it consisted of the bed of the Máhi river after it takes its peculiar bend near the village of Anant. From flowing almost due north at this place the river sweeps suddenly round and flows south-west into the Gulf of Cambay. The triangulation extended chiefly over the Bánswára, Dongarpur, and Udepur territories.

Country plane-tabled.

The country plane-tabled was adjacent to that triangulated, and the nature of the ground very much the same, there being only 190 square miles of open country out of 1,092 square miles surveyed, the remainder consisting of hilly, jungly, and intricate ground, being chiefly below the Ghát and amongst the feeders as well as the bed of the Máhi river.

Towns.

There were two towns surveyed this season on the large scale—Jaora and Bánswára. The former is well known, and is the residence of the Nawab of Jaora, a chief who takes much interest in the welfare of his estate. The city is kept generally very clean, and is in this respect a contrast to some other large cities. It is situated in flat, open country; a high wall with bastions runs three-fourths round. Opium is grown on almost every inch of ground. Bánswára, on the contrary, is a dirty, ill-kept, half-deserted, overgrown village, the residence of a Rájput Rájá. The town is situated on a spur and at the foot of some high hills.

These hills are to its south-east, and completely overlook the place. There is an attempt at fortifications in the shape of a high wall running nearly all round the city; but the wall was never intended to resist artillery, being only a protection against the Bhils with their bows and arrows. The city to the north being on a slope is completely commanded from some high, open ground to the north. The country round about is remarkable for its numerous small lakes, Bánswára itself having six within a radius of a mile, and another large and deep one some two miles due east. A building built on its banks is the Rájá's summer residence.

Roads.

There were no roads of importance in this year's work; in some parts even carts were not to be got owing to there being no roads along which they could go.

Rivers.

The Máhi was the only river of importance, a considerable portion of which runs through the work. This river is much broader now; its bed continues to be very rocky and shingly. It is not passable during the rains, but can be crossed almost anywhere after the rains and before the monsoons. There are a few fords and no ferries. The principal passes across the river are between Nain and Bajrangarh, Seogarh and Bájna, Bájna and Kelgaj, Kelgaj and Khandu. This last road crosses the Máhi river three times.

Inhabitants.

The inhabitants are chiefly Bhils. Their manners and customs have been fully described in the *Rajputana Gazette* and the reports of other survey parties. I mentioned in a previous report the peculiar custom of the Bhils of branding their male children on the arms above the wrist with burning cotton dipped in oil. This leaves a permanent mark for life, and the Bhil proper is to be recognized by this mark. The children are branded at about the age of seven, or when they get their first permanent tooth. I have not seen this custom mentioned in the *Gazette* referred to above, nor in any previous survey report, nor in the general annual report of surveys; and as it is a principal custom, and was not known to officers in the Bhil corps or Political Agents with whom I came in contact, I have alluded to it again.

Products.

On the upper plateau opium is most extensively grown, being the chief product of the country. The usual fields of corn are cultivated, but are of very small importance compared with the opium cultivation. Below the ghâts, amongst the bhils, rice and Indian corn are mostly cultivated, though not in very large quantities, sometimes barely enough for their own consumption, except in parts of Dongarpur, but this has not come under survey yet. The cultivation of opium is gradually being introduced, but the Bhil is not willing to give up his old ways of living, and it is not until they realize the profits of opium cultivation that they take to it with any faith or zeal. The nature of the country is against opium cultivation to any great extent, but it grows well on either side of rivers and low flat ground.

Extract from the Narrative Report of Brevet Lieutenant-Colonel R. G. Woodthorpe, R.E., *Officiating Deputy Superintendent, Survey of India, in charge No.* 6 *Topographical Party, Khasi and Garo Hills Survey.—Season* 1881-82.

The country to be surveyed consisted of the lower spurs of the Tipperah Hills running northwards past the boundary into the plains of South Sylhet, as well as some isolated hilly country due south of the station of Sylhet lying between Fenchugunj and the Manu river and a portion of Hill Tipperah, the whole lying west of and being a continuation of last year's work.

Triangulation.

Very little triangulation was necessary, as several stations of the Great Trigonometrical Survey and others previously fixed by this party fell in the different portions of the country to be surveyed, affording sufficient points to start work from. A small amount of subsidiary triangulation was done, but the exigencies of superintending the new sub-surveyor's work prevented my carrying on any triangulation in advance of the plane-tabling.

Work of Assistants.

Major Badgely did not, I believe, mention Mr. Ogle in his report on the Manipur-Burmah survey, and in this report I have also unintentionally omitted his name I find, as it did not occur in connection with the field work under my own immediate supervision. His work in Manipur, I have reason to believe, is exceedingly good; and I hear that he availed himself, with his usual energy and enterprise, of every opportunity after Major Badgely left of extending our knowledge of that country. He has been associated with me in many different and dangerous undertakings, and has always so fully justified the confidence placed in him by all with whom he served, that I am exceedingly sorry to find he has not been as fortunate as he deserves, and has had no promotion for almost ten years. I should be very glad indeed to see his long and meritorious service speedily rewarded.

Mr. Chennell, to whom the survey of Hill Tipperah on the ½-inch scale fell, completed it by the end of March, and managed to survey 222 square miles. He secured the services of a large number of Kuki and Tipperah coolies, who were of great use to him. I was unable to visit the hills in which he was working, but I have every confidence in him, and have no reason to question the accuracy of his work.

Mr. McCay surveyed an area of 50 square miles on the scale of the rest of the work, viz. 2 inches=1 mile, and finished it by the 23rd February, when I sent him to assist Mr. Ewing, who, being entirely new to the work, found himself occasionally in difficulties. Mr. McCay's work seemed to me to be very well done ; but he unfortunately, in one or two places, took as his boundary the revenue survey line, and left the western side of some low spurs untouched, somewhat spoiling the look of the fair map This defect will be remedied. Mr. Keating did 31 square miles, which, as far as I could test it, seemed accurate. His work will be still further tested this season. Mr. Campbell had some difficult country to do, but turned out 41 square miles of very good work. Mr. A. Ewing had never done any survey work before, and the country in which he found himself set down is such as to try the resources of the most accomplished surveyor. It is therefore not to be wondered at that his progress was slow, but he surveyed 21 square miles with very fair accuracy.

Shah Nasiruddin turned out 31 square miles of very good work.

Description of country, &c.

The country surveyed on the 2-inch scale presents few actual physical difficulties, inasmuch as it is easy to chain up the several streams which flow with an almost level course from the low hills in which they take their rise to the plains. In the part worked by Messrs. Keating and Ewing and the sub-surveyors this was the case, except in a few places where the swampy nature of the valley made it impossible to chain along the banks of the stream, or even to distinguish its course, which frequently loses itself in the marsh. As a rule, the centre line in these blocks of hills is the watershed, and the streams flow thence nearly due east and west. The highest hills in these tracts are not much more than 100 feet above the plains; and as the streams descend in the first hundred yards of their course some 50 or 60 feet, it follows that, for the four miles, which is the average distance they have to traverse before reaching the plains, their fall is only 12 feet in a mile, which just keeps the water flowing. These streams are only 3 or 4 inches deep (except here and there, where shallow pools occur) during the cold weather, but in March, after a heavy shower, they rapidly become impassable. On one occasion, when traversing one of these streams, I found myself at noon only a mile from the tea-garden Chaotali, at which my camp was pitched, and as the planter had asked me to breakfast at 12½, if I found myself near enough, I left my men in a small out-garden to rest and await my return, and went on. A good road runs from this out-garden to Chaotali, being crossed several times by the stream, which here has cut a deep and narrow channel for itself through the sandy soil ; but I had no difficulty in wading across the stream, without getting any water into my boots. While at breakfast, one of the very heavy storms of thunder and rain, so prevalent in the latter half of March, came on, and sheets of water fell till 4 P.M.; when the storm passed away the sun came out, and I sallied forth on a pony hoping to finish my traverse before nightfall. On arriving at the first crossing I found a swollen torrent laden with boughs of trees, grass torn up by the roots, and other debris, sweeping past, and men and women gathered on either bank unable to cross. They told me if I tried to cross on my pony I should be swept away, and they were evidently right. Fortunately I had an elephant with me, and sending for him I crossed and went on, the river (for such it then was) having risen at least five feet in the three hours. At the crossing nearest to the out-garden I found my men trying to pass over; one or two had managed it at the imminent risk of being carried down and entangled among the bamboos and creepers lining the banks and hanging into the water. There would have been no chance of getting the instruments across. The elephant had to make two journeys at every crossing, and it was 7 o'clock before we had reached Chaotali, only three quarters of a mile from our starting point.

The difficulty caused by rising streams was not, of course, experienced till March, and although the sharp turns and winding courses of all these small streams, as they thread their way between the low but steep-sided hillocks, prevent traverse along them being carried on with anything like rapidity, yet the real difficulty of these surveys lies in the fact of the low hills being all of one general average height, and all densely clad with forest and close bamboo jungle. What looks a prominent hill from the eastern plains is seen to be entirely hidden by another equally prominent hill from the western plains. On this account many of the triangulated points in these ranges are of no use in extending the triangulations, but are very serviceable in affording checks to the plane-table traverses, though it is always a work of time and trouble to find them, as at a distance of a few yards only in that jungle the most conspicuous marks in the most conspicuous trees are not always visible to the upturned eye, searching in vain to catch a glimpse of the shining bamboo basket through the tangled lacework of the beautiful leafy canopy overhead. Platforms were built in trees at heights varying from 60 to 90 feet from the ground ; but although the view obtained from such "coigns of vantage" over the expanse of hills and forest was extensive, it was seldom instructive, as the indications of the general run of the streams are of the slightest, and the gentle dips between the waves of the unbroken sea of pale green bamboo or dark tree foliage below might indicate a small dry ravine merely, or the course of a large stream, and it is impossible without actual exploration to say which. Hence very little actual plane-tabling could be done; and the method generally adopted was to traverse all the principal streams and their affluents, and cut lines between, connecting the different streams in such directions as seemed to afford the best opportunities for ascertaining the general topographical features, and, where opportunities offered, platforms were constructed on lofty trees, from which a plane-table fixing could be obtained as a check on the work.

The scenery in South Sylhet is exceedingly beautiful, and especially lovely in the evening light. Here is one scene which is only a type of many such. At 4 o'clock in the afternoon I am standing on a cleared hill just above a large tea-garden. The air is beautifully soft and balmy, and looking to the east I see below me the gentle undulations and flat ground under tea cultivation, the rich dark green bushes standing out in bold contrast on the red brown soil. Among the bushes the busy coolies are at work, the women adding brightness to the scene with their brilliantly coloured robes. In the midst of the cultivation, on the banks of a clear stream in a small well kept enclosure with a pretty tank, stands the Manager's bungalow, a large, commodious house with white-washed walls and lofty thatched roof slightly hidden by tall plantain-trees. Rose bushes and other shrubs flourish in the garden, in which from my elevated standpoint I can see that the useful is not overlooked in the culture of the beautiful, as testified by a corner where many tempting looking vegetables are growing. With the orange glow of the afternoon sun upon it, the bungalow with its garden looks, as indeed I find it, a very haven of rest, comfort, and hospitality. I hear voices behind the bungalow near some large neat tea-houses, and looking in that direction I see an excellent tennis court, where an exciting contest is being carried on between the young planters of this and a neighbouring garden. Beyond the tea, the view due south is closed by the virgin forest of dark trees and feathery bamboos, the greater portion of which will soon, by the enterprise of the planters and the extension of the tea-gardens, disappear. To the south-west and west the eye wanders over the plains of South Sylhet, bounded on the south by the jungle clad hills of Tipperah, purple now and indistinct. The flat green fields, above which, as the sun sinks, soft mist wreaths float, are broken up by frequent clumps of mighty bamboos or fine old banian-trees, amid whose dark recesses a few glimpses of reddish roofs and the light blue smoke curling upwards denote the presence of villages. Beyond these, to the west and north, lie open expanses of what at this season is dry, or at the worst only damp ground, but which a few of the March and April storms will speedily convert into swamps and even lakes ("haor" in the vernacular). A thin dark line appearing here and there marks the course of a river, its waters very low now and hidden by the high banks, above which the masts of country boats and the smoke from the funnel of a steamer, just about to anchor for the night, are visible. Far away to the north, beyond the plains, the trees, the villages, and the station of Sylhet itself, rises the long, level outline of the Khasia hills faintly glowing in the sunset. A hum of voices ascends from the villages below, cows wend their way homeward through the deepening gloom, and, as the sun sinks in the brown obscurity of the distant horizon, I shut up my theodolite, and running down the hillside soon find myself at the bungalow, where a hearty welcome and an excellent dinner await me.

And here I should like to take occasion to acknowledge the very great kindness, hospitality, and assistance I and my party have always received from the planters in carrying on our work in their gardens or the adjacent country—kindness which has extended to our kalassies and coolies, who have frequently had a dry, warm shelter found for them when the inclemency of the weather rendered life in tents unpleasant.

Some good roads are being made in South Sylhet, and I hope they will be finished this year—one from Sylhet to Fenchuganj and south to Langla being very much wanted. A narrow riding road, raised a few feet from the fields adjoining it on either side, already exists between Fenchuganj and Langla, and is being improved and extended across the Manu river down to a large garden called Shamshanagar. A road is much to be desired between Companyganj and Sylhet. At present the Government road exists only in the imagination, though tall bamboos stuck in the ground at intervals are supposed to guide the traveller along it. It runs through fields, and when I passed down last December the *dhan* had just been cut, and was lying on the ground quite covering the (at all times) rather obscure path. In many places the villagers through whose fields the path passed had removed the bamboos to their neighbours' fields, and I was only aware that I was going wrong by some infuriated villager rushing at me,—

> "He cried, he roared, he storm'd, he tore his hair,
> "'Death, hell and furies! what dost thou do there?'"

Then I found that the deceitful bamboo had taken me half a mile out of my way. A bright thought struck me—"follow the telegraph line;" but this landed me in a swamp, and I only got right again after a couple of miles' detour. Most of the other so-called Government roads are merely tracks across the fields and open country marked out by bamboo stakes, a little scraping here and there through the low mud partitions between the fields showing how wide the road will be in the millenium. In December, January, and part of February a ride across the fields is not unpleasant, after that the dried-up earth cracks under the powerful sun, in all directions, making walking unpleasant and riding almost dangerous; while in the end of March, and onwards till the rains, the traveller ploughs his painful way, knee-deep, through the mud flats, over which a little later on he can gaily take his way in boats. There is a hill road across the Harargaj range leading from Sagurnat to Hingajia, which is passable in the dry weather, but ascends and descends so steeply in many places as to be difficult for laden animals, and I should think so slippery after rain as to be dangerous even for foot-passengers. The paths through the lower ranges generally follow the course of the streams, which, as I mentioned before, are very level, the only rise being one of a few feet at the watershed. In the rains these roads are impassable. In some places, as between Indanagar, Indessa, Ita, and Kijildara, the planters are opening out communications and making good roads for themselves.

The only rivers actually under survey last season were the Manu and its affluent the Deo, for that portion of their course through the Tipperah hills which fell in Mr. Chennell's work. I had received two very nice little subtense theodolites from the Mathematical Instrument Department, Calcutta, one of which I found very useful and accurate in running check traverses through and round the sub-surveyor's work. The other enabled Mr. Chennell to traverse the Manu and Deo rivers in boats with greater rapidity and accuracy than he had been able to attain the year before by cane measurements from boats.

The hills in the Tipperah territory immediately bordering on South Sylhet are not inhabited to any great extent, but within our territory all the ranges are being taken up and opened out for tea by various companies or individuals, and the words "low hills covered with impenetrable jungle" may soon be left out altogether from the maps; for the jungle, far from being impenetrable, will in a great measure have ceased to exist.

The plains in South Sylhet are very fertile and populous, and we never had any difficulty in getting our supplies at any of the many numerous bazars which are so frequently held in that part of the country.

Extract from the Narrative Report of G. A. McGILL, ESQ., *Surveyor, Survey of India, in charge No. 7 Topographical Party, Rájputána and Simla Survey.—Season* 1881-82.

Description.

DEGREE sheet XX, surveyed during the season 1881-82, is unquestionably the finest bit of country that this party has had to survey for the past five years. It is quite different from the usual run of the degree sheets of Rájputána, being more or less fertile, with clumps of rocky hills of from 200 to 400 feet above the ground and extensive plains of a hard soil composed of clay mixed with sand, besides the usual rolling sand hills and ridges of the desert. The eastern half of it may fairly be called the land of Goshen, the western being arid sand-wastes, with few villages and little or no water.

Water.

There is no doubt that from the great experience acquired by a Surveyor he is well able to surmount great difficulties; but the one great difficulty which at times quite bewilders him is the making of arrangements for drinking-water for himself, his camp followers, and baggage camels. In the north-east section of this degree sheet, although water is plentiful, it has to be got with great difficulty. The country depends on its supply of water on wells which are very far apart, some villages having no wells at all and are dependent on other villages for water.

Wells.

These wells contain delicious cool water and are of extreme depth, the average being 270 feet; but one measured by me at the village of Bhakri in lat. 26° 54′ 4″, long. 72° 38′ 41″, was found to be 480 feet deep. The water is drawn up from this well by a relay of bullocks and camels. I have endeavoured to get every information I could about these wells from the villagers. They have all been dug by the charity of some rich mahajan or bania; they are well built, throughout of stone, and have one or two large cisterns on either side, round each of which runs a stone trough for the cattle to drink out of, and this is the only water that they can get, as for five months in the year the tanks are quite dry. I was told that after a depth of three "pursas" (18 feet) the sand ceases, and a coarse kind of sandstone is reached, which is easy of penetration; but at a great depth hard rock is encountered, which is blasted through till the remaining portion sounds hollow. The labourers then carefully tap through this, when a jet of liquid mud rises of an offensive smell. The work is now over, and the workmen are pulled up. The well then fills fast with water, and all that is necessary is to draw away a quantityof it, and the result is a spring of water that never fails.

It often so happens that a bucket falls in; men then are sent down seated on stout leather ropes, to which a cross-pole is fixed; they take down with them hooks for dredging the water and bring up the lost bucket. These people have told me that in some cases the hard rock that had been tapped has fallen in, and that the water below was in motion as if it were a flowing stream, and in all such cases the bucket is never found, as it is carried away: they also say that the depth of water is seldom over 12 to 14 feet. The measurement taken by me to determine the depth of the well was to the surface of the water. The wells are not broad, only 8 to 10 feet across and circular, and during the middle of the day the water is seen below like a six-inch mirror.

To form an idea of the depth of the well it may be illustrated that its depth is 120 feet more than the height of St. Paul's at London, 12 feet more than twice the height of the "Kutub" at Delhi, and 6 feet less than three times the height of the Taj at Agra.

Height St. Paul's	... ...	360 ft.
,, Kutub	... ...	234 ,,
,, Taj	... ...	162 ,,

Lakes.

On the north-west corner of this degree occur extensive plains of hard ground and fields of red sandstone, and here I came upon several dried-up salt lakes. Before the Inland Customs Department put a stop to the manufacture of salt, the Tehsildar of Phalodi used to farm out the lakes to the "Kharwals," and large quantities of salt used to be manufactured. This was before 1877, when I triangulated the country, and at which time the lakes were perfectly dry. This year, owing to the heavy rains, all the lakes had water; the larger of them is 7·1 square miles, and the smallest 2·4 square miles in area.

Sand hills.

The largest portion of this degree, lying to the south-west, is an extensive sea of rolling sand ridges of a uniform height of 100 feet. Strange as it may seem, the people of the country prefer to cultivate crops in this sort of ground; and with a good monsoon, rich crops of bajra, mót, and til are produced.

Fruits.

The fruit of the country is the matira, a luscious sort of water-melon, the seed of which is said to have been imported from Kabul. It grows almost wild, and is the great mainstay of the people and the cattle, who make use of it as food as well as to quench their thirst.

Produce.

The produce of the country depends upon the season's rainfall. Bajra, mót, and til grow well, and wheat in small quantities is raised where the ground is favourable. Melted butter (ghee) is also exported.

Manners and customs.

The population is partially agricultural and nomadic, the latter preponderating. Large flocks of sheep, goats, and herds of cattle and camels are raised. The oxen are short, but seem to be particularly strong. It is surprising to see a yoke of them dragging a heavy cart laden with large "gharas" of water over heavy sand and across country covered with low sand ridges. The cattle, owing to the scarcity, are only given water once in three days, and for the same reason the habits of the people are exceedingly dirty. The men and women of Rájputána are, I think, the most unsavoury creatures I have ever seen, even dirtier than the Thibetian coolies employed on road-making at Simla. All the people smoke, and men, women, and children are, without exception, opium-eaters.

Forest.

As may be expected, the country has no forests, but large tracts are especially reserved for the growth of timber for house-building. The larger kind of trees, are, bair (*Zizyphus jujuba*), babul (*Acacia Arabica*), and khejra, also of the accacia kind. These reserves are cared for, and trees yielding timber of 12 feet in length by 8 square inches are obtained. But owing to the plentiful supply of slabs of sandstone, the thakurs and mahajans build their houses entirely of stone.

Manufacture.

Salt used to be plentifully manufactured until it was put a stop to by the Inland Customs Department. Woollen serges of different qualities are also made, but are not exported. The rude village loom is employed in making them, and it is surprising to see how good a material is produced, almost equal to military serge. Coarse felt is also made, and is chiefly used for padding camel saddles.

Climate.

The climate is particularly fresh and healthy from 15th November to February; nothing better could be desired; a cool refreshing breeze blows all through the twenty-four hours. During these months rude health is enjoyed by every one. During the night it is bitterly cold, and water gets frozen inside the tent. With February a decided and sudden change comes on: the thermometer rises every day; and in March sandstorms are very common. The misery experienced during this time can only be described by one who has had experience of it. The sand penetrates everything, including eyes, nostrils, and ears. The box of clothing, and even a strong iron despatch-box, is not proof against its penetrating power, and as a consequence there is no partaking of a meal as long as it lasts, as everything cooked grates under the teeth and makes the blood curdle. My experience of Rájputána only extends up to the end of April; but I would presume the heat must increase greatly later on, and life must feel a burden to him who has to remain there. The salt people, with whom I spoke on this subject, and who live in a *paka* house at Agar, told me they have experienced the sandstorms for days, and that it was impossible to keep their *khas-khas* tatties wet for any time, the lake water thrown on them turning into fine salt from the intense heat of the wind.

Degree sheet XIX.

Degree sheet XIX was also partially surveyed during this season, and the triangulation extended through it, and also degree sheet XVIII. These two degrees are sparsely inhabited, XVIII being almost if not a howling wilderness. Sheet XIX contains parts of Jodhpore, Bickaneer, and Jeysulmere. A line drawn connecting $\frac{\text{Lat. } 28°\text{-}0'}{\text{Long. } 72°\text{-}45'}$ with $\frac{\text{Lat. } 27°\text{-}0'}{\text{Long. } 72°\text{-}30'}$ will divide the sheet into two parts; the eastern representing the sand, and the western the hard soil consisting of sand and clay. Water is very scarce in the whole of this degree, and especially so in the northern half, which is also very sparsely inhabited.

Towns.

The only two large towns are Phalodi of Jodhpore and Báp of Jeysulmere; the former has a *paka* walled enclosure called a fort; it is a place of importance and a tehsil, and water is plentiful. Báp is also a tehsil, but in appearance it is little better than a village; there is a fine tank of water at this place.

Phalodi ... { Lat. 27° 8′ 0″. Long. 72° 24′ 14″.

Báp ... { Lat. 27° 22′ 30″. Long. 72° 23′ 40″.

Agar Salt Lake.

Between both these places, 12 miles north of Phalodi and 6 miles south of Báp, is the dry salt lake of Agar. This place has now been selected and made into a depôt of the Inland Salt Customs, and is officially known as Phalodi salt source. There is a large lake here, about 25 square miles in area; it is generally dry, but during a heavy monsoon contains water to the end of May. The salt is made by evaporation of water in large pans; the water is drawn from

wells which are sunk in the bed of the lake. The water is reached at 8 feet below the surface; it is exceedingly salt, and readily evaporates and forms into salt in the pans.

Degree sheet XVIII.

Degree sheet XVIII might well be called a "terra incognita;" it is the worst bit of desert ground I have seen. It is almost devoid of villages, and water is exceedingly scarce: very frequently a well of water only occurs in 270 square miles. In this degree I frequently came upon wells yielding poisonous water; it is very very cautiously used by the people, and only taken after a good meal, and even then most sparingly. If freely drunk it acts as a violent emetic and aperient, and frequently causes death.

Tánkás or reservoirs.

Cattle are watered from it but sparingly, and only once in three days. In some villages the rain-water is carefully collected and preserved. This is done by sinking a cistern in the centre of a funnel-shaped enclosure of some hundred yards in circumference; the rain-water rushes down the slope and collects in the cistern. These cisterns are covered over and jealously guarded; they have a door on top of the covering, which is kept closed and locked. I was told that a man or animal poisoned with poisonous water, if early taken in hand and given a free draught of this rain water, always recovers. These cisterns or wells are called by the people "tánkás," and, as might be expected, are much valued by the people of the country; and it is not till they are coerced by the vakil that their existence is made known. The water in them is clear and deliciously cool and fresh.

Sport.

Although Rájputána is in many places a perfect desert, sport in some form or other is plentiful. The Chikara, a small species of deer, is very common. They are to be met with in numbers, more especially in the grounds belonging to the Bishnoies, where they are as tame as goats. This is the only large game of the country; but bustard, both the giant and small species, as well as florican, can be shot. Partridges and grouse are plentiful. The blue pigeon and the peacock are more or less domestic birds, as they are worshipped by the people; and although the sandy plains can't afford anything of the picturesque to a desert village, still the large numbers of these birds, especially the peacock with its gay plumage and flowing tail of gold and azure, lend a cheerful aspect to these otherwise uninviting habitations.

Religion and caste.

Rájputána, like most parts of India, has a mixture of the various forms of religious persuasions. I was most struck, however, with the Bishnoies, a class of people who live by themselves and are seldom to be found in the same village with the other castes. These people hold sacred everything, animate and inanimate, carrying this belief so far that they never even cut down a green tree; they also do all in their power to prevent others from doing the same, and this is why they live apart from other people, so as not to witness the taking of life. The Bishnoies, unlike the rest of the inhabitants, strictly avoid drink, smoking and eating opium; this being prohibited to them by their religion. They are also stringently enjoined to monogamy and to the performance of regular ablutions daily. Under all these circumstances, and, as may be expected, the Bishnoies are a well-to-do community, but are abhorred by the other people, especially as by their domestic and frugal habits they soon get rich and are the owners of the best lands in the country.

Extract from the Narrative Report of MAJOR H. R. THUILLIER, R.E., *Deputy Superintendent, Survey of India, in charge No.* 8 *Topographical Party, Mysore Survey.—Season* 1881-82.

Remarks on the country.

THE country topographically surveyed this season may be conveniently divided into two classes, each of which has distinctive features. That in sheets 2, 19, 23, and 24 in the Shimoga and Kadur districts, executed by the European assistants, comprises an area of 1,460 square miles, and is of a similar character to that previously surveyed in the Malnád, consisting of forest-clad mountains and valleys presenting alternations of varied and charming scenery, but dense forests shut in the view and render the survey of these parts not only difficult, but slow; plane-table intersections from surrounding fixed points cannot be obtained, and work has to be done almost entirely by traversing with the chain. The twin rivers Tunga and Bhadra run through sheets 23 and 24, and meet at the northern edge of sheet 23, from which point they become a united stream called the Tungabhadra; and the Sharavati river flows in a north-westerly direction through sheet 2 till it reaches the ghâts, where it precipitates itself down the celebrated Falls of Gersoppa, the largest of which descends in an unbroken column to the depth of 830 feet. The Bába Budan mountains, the loftiest range in Mysore, skirt the southern edge of sheet 24, and rise like a gigantic wall to a height of some 4,000 feet above the general level of the country to the north; the summits are clear, but their slopes and water-courses are thickly covered with valuable forests, giving shelter in parts to coffee cultivation. With the exception of a small portion of open country about Shimoga in sheet 23, and around Tarikere in sheet 24, the whole of this area is covered with dense forest and jungle. The difficulties and delays which arise in surveying such country have been previously described, and it is only necessary to add that the obstacles met with in the sheets above alluded to were as great as those experienced in former seasons, and that the same care and patience have been bestowed in overcoming them. Sheets 10, 11, 14, 15 in the Chitaldroog district, and 30 in the Hassan district, comprising an area of 2,766 square miles, are in the Maidan division or open country. This portion of the Chitaldroog district is almost throughout

a barren and dry land. It is included in the valley of the Vedavati or Hagari, which during the hot months is for the most part dry. The general level of the ground is about 2,000 feet above the sea. It consists of great undulating plains, traversed by a belt, about 20 miles broad, of approximately parallel chains of hills, mostly bare and rocky, the highest point being 3,863 feet above sea level. Trees are few in number, and the low ground, where not cleared for cultivation, is covered with stones and a dwarf species of mimosa Water is scarce, and the climate, as compared with other parts of Mysore, is drier and hotter. The greater part of this area was executed by the sub-surveyors, and is for the most part open and easy, where the plane-table was utilized to its best advantage, and the chain hardly ever needed.

General remarks.

The programme arranged for the season's operations proved to be somewhat more than could be got through, and sheet 2 had to be left incomplete. Nevertheless a larger out-turn was completed than had yet been accomplished, and this with a reduced European staff. The success of the season's operations was in a great measure attributable to the good health of the surveyors, who were able to work uninterruptedly throughout, and also to the energy they displayed in taking every advantage of it. The whole of the work has been carefully examined, and that executed by the European assistants has stood the tests remarkably well, and was found to be accurately and carefully surveyed. The plane-tables done by the sub-surveyors were also found accurate as far as the position of the details was concerned, and with two or three exceptions the general direction of the lines showing the configuration of the ground was found fairly correct, but the drawing of some of them is still crude. The general tendency with natives is to exaggerate the features of the low ground, and on this account I took special precaution to have a large number of well determined heights taken in a systematic way with a theodolite, over their work. In the five sheets which were chiefly executed by them in the open and undulating ground, 1,061 heights were observed, giving an average of one height to every 2·8 square miles. By the aid of these extra heights, in addition to those fixed trigonometrically, the draughtsmen found no difficulty in modifying the drawing in the fair maps. All the surveyors were furnished with the clinometers designed by Major G. Strahan, and observed heights therewith throughout their work. But the results are more or less unsatisfactory, especially in the ground where the variations of height are small, and having such a large number of theodolite heights there was no necessity to utilize them. I have endeavoured to adhere to 50 feet vertical intervals for the contour lines as far as feasible throughout the whole of the season's mapping, and to follow out, as far as the nature of the ground would allow, the method of keeping the contours closer to the streams, as introduced by Major Strahan last year in sheets 27 and 29.

Extract from the Narrative Report of MAJOR T. H. HOLDICH, R.E., *Deputy Superintendent, Survey of India, in charge Kohat Topographical Party—Season* 1881-82.

Plan of detail.—Survey operations.

THE plan of operations for the party (with the exception of Mr. McNair) was simply to resume plane-tabling from the line to which it had been completed the previous year, the starting points of the various plane-tablers being all more or less contiguous to the western boundary of the Kohat district forming the line of our north-west frontier, and the general direction of the work from west to east. Mr. McNair formed no exception to the rule as far as his plane-tabling was concerned, but he had in the first place to fix extra points by triangulation over an area of about 500 square miles, and in addition to extend a reconnaissance across the frontier wherever opportunity offered.

Party breaking ground in the field, &c.

In order to gain a little time, Mr. McNair left Dehra for the field in advance of the rest of the party, at the end of November. Mr. Claudius (who took charge in the absence of the Deputy Superintendent) followed with the party about the 12th December; and the plane-tablers were at work by the end of December, commencing on dates varying between the 23rd and 30th. As the field season closed about the 16th April, its actual length was thus reduced to a very short four months.

Run of triangulation and arrangements.

Mr. McNair's triangulation consisted in fixing a few secondary stations on points in the neighbourhood of Bahadur Khel, and intersecting sufficient natural objects to give him the basis for his plane-tabling and to determine a sufficiency of heights. The most important point he reached was the celebrated Kafir Kot peak, an account of which will be found appended. On joining the party on the 4th February, I proceeded to the north-east corner of the district, and there fixed a few secondary stations, which were sufficient, with the addition of such great trigonometrical stations as existed, to secure the triangulation of that (the only untriangulated) part of the district. Subsequent to inspecting and checking the topographical work of the party, I triangulated for the Kohat City and Cantonment plan, which, with reduction of supplementary heights, and other computations, occupied the rest of the season.

Triangulation completed.

The total area traingulated was about 500 miles by myself (independent of the city triangulation) and 500 by Mr. McNair, or 1,000 in all. The secondary triangulation of the district executed

by Lieutenant Walker 30 years ago was quite sufficiently well marked to enable the triangulators to intersect a sufficient number of points from these stations to serve the purposes of topography. No previous reconnaissance was necessary, and no time or money was wasted in the erection of poles or points to intersect. The natural features of the country were abundant, and as the class of instrument used was no higher than the 6-inch theodolite, they were sufficiently definite for the purpose. Of course, the linear errors are large—larger than they would have been had the instruments been perfect of their sort, but not too large to affect the results as the basis of topography on the one-inch scale.

Remarks on the country triangulated.

The country triangulated to the north between Khushalgarh and Attock is remarkable for nothing but its general roughness. It is fairly open and free from anything like heavy jungle. The Jawaki and Peshâwar district hills close it in on the west with a long, continuous, rugged line of peaks, running to an altitude of between 4,000 and 5,000 feet. On the east the river Indus forms the boundary between the Kohat and Rawalpindi districts. The river between Attock and Khushalgarh is always picturesque, and often grand in scenery. It flows between steep rocky banks formed by bands of many-coloured limestone fringed with patches of deep white sand. There is not much vegetation—a few scattered tamarisk-trees, and an occasional grove of stunted olives, are generally all that can be seen from the river banks; but here and there a patch of cultivation slopes down to the river and modifies its excessive wildness. A spur from the Jawaki hills, called Nilabgash, extends eastward to the river, and is the only obstacle to a fairly level line between Attock and Khushalgarh. A road exists already, running nearly parallel to the river, without which this portion of the Kohat district would be difficult to traverse, from its extreme roughness. It all belongs to the Khattak section of the Pathan tribes. The country triangulated by Mr. McNair consisted chiefly of the flat, open, sandy district which extends southward from Latammar to Bannu. Its flatness rendered it difficult to find or fix points along the western edge of the district, but the few that could be fixed were sufficient, with the well-known peaks of the Lawâghar hills on the east, to enable Mr. McNair to plane-table all this area. The peculiarity of this part of the Kohat district is its waterless character. In the month of March the Kummer wells form the only water-supply for a distance of from ten to sixteen miles round, and the daily collection of people (chiefly women) at these wells in the early morning rather resembles a *mêla* (or fair) than anything else. The water is carried in small goat-skin *mussaks* on the backs of donkeys, long strings of which, driven by women, who are generally handsomely dressed, with a profusion of silver ornaments on their breasts and arms, may be seen in the early morning, converging to the wells from every point of the compass.

Remarks on the country plane-tabled.

The country plane-tabled consisted of the upper valleys of the Kohat and Teri rivers, the Surdâg hills, and the Lawâghar hills, with the low-lying plains at their foot on the west, bordering the Bannu district. All the smaller tributaries of the Kohat river, as well as the main stream of the Teri, flow generally from west to east towards the Indus, in approximately parallel lines, and through narrow valleys fairly well cultivated by means of irrigation The hills dividing these valleys are rough and precipitous, their apparent formation being limestone, above which occurs a rock closely resembling laterite, which may be the pisolitic ferruginous clay referred to in page 563 of the "Manual of Geology of India." There is often great apparent regularity of outline, both in section and plan; and where the strata dip at any considerable angle, there is usually a sharp knife-like ridge defining the summit, which is difficult to traverse. But rough and difficult of access as they are, they are entirely free from heavy jungle, and possess great command of view over the surrounding country; so that this part of the district cannot be called difficult for plane-tabling. The general level of the cultivated portions is high, between 1,000 and 2,000 feet above sea level, and the climate cool and pleasant. The Surdâg hills, stretching east and west below Bahadur Khel, are different in formation. They are red and purple clays and sandstone, overlying large masses of grey rock-salt, which is dug out of them for trade. They are peculiarly intricate in character, breaking up into minute detail, which is tedious and troublesome to define topographically. But they are also free from jungle: and difficulty of detail, when that detail is visible, is not to be compared to the difficulty caused by heavy jungle. The Lawâghar hills are wholly sandstone, and run parallel to a range of hills called the Sûrghar, which is almost wholly limestone. They are difficult of access, and the labour of making way about them is severe. The low ground west of them is open plain, almost entirely under dry cultivation, but very destitute of water. Throughout an area of some 300 square miles water is only to be obtained at 14 (out of 140) villages, chiefly from deep-sunk wells.

Forts, towns, cities, &c.

The only fort or town of any importance in the district are those of Kohat itself and the posts maintained along the frontier line to Bannu or in the Meranzai valley. The town of Teri is prettily situated on a small hill bordering the Teri river, and it contains a few strongly walled buildings. The command above the river is about 100 to 150 feet, but it is not a place of much importance. The chief lines of hills in the district have already been referred to. The ridge, of which Halwat and Swani Sir are the two principal peaks, the Surtang line of hills, the Surdâg (already described), and the Lawâghar, are the most definite of these minor hill systems. The Surdâg pass, connecting Bahadur Khel with Latammar, is the only one of any importance falling within the limits of last season's work. Of other ranges it would be safe to record that they are impracticable. The Surdâg pass is only a part of the main frontier road connecting Kohat and Bannu, and as such is well known and frequently traversed. None of the rivers

are navigable. They flow down to the Indus through steep, rocky defiles and high banks, and their beds seldom even afford foothold for a narrow path. The beds of the Kohat and the Teri streams are never absolutely dry. The Bungush and Khattak tribes divide the whole district between them. Both of them are Pathán or Pashtu-speaking people, and in manners, habits, &c., it is not easy to distinguish between them. As a rule they are frank, pleasant people to deal with, and there was not a single case of dispute between the surveyors and villagers during the last field season; but they are true Pathans, with regular Pathán love of border fighting and raiding. Blood feuds and reprisals are of constant occurrence, and lead probably to far more murders than the accidents attendant on robberies and raids. In appearance they are a sturdy-looking, well set up race of men and women. Their dress is flowing and picturesque, and, in the case of the women, often very handsome and well set off by heavy silver ornaments. They prove to be excellent soldiers in our frontier regiments.

Addenda from a Report by MR. W. W. MCNAIR.

I HAVE the honour to submit a report of my reconnaissance of the tract of independent territory lying east of the Kurram river and immediately north of Edwardesábád or Bannu.

The tract in question embraces an area of 350 square miles, and through it from east to west extends the range of hills generally known as Laki Juni or Kafir Kot. This range, which consists generally of conglomerate, terminates at each end in huge excrescences of grotesque shape, which rise considerably above the level of the ridge and strike the observer's eye from every direction.

The four most prominent of these excrescences, perched as it were on the eastern end of the ridge, are collectively called Kafir Kot, an appellation which, I believe, may signify either the "infidel's abode" or an "inaccessible nest." I am informed their summits have hitherto not been reached.

One of the mounds on the western end of the ridge assumes a form not dissimilar to that of a well developed woman. This resemblance appears to have received local recognition in a legend, which attributes the peculiar formation to a forsaken maiden, whose prayer to be turned to stone was granted.

The heads of two streams, the Changos and Jangana, constitute the northern boundary of the tract of country, the subject of this report. The eastern and western boundaries are the Changos and Kurram rivers, and the southern a range of hills through which burst the Kurram, Goumati, Barganatu, and Changos.

The two streams, the Changos and Jangana, flow some distance in opposite directions. The Changos, after proceeding eastwards for about two miles, turns sharply round to the south and finds an exit through a range of hills, finally joining the Kurram six miles south of Bannu. The Jangana runs parallel to the Kafir Kot range of hills until it empties itself into the Kurram.

In my observations of the passes leading into the heart of this tract of country I was careful to notice that there were no obstacles calculated to interfere with the progress of wheeled artillery.

Throughout the entire area of 350 miles I noticed only four villages containing *permanent* dwellings. They were Goumati, Sapari, Shazman, and Garang; and I estimate there were about half a dozen other villages which consisted entirely of temporary structures.

The general aspect of the country is wild. Of cultivation there is very little. A very fair supply of water throughout the year, and grass in fair quantity, are to be had, but fuel is scanty.

The inhabitants are sections of the Daresh Khel Waziris, and are divided into clans, of which the principal are the Hati Khels, Utmanzai, Umarzai, and the Spinkhi Turi and Gagan Khels.

In winter and spring as many as 6,000 fighting men are estimated to occupy the hills, but during the hot months, from May to September, scarcely 500 remain behind, while the main body betake themselves to Shawal. For subsistence I have reason to believe the inhabitants largely rely on robbery, carried out on the Bannu and Kohat border. Their reputation as highwaymen is great, and I think I am right in saying they are a source of considerable anxiety to the Deputy Commissioners of Kohat and Bannu.

This tract of country is an asylum for all the bad characters and refugees from British territory; and whatever the price at which such men may secure shelter, the protection they receive is proof against all treaty obligation. On the occasion of my visit to Kafir Kot I was accompanied by some of the Nabab of Khattak's men, and from them I afterwards ascertained that one of the Daresh Khels, who engaged a good deal of their attention, was a murderer and a refugee from British territory.

The ostensible means of livelihood of the Daresh Khels is the sale of cattle and sheep, of which they possess large numbers, and the hiring out of camels. From the Bannu plains they draw supplies of the ordinary necessaries of life through permanent settlers located there by each of the above mentioned clans.

Like most Afgháns, the Daresh Khels are men of splendid *physique*, of great endurance, and inured to the inclemency of all weathers. I have not heard of any of their numbers accepting employment under the British Government.

Like all Muhammadans, their graves face north and south; but whilst all other sections of Afghâns erect two upright stones—one at the head of the grave and the other at the foot, with this distinction for that of a female, that they have the flat face of the upright stone at the foot turned towards the north—the Daresh Khel Waziris place three stones over the graves of their women and only two over those of the men.

Addenda from a Report by Mr. T. E. M. Claudius.

I have the honour to submit the following report of the working of the party during your absence from 27th November 1881 to 3rd February 1882, as also a few notes on the country plane-tabled by me. The programme left by you for the last field season was followed out as closely as possible. With the exception of Mr. McNair, who started a few days in advance of the party for Kohat, with the expectation of immediate trans-frontier work, and sub-surveyors Esuf Sharief and Kadar Sharief, who were employed by the orders of the Surveyor-General for about a month in plane-tabling on the half-inch scale a portion of the country between Nagtiba and Mussoorie, the party continued working at the Afghánistán fair mapping till about the 10th December. On the 12th I started with the whole establishment and reached Kohat on the 15th. The usual preparations for field work were taken in hand at once, and all the plane-tablers, fully equipped, started for their respective portions on the 21st. The plan recommended by the Deputy Commissioner, of supplying each surveyor with a responsible man from the police, with the authority for engaging a certain number of men picked from the ground on which each plane-tabler was to be employed, answered admirably, and was found even preferable to a military escort. On account of a severe attack of fever, which is always prevalent in Kohat during the winter months, I was unable to start my own plane-tabling till the 1st of January. Kadar Sharief, from an attack of rheumatism, was reported unfit for work a week after his departure, and continued in that state until your arrival. Mr. Warwick, who had been on sick leave, reported himself at Kohat on the 23rd January, and on the day following he accompanied me *en route* to his work, while I proceeded to inspect sub-surveryor Atma Singh, who had been making slow progress out of all proportion to that of the others. I found him employed in exceedingly intricate ground, and it was merely his want of experience in delineating such ground that deterred his progress. He is very apt though, and soon put into good effect whatever he was told. On my return to Kohat, I was surprised to find that Mr. Warwick was obliged to wend his way back on account of a relapse of sickness. He was never able to undertake any field work after that.

The area surveyed by me, 260 square miles, included Kohat itself on the north-east corner and the hill sanitarium of Mirkhwaili on the south-west; the former surrounded with smiling gardens and fields of luxuriant wheat cultivation, while the latter surmounts a mass of exceedingly stony and rough hills. My out-turn, perhaps, would have far exceeded what it did but for the scarcity of villages in my western corner, and the time thus lost in tracing and retracing my steps from and to camp morning and evening over cut-up and waterless tracks. The hill Mirkhwaili affords a cool retreat to a few of the inhabitants of Kohat during the summer months, and but for the extreme difficulty of conveying building materials to the summit would, no doubt, be utilized to a greater extent than at present. The only respectable building up there is the one Major Cavagnari took the trouble of erecting, and to this the fashionable society of Kohat are obliged to resort by turns.

Thieving, cattle-lifting, and murders are of course of frequent occurrence all along the Kohat frontier, but I was very much surprised at the daring displayed by some Afridis at Kohat in an attempt to steal my horse in the month of April after the completion of my work. Twice on the same night attempts were made, although on the first occasion they were fired at by my havildar and guard, and one would have thought that, having aroused everybody's attention, the attempt would not have been repeated, yet to our surprise a second and more daring trial was made to effect an entrance into the stable by digging a hole in the back wall. This of course was soon heard and discovered, but the thieves managed to make good their escape with a few ineffective bullets whistling after them.

As notes regarding my work of season 1880-81 were not sent in at the proper time, I trust they will not be considered out of place here. About a mile to the north-west of the well-known village of Jangal, latitude 33° 37′ 10″, longitude 71° 12′ 10″, there exists a most remarkable spring, situated at the northern base of a hill which terminates one of the longest spurs jutting out from the Langardarra range. It is a delightful spot, with a splendid grove of immense mulberry-trees growing around, and the large body of water, pure and clear as crystal, which bursts out of an excavation 5 feet long and 2 feet wide in a perpetual flow, gives the visitor a strong disinclination to leave such a beautiful spot after traversing the sterile tract all about. Great care is bestowed on the cleanliness and arrangements of the place; and not only has the usual marvellous tradition been handed down from father to son regarding its origin, but an extra amount of veneration and superstition is attached to the spot. The very fish in the immense pool immediately below the spring are worshipped, and nobody dare attempt throwing in the "barbed hook with its dainty allurement." The story repeated to me was that about 70 years ago "Kachai" (the name of that part of the country) was entirely devoid of water, when "Mír Rahim Syed," a very religious and devout man, promised to obtain the needful supply. A spring did exist, I believe, prior to Mír Rahim Syed's

promise, but the water which issued was very scanty, and of a milky appearance. The Syed, however, determined to emulate Moses and his rod, and after excavating a little himself, made good his entrance into the rock and disappeared. For a whole week he was not seen, nor could any one pretend to conjecture what had become of him. During this time, however, Mír Rahim was not idle, for he managed to traverse more than a mile right into the heart of the hill, and after the lapse of eight days he reappeared, but about 100 yards away to the west of his entrance, and on about the same level. Immediately on his reappearance the magnificent flow of water which continues unabated to this day burst out with an impetuous rush, and so not only the whole of Kachai, but villages farther eastwards, have all a plentiful and wholesome supply. After this exploit some return was thought necessary by the inhabitants for Mír Rahim's miraculous work. He was very modest in his own request, for he only asked for a piece of arable ground as long as the shadow that would be cast from a wand of his. This was readily and gladly granted by the people, for they did not expect to get off so cheaply; but to their indescribable astonishment, when the Syed planted his wand perpendicularly at one extremity of a field the shadow stretched far away for miles. A compromise was however made, and a tract of ground given him, which to this day is held by his descendants.

Regarding the passes into Tirah from the Kohat side there are three,—the route from Bar Marai, the Landukai pass, and the route along the Gorbin river. The Landukai pass is the most difficult, but the shortest, and the Gorbin river route the most feasible. From the village of Sheu, six miles north-east of Hangu, the road is traced alongside the Gorbin river for about 20 miles until the large village of Kandi is reached. The route then strikes north across the Senpaghar range, over a rather low *kotal*, or saddle of the hills, and thence leads right into the heart of this little known country. As far as I could ascertain from numerous enquiries, this is the only road that, with little trouble, could be made practicable, not only for mounted batteries and cavalry, but also for laden camels.

Among the different clans inhabiting Tirah (of which a complete list is subjoined), there is, as usual throughout Afghánistán, a great deal of tribal animosity and jealousy. Constant bloodshed and pitched battles are more the rule than the exception; but perhaps the undying antipathy displayed by the Meeshties towards the Mania Khels and *vice versâ* is unsurpassed even in Afghán feuds. I believe, as the former clan have invariably proved themselves the stronger, the latter have suffered so dreadfully at their hands that the clan is actually approaching a state of extinction. While on Kudumb H. S., observing and reconnoitring, I witnessed a regular pitched battle below on the north side between the Feroz Khel and Akha Khel clans, the former acting on the defensive. The attack was most determined, and the sound of musketry continued all day without interruption. I was glad I was not seen and disturbed, for I had a considerable descent to make and a great distance to traverse before reaching camp. This, however, I could not manage till 10 at night. The ascent was made at 3 in the morning. The whole of Tirah is well supplied with Snider rifles, and I came across a number of men on different occasions bearing well-cared-for Martinis. The owners were quite proud of their weapons. They boast that these rifles are plunder secured during the two last campaigns, both on the Khyber and Kurram routes. For the Sniders they appear to have such an abundance of ammunity that cartridges are actually bought from Tirah by men from our side of the frontier cheaper than they can be obtained by them in India. The manufacture of cartridges for the Martini has already been commenced by the Afridis of Tirah with great success, and I was shown one thus manufactured. The case is very similar to those manufactured in Kabul during the seige of Sherpore, and although rather thick and heavy, would stand any amount of reloading.

Tirah.

Clans.	Approximate population.	Products.
Alikhel*	3,000	Rice.
Mamozai	3,000	Wheat.
Shai Khan	2,500	Indian corn.
Malakel	1,000	Potatoes.
Alisherzai	3,000	Gram.
Meeshti*	3,000	.....
Rabiakel	700	Walnuts.
Akhel	700	Grapes.
Mamazi	400	Peaches.
Bar Mohammed Khel ...	2,500	Pomegranates.
Mani Khel	800	.....
Abdul Aziz Khel ...	300	.....
Sipahi	500	.....
Feroz Khel	600	.....
Bazoti	500	.....

* Zusufzais, but combined with Uraknzais.

Extract from he Narrative Report, dated 31st October 1881, *of* COLONEL C. T. HAIG, R.E., *Deputy Superintendent, Survey of India, in charge Guzerat Party.*

OF the country topographically surveyed sheet 76 is almost entirely Baroda territory There are but 8 small villages of the Pálanpur State. It is mostly flat and open, but in the north-east corner there are a few small detached hills and an area of 70 or 80 square miles; in the south-east it is pretty thickly wooded. The Saraswati or Kuwarika river crosses the sheet from east to west, and is a stream of some importance. Its banks are shallow, seldom more than 10 feet deep; but the width varies from 400 to 900 yards, with a considerable body of water always flowing in a more or less narrowed channel with a velocity that strikes one as being excessive for the apparent gentle, almost imperceptible, fall of the country. The Rájputána Railway crosses the sheet from north to south through the eastern half, where it taps a very populous district. There are two railway-stations in the sheet, Sidhpur and Unjha, which towns have respectively populations of 13,600 and 10,500. About 20 miles to the west is Pátan, with a population of 32,600. There are two other towns of populations between 4,000 and 5,000, two more between 3,000 and 4,000, six between 2,000 and 3,000, twenty-eight between 1,000 and 2,000, and of course very many smaller villages. This part of the country is full of historical interest. Pátan is built on part of the site of Anhilwáda, the old capital of Guzerat before Ahmedabad was built. Anhilwáda is said to have been a city 18 miles in circumference, and the heaps of old ruins and bricks to be found for miles round Pátan seem to corroborate the statement. Sidhpur is a noted place of pilgrimage, and the remains of the Rudra Mala Temple of Shiva are an object of considerable archæological interest. Sidhpur and Pátan are both on the Saraswati river, which is itself venerated as a goddess.

The area embraced by sheets 35 and 36 is divided between British Baroda, Bánsda, and Dharampur territory. It is traversed by the Purna, Ámbika, Káveri, and other smaller rivers, which, with their many tributaries and feeders, make the country very intricate and difficult for the surveyor. It is wooded also, and the east of sheet 35 and the adjoining strip of sheet 49 between it and the Dángs is hilly country. The railway-station of Bilimora is just inside the western margin of sheet 35; the railway, following the general trend of the coast, enters sheet 35 two miles north of Bilimora, and leaves sheet 36 about six miles to the south. From Bilimora is a made road of 29 miles in length to Bánsda, forming the chief outlet for the timber from the Dángs. On this road, at six miles from Bilimora station, is the British taluka town of Chikhli, and about two miles north of the road, from a point about three miles from Bilimora station, is the Baroda town of Gandevi, of some importance from its size, having a population of over 7,000. The State town of Dharampur falls in sheet 36, having a population of 4,470. The population in these parts consists largely of Bhils and such like folk, who prefer living in huts, apart, or in groups of two or three huts, which adds much to the surveyor's trouble, particularly as the country is fairly thickly populated. Bilimora has a population of 4,442, Chikhli 3,153, and Naldhara, a Gaikwari inami village, 3,650. Besides these, there are in sheet 35 and the half of sheet 36, thirteen towns and villages of populations between 2,000 and 3,000, and fifty of populations between 1,000 and 2,000, and a multitude of smaller villages; but even the populations of the large towns contain a considerable Bhil element, which is scattered in huts over the fields.

There is in sheet 35 a hot sulphur spring at a place called Unái, on the boundary between the Baroda and Bánsda States. The following mention is made of this spring in the "Imperial Gazetteer," volume I, page 402:—"At Unái, within the limits of this (Bánsda) State, is a hot spring, the temperature of which is generally but little below boiling point; but once a year, at the time of the March full moon, the heat abates sufficiently to allow a company of pilgrims and devotees to bathe in it." This is the popular account, but it states too little and too much. The bathing takes place on the day of the full moon of the Hindoo month Chaitra and the two following days; and if during all the rest of the year, as is commonly said, the temperature of the water is but little below boiling point, here is a miracle indeed; and the phenomenon is popularly ascribed to the power of the local goddess of Unái, Matha, in whose honour thousands congregate at an annual fair. I was in camp not far from Unái very shortly after the fair this year. The new moon occurred on the 3rd April, and the bathing took place on that day and on the 4th and 5th. On the 11th I took the temperature, which was said to have returned to its normal height on the 6th, and I found it to be 138° Fahrenheit, considerably below boiling point. I was informed by a Bánsda official at the place that the bathing commences by a sudden rush into the water of some hundreds of Bhils and others, who previously fortify themselves with an intoxicant drug (*bhang*, hemp), and that this cools the water, so that the bathing can afterwards be kept up by the continual stream of the visitors to the fair—men, women, and children—who plunge in but for a moment and so keep down the temperature, for they continue all through the night. This is confirmed by a Mahommedan sub-surveyor who witnessed the first rush last year. If this is the only explanation of the phenomenon, to my mind it leaves it yet to be explained how people, in whatever numbers, can plunge into water at 138° without being seriously scalded, which does not appear to be the case, though, as has been proved on more than one occasion, a single individual falling in at any other time of the year meets his death. I was suspicious of some cold tap capable of being turned on in the adjoining temple by a local Brahmin on behalf of the local goddess, but could discover no appearance of anything of the kind. The spring is enclosed in a masonry tank or *khund* 50 feet by 45 feet, in which the depth of the water varies from 4 to 6 feet. The Baroda and Bánsda State boundary passes along

the edge of the *khund* where it adjoins the temple, so that the temple is in Bánsda an the *khund* in Baroda territory.

The portion of the Dángs surveyed this year consists of five sections of sheet 49, numbered 7, 13, 14, 15, and 16 on the index map. Captain Hobday, under whom the work was carried on, states that the character of the country is similar to what has been met with in former years, but perhaps the features are larger as one approaches the Ghâts. It will be seen from the index map that sections 14 and 16 reach the Ghâts where the Guzerat survey meets the North Deccan survey. The highest peaks at this part of the Ghâts are between 4,000 and 5,000 feet high, and Saler fort, which is about a mile south-east of the south-east corner of sheet 49, is over 5,000 feet. The chief river is the Purna, which rises at Saler and traverses the surveyed area in a north west direction. The Eastern Dángs are more populous than the western, and the forest clearances are in consequence more extensive. On the plateau there was a great scarcity of water, and what little there was, was very bad. One principal road, by no means a good one, traverses the area surveyed; it is the continuation of the road from Bilimora and Bánsda to Garvi into Khandesh.

In the 42nd paragraph of my last year's report I mentioned an experiment made by Lieutenant-Colonel Leach and Captain Hobday with a water level, and stated my intention of giving the method a trial on a larger scale. I have now the satisfaction to report that out of the 10 plane-table sections surveyed in the Dángs this year 8 were contoured with water levels, and the method has proved a success beyond all my expectation. The time taken to contour these 8 sections comprising the south-east quarter of sheet 49, giving a contour at every 25 feet, was but very little more than it would have required to have surveyed the area on the old system; and now that the hands have been trained to the new method, I anticipate that they will be able to work quite as fast as on the old.

I must, however, here explain that the method differs materially from that of a rigorously contoured survey, inasmuch as that only the few contours near the tops of the hills and at the foot of the slopes were actually rigorously surveyed. A great many sections were taken, the principal sections starting from and closing on trigonometrically determined heights, and auxiliary sections emanating from the principal sections were taken down all convenient spurs, and sometimes down very inconvenient slopes when the convenient spurs were too far apart. The water-courses and the plateaux were of course carefully surveyed as usual, and the contours on the slopes were sketched in from section to section; the surveyed contours at top and bottom of the slopes enabling this to be done with great accuracy.

Extract from the Narrative Report, dated 20th August 1882, *of* Lieutenant-Colonel A. Pullan, *Deputy Superintendent, Survey of India, in charge Kattywar and Cutch Party.*

General aspect of the country.

Of the country topographically surveyed this season, sheets 17 and 18 are portions of the featureless salt "Rann" which I have already described in former reports. Sheet 19 contains the remarkable little island of Pachham. Having an area of 275 square miles, the island contains 19 villages, the largest of which are Khawada, population 1,222, and Kunria, population 525. Two ranges of hills, called Kala and Gora Dongar, run almost parallel from west to east. The island is surrounded on all sides by Rann and waste grass, and on three by shallow water for 8 months in the year. During the monsoon shallow water encloses the island on all sides. The remainder of sheet 19 is Rann and the level grass steppes of Banni.

Sheet 20 comprises a major portion of Banni, a grassy plain, dotted here and there with clumps of *babul*-trees and the huts of wandering herdsmen from Sind and Cutch.

Sheet 21 contains a portion of the Rann between Cutch and Banni, together with the belt of fertile ground which skirts Cutch on all sides; the remainder of the sheet is mingled hill and valley, rocky and poorly cultivated.

Rivers.

The principal streams in this season's work are—1*st* "Nagmati," rising in the hills near Kera in sheet 22 and flowing into the Gulf of Cutch; 2*nd* "Phot," rising to the east of Kera and flowing into the Gulf of Cutch at Navinal point; 3*rd* "Bhukhi" and "Sakra": these streams rise in the hills south east of Bhuj, flowing south and effecting a junction one mile south-west of Bhadresar town, and falling into the Gulf of Cutch near that place; 4*th* "Khári," takes its rise in the hills south of Mankua in sheet 22 and terminates in the sand of the Rann near Sumrasar village.

Hills.

Kala Dongar, the highest range in Cutch, is to be found in sheet 19. One peak, "Babia," rising to an altitude of 1,520 feet above sea level. The other ranges in this season's work are "Warar," with an altitude of 1,125 feet; "Jhura," 1,062 feet altitude; and "Habo," 974 feet altitude.

Towns.

The principal towns and villages in the season's work are—Bhuj (the capital of Cutch), a very pretty, clean town, picturesquely situated in a well-cultivated valley surrounded on three sides by low rocky hills; Bhujpur, population 2,892; Khawada, the principal town of the island of Pachham, population 1,222; Niruna, a large village on the borders of the Rann, population 1,444; and Bhadresar, population 1,943, situated on a creek two miles north of the Gulf of Cutch and remarkable for its very fine old temple.

Extract from the Narrative Report of MAJOR R. BEAVAN, *Officiating Deputy Superintendent, Survey of India, in charge Beluchistan Topographical Party.—Season* 1881-82.

Plan of detail. Survey operations.

THE work in hand on the 1st October was continued without interruption, and consisted of the detail survey, on the scale of half an inch to a mile, of the hilly country lying between Quetta and Kelat, adjacent to the Bolan and Rodbar passes. I received orders to accompany a military expedition, under Brigadier-General H. C. Wilkinson, to open out the routes between Thal Chotiali and Dehra Ghazi Khan. I also took advantage of such opportunities as occurred for filling in, on the quarter-inch scale, portions of country hitherto unsurveyed, and for getting observations to complete the Sewestan triangulation.

Arrangements for prosecuting the work.

The plan of operations already in force continued to work throughout the season, the only exception being that less assistance was available from the Military Department in the matter of transport and commissariat. This was partly due to the fact that our survey parties were gradually working further away from the military line of communications, and partly also to the reduction of troops and the curtailment of the transport and commissariat establishments consequent on the cessation of military operations.

We continued, however, to receive assistance from the Transport Department till January, after which we were able to hire camels at Sibi for work in the lower country and in the Marri hills.

Triangulation. Arrangements for—.

Owing to pressure of other work, and particularly the great importance of completing as much topography as possible during the remainder of the field season, it was not found practicable to advance with the triangulation in a systematic manner, or to employ any of the party on this work alone, but every opportunity was taken for completing the observations at the different hill stations selected for the purpose, as they happened to come within reach during the progress of the detailed surveys and reconnaissances.

Triangulation completed.

In this manner observations were taken at eleven stations, besides one hill (Bútúr), which was ascended and found to be well adapted for a station; but time was wanting for taking a regular series of angles, and no opportunity offered for revisiting the place Some difficulty arose from several of the cairns erected the previous season having been destroyed, but considerable progress was made both in improving the accuracy of the triangles previously laid out and in extending the series, which, starting from three stations of the Beluchistan series south of Sibi, spreads itself over Sewestan and the Marri hills, and will eventually join the Great Indus Series near Dera Ghazi Khan. There is only one hill near Vitakri which has not been actually visited in this series of triangles, but observations are still wanting at several stations in order to complete a satisfactory connection.

On the 14th October I received orders to accompany an expedition proceeding from Quetta to Dera Ghazi Khan *viâ* the Saoura pass. I obtained permission to start ahead of the troops, and left Quetta on the 25th October, joining General Wilkinson at Shahrag on the 7th November. In this interval I took observations at Khost, H. S., and succeeded in sketching in several portions of country that had hitherto been very roughly delineated. After this I accompanied the force on the march *viâ* Mandai, Shal, and Chamálang to Dehra Ghazi Khan, which place we reached on the 11th December. *En route* I visited and observed at Torgarh, H. S. and Dadar, H. S. (= Chamálang Sir:—Heaviside), and also visited Bútúr hill, but had not sufficient time for taking regular observations there. The results of my plane-tabling work during the march were embodied in a map which I prepared for General Wilkinson, and which has since been published.

On the 1st January the office was moved down to Pir Choki, at the mouth of the Bolan pass, and I went on with the triangulation, visiting the following stations during the month of January:—Kirta, Great Trigonometrical Station; North Band, Great Trigonometrical Station; Sangon, H. S.; and Nari, H. S. At the last named station, owing to cloudy weather, I was unable on this occasion to secure the observations I wanted, and had to visit it again later on. In February I observed at Khanki, H. S., and made arrangements for continuing the survey of the Marri hills with an escort of Marris furnished me by the Assistant Agent. Mr. Corkery having finished his work in the Rodbar pass, and being at that time in fairly good health, accompanied me, and we left Sibi on the 13th February. We marched *viâ* Talli and Daho as far as Tatra hill, a few miles north of Kahan. I took observations at Bagrai, H. S., and Tatra, and we returned *viâ* the Sart valley to the Chakar river. During this period it was necessary to carry provisions with us, not only for our men and animals, but also for the Marris, who accompanied us, and grain for their horses. I had arranged for a fresh supply of provisions to have been brought out with the 3rd Native Infantry who were marching in this direction, and they were timed to meet us on the 3rd March. They did not, however, leave Sibi till about the 6th, and my provisions were consequently delayed. I therefore decided to divide our party, and leaving the remainder of our provisions with Mr. Corkery returned myself towards Sibi, marching *viâ* Quat Mandai, and completing the observations at Nari, H. S., that I had been obliged to leave unfinished on the previous occasion. I returned to Sibi on the 13th March.

Remarks on the country under survey.

The whole of the country in which survey operations were carried on presents the usual characteristics of Beluchistan—dry and arid, with no vegetation; water very scanty; only procurable in certain places, and generally brackish; bare rocky hills and stony plains.

Duration and close of the field season.

The field season continued over 12 months; the party left Sukkur early in April 1881, and continued at work till nearly the end of March 1882.

There was no serious sickness during the whole of this time, but most of the members of the party suffered from fever more or less, and owing to bad food and water were seldom free from diarrhœa and mild forms of dysentery. Mr. Coxen had a serious attack of erysipelas, and Mr. Corkery was obliged to take sick leave to England in order to recover his health.

General remarks.

As explained above, the great object kept in view during the field season was to get as much topography completed as possible, and at any rate to complete the map of the hilly country which lies between the Bolan and the Rodbar passes on the half-inch scale. This was satisfactorily accomplished, and the results are now ready for publication, and in addition to this a great deal of new work has been done on the smaller scale of 1 inch = 4 miles for the purpose of incorporation with the maps previously published. To attain this result, however, it was necessary, in a measure, to subordinate the progress of the triangulation, which is consequently still in a somewhat incomplete form. When opening out a new country, a number of points fixed with moderate accuracy are of greater value than a few stations of which the positions are rigorously determined within an inch or so. The former can, moreover, be more expeditiously secured than the latter, and the observations necessary to secure rigorous accuracy can be taken at a future time if required.

In the Sewestan series the triangles have to be laid out on a large scale, the sides of several of them being 40 miles in length. This arises from the nature of the country, which contains a few prominent hills, and between them a broken irregular mass of smaller ridges. To establish stations on the latter is useless, as the rays from one to another get blocked by intervening ridges of equal height. Hence it becomes necessary to utilize for triangulation only the larger and more prominent hills, which are all mutually visible, but lying far apart from one another.

Under such conditions one might expect to attain a high standard of accuracy in the observations if only one could secure a clear atmosphere, but unfortunately this is very rarely to be had in this dry and dusty region. Thus it happens that frequently after a journey of seven or eight miles from camp, and a climb of 3,000 feet or so, some of the stations to which observations are to be taken are quite indistinguishable in a dusty haze, especially if there happens to be a dark background of more distant mountains. If in addition to this it should happen that the pile of stones which the observer is straining his eyes to detect has been destroyed by wandering shepherds, the chances are that he observes to some bush or rock, and does not find out till long afterwards that he has mistaken his point altogether.

Short Description of the Tract of Country in District Rawalpindi, known as "Kala Chitta Pahar," by Lieutenant-Colonel D. Macdonald, *Deputy Superintendent, Survey of India.*

"This range is in the shape of a wedge, entering the district (Rawalpindi) between Attock and Nara, where its width is about 12 miles. It comes to a point at its eastern extremity four miles due south of the Margala pass, and is about 50 miles in length. It lies in what is known as the 'Khattar' tract, so called after the 'Khattars,' an important tribe of the Awans."

"The 'Chitta' pahar is composed chiefly of nummulitic lime-stone, but the formation of many portions of its southern side is of soft sand-stone. The outer surface of the latter has, owing to the action of the atmosphere, assumed a dark, almost a black colour, giving it the name of 'Kala' pahar. The whole mountain is known as the 'Kala Chitta Pahar' (the black and white hills); but it is more generally called by the latter name."

* * * * * *

"It is more or less thickly covered with 'kow' (wild olive) and 'phoollah' (*acacia modesta*). Grass grows plentifully on the lime-stone hills. A rich lime is the most valuable production of these hills. The trees are excellent for fuel and charcoal."

The above paragraphs are quoted from Major Cracroft's Settlement Report of the Rawalpindi district, dated October 1864.

It is a wild and gloomy region, not wanting, however, in the picturesque. The range at the eastern extremity is composed of low rounded hills. Proceeding westward, the hills increase in height and become more broken and rugged in their formation. The highest peaks, some of which range over 3,500 feet above mean sea level, are to be found in the north-western corner, abutting on the river Indus. The Indus forms the western boundary of the range, separating it from the Kohat district. As a rule, the hills in the north are higher than those farther south. The former are rugged, precipitous, bare on their summits, and rise in huge masses abruptly from the adjacent plains. Between these and the more southern portions of the range are a few open valleys, but not of any great

extent. Then succeeds a series of rocky hills, very broken and disjointed. In parts they consist of narrow, almost perpendicular ridges of rocks, running in straight and parallel lines with deep gorges between. Sometimes these ridges assume the most extraordinary curves. In one place their shape is almost elliptical, enclosing an elevated and oval plateau. This again is varied by collections of isolated and conical peaks huddled together in the most inextricable confusion. Altogether the configuration of the ground in this region is very remarkable and unusual. A storm chart suggests a not inapt comparison.

It is a most desolate and inhospitable tract. Water is very scarce, and in the dry season hardly procurable, and of bad quality. It may at times be considered as an almost uninhabited region. There are no large villages in the interior. Hamlets, consisting of half a dozen rude huts, are few and far between, and only occupied during the rains, when water and fodder are procurable for cattle. The communications, once you leave the beaten tracks, are atrocious. These foot-paths, if they can be so called, which connect one hamlet with another, are hardly traceable on the rocky soil. A guide well acquainted with the locality is indispensable. These paths in their sinuous courses traverse all kinds of ground; they run over huge boulders, through clefts and fissures of rock, and along the dry and stony beds of mountain torrents by turns. Walking in these parts is certainly the safest, and often the only possible, mode of travelling.

The principal roads through these hills are four in number; by far the best is a metalled road from Campbellpur and Attock to Pind Sultani on the Rawalpindi and Kohat road. This can be used for wheeled carriage throughout its entire length. Near its entrance into the hills, and again at its exit, are two halting places, where there are large seraies for native travellers, with accommodation for Europeans in a corner. "Choi" is the name of the camping ground to the north. The other halting place is "Lambadan." Midway, in the very heart of the hills, at a place called "Lall-ki-ban," is a bungalow on the road, occupied by a customs officer.

The other roads are—

1*st*. From Fatahjang, the head-quarters of a tahsildar on the Rawalpindi and Kohat road, to Hasan Abdal.

2*nd*. From Fatahjang to Campbellpur.

3*rd*. From Campbellpur to Gaggan, a camping ground on the Rawalpindi and Kohat road, one march west of Fatahjang. All these three roads are very inferior, and can only be partially used for wheeled carriage.

Animal life in these hills is not very plentiful. A species of wild sheep, called "orial" or "horial," is found in some parts. "Chikor," or hill partridge, are tolerably abundant. There is also a smaller bird, a kind of partridge, called locally "soosee." Sand grouse, both large and small, are found in large numbers in the adjacent sandy plains.

This region is alluded to in Major Cracroft's report as a place "where crime flourished." "Many deeds of violence," he says, "were perpetrated with impunity; the robber, the murderer, and the offender against the State, found shelter here." He adds "that it is only in recent years that life and property have become secure."

The heat in summer is said to be intense, and no wonder. This can easily be accounted for by the absence of moisture in any shape, the hills being composed of huge masses of bare rock, and the adjacent plains consisting of a sheet of almost unadulterated sand.

The total area of the tract known as the Kala Chitta Pahar, inclusive of hills and plains, amounts to 531·3 square miles. The following table shows how this area is made up:—

				Square miles.
Government forest reserves	...	...	...	154·1
Sirdar Fatteh Khan's jagir	...	...	...	4·3
Five village of tahsil Rawalpindi		...	...	23·2
Twenty-six ditto Fatahjang		...	...	127·0
Eighteen ditto Attock		...	...	120·9
Six ditto Pindigheb		...	...	101·8
	Total		...	53·13

Notes taken during the Field Season of 1881-82 *by* Mr. G. W. Jarbo, *Assistant Surveyor, when engaged on the Forest Reserve Survey in District Tharrawaddy, British Burma.*

The tract of country in which the survey party operated is known as the Thonezeh and Koonbeeling reserves. The former is bounded on the north by the water-shed between the Beeling Toung and Thonezeh streams, which is one of the main spurs of the Yoma; on the south by the Meening *Kyoung;* on the east by the Pegu Yoma range of hills; and on the west by the water-shed between Koonbeeling and Thonezeh streams, a continuation of the spur which forms its boundary to the north. The latter, Koonbeeling reserve, is bounded on the north by the water-shed between the Kadeen and Koonbeeling *Kyoungs;* on the south and east by the Thonezeh forest reserve; and on the west by a demarcated line which is shown by mounds of earth, four feet high, heaped round posts about five and a half feet high, on which are nailed zinc plates with numbers cut into them in the Burmese character.

The Thonezeh reserve is in fact the valley of the Thonezeh *Kyoung*. Being almost surrounded by hills, the exhalations from the forests are so confined that this piece of country is more than ordinarily malarious. The difference of temperature experienced by the surveyor, who has perhaps been marching during the great heat of the day along the Thonezeh stream, when he reaches the summit of the Yoma hills towards evening and inhales the sharp breeze (which I have invariably observed prevails there from sunset to sunrise), is indeed great, and is of itself enough to try a strong constitution.

This tract of country of hills and vale is for the most part covered with dense and nearly impenetrable jungle, and, as observed by the Assistant Commissioner of Beeling, "is impassable for ordinary beasts of burden all the year round, and for men during a great part of it." The only clearances are those made by Karens; and were it not for the six Karen villages, which are all confined within one block of about 20 square miles in area, the whole of the country surveyed is a lonely region, uncheered by the presence of man; and its perils are realized when one thinks of the sad fate of two poor khalassies belonging to the survey, one of whom, whilst out with me this year, surveying along the Yoma, was attacked by dysentery and was first missed when we had encamped for the night after finishing the day's work. On hearing this, next morning, I ordered the mahouts, who were returning with the elephants to the standing camp at Weh village (as it was found impracticable to take them further into the hills), to pick up and take the missing man, Bodhee, with them. On my return to camp, days afterwards, I learned that he had not been found. As a batch of men were on the point of starting to remeasure traverse lines, they received strict orders to search all about the place where Bodhee was first missed, and a second party was also sent. The first failed to obtain any trace of him, but the latter discovered his remains within a few yards of the survey lines; they were partially consumed by jungle fires, which had also burnt his purse, for its contents, nine rupees, were lying under the body. The second man, a line-cutter, while travelling through the jungle, had felt feverish, and told his companions that he would seek for a little water, drink, and rejoin them; but he has never since been heard of. He doubtless lost his way, and eventually perished from starvation. It is unlikely that he has absconded to shirk work, as do some of the Boonias, for he was a well-conducted man from the North-West Provinces, whose friends have since written to know why he has not returned home for the recess season. Moreover, he had left his belongings, cooking utensils, &c., which for one of his class were valuable, at the main standing camp; besides a month's pay from Government, and other sums due to him from one of the establishment, have never been claimed by him. A third man was also missed early in the season, who, I now think, was lost in the jungle and died; but as he left no property in camp, and had little or no pay to receive, it is possible that he may have become frightened at the wild country and absconded.

Of the hills, the principal range is the Yoma (*i.e.* backbone). Its average height here is from 2,000 to 2,800 feet above sea-level. The width of the ridge at its summit is in most places but three or four feet. The southern and western slopes, and main spurs in the same directions are, as a rule, more steep than those of the north and east of the range. So precipitous are they, that there are but few places where one can cross from the Tharrawaddy to the Okhan side of the Yoma without cutting a series of steps to enable one to climb the ascent.

Among the more important streams which drain the Koonbeeling reserve may be mentioned the Koonbeeling and its feeders, the Kyouktaga, the Shawdon, and the Hmya *Kyoungs*; whilst those in the Thonezeh reserve are the Thonezeh and its affluents, the Nat and Kadogway *Kyoungs* on its right bank, and the Yaygyee, the Gonyin, the Thabyoo, and the Bawlan streams on its left. Streams are the only highways through the forests; with the exception of a few dragging tracks, it is by them that timber is brought down to still larger streams, till eventually it reaches, and is landed at the depôt where it is sold or sawn up. The dragging tracks, which for the most part run along the tops of some of the spurs of the Yoma, are few in number. They are the rough roads over which logs are dragged by elephants or buffaloes to the beds of streams, there to await the rainy season, when the rush of waters carries them into larger rivers to be floated on as before mentioned. One peculiarity of these streams is their narrow mouths at the confluence with the large streams. For instance, when travelling along the Thonezeh *Kyoung*, the narrowness of the mouths of its feeders would lead one to suppose that no streams worth surveying flowed into it. This is found to be an error on following up the seeming rivulets, for they are almost as wide as the Thonezeh river itself, their beds often measuring 100 and 150 feet in width. These are sometimes so nearly level and so neatly gravelled, that for some miles they remind one of a well kept drive through an English park; at other places, they have the appearance of being paved with petrified trunks of gigantic trees. Where they are very rocky, or are broken by water-falls, as are the Koonbeeling and Thanay *Kyoungs*, they are not considered, from a forester's point of view, as being "first-rate floating streams." The difficulty is often overcome by blasting the obstruction.

The forest is mainly a bamboo one, but there are fair quantities of teak, pajukadoe, pymma, thingan, and kanyin; whilst the banks of many of the creeks are interlaced with canes varying in thickness from that of a man's arm to the smallness of an infant's finger. Of the bamboo there are several varieties; if they are all valuable to the paper manufacturer, as they are said to be, there are here sufficient quantities to keep his mills at work for years without going further afield. Bamboos may be cut from the reserve by paying four annas for every hundred. Within this portion of the forest reserves I have not seen teak-

trees (*tectona grandis*) of any great girth, nor in any large quantities: in fact, of two strips of country, say a mile wide along the two sides of the reserve boundary line, I am sure that the one without the reserve holds more and better teak than that which lies within. This is not likely to be true a few years hence, as Karens are allowed and encouraged to clear and cultivate for their own use, temporarily, any suitable portions of jungle land, on condition that they plant them with teak, for which they are paid at a liberal rate per hundred.

As respects size, the most striking tree is the *kanyin*, known in India as the *gurjan*-tree. From it is extracted an oil said to be a cure for leprosy. It is also used by the people for their lamps and torches. The Assistant Commissioner of Beeling says that "in manufacturing torches decayed wood is triturated and saturated with the oil. This is then rolled up in leaves of the *paloo* palm, much after the fashion of the ordinary maize cheroot, and tied up at intervals of two inches with bamboo withes." When burning, they give out an aromatic odour. They sell for about three rupees a hundred. The method used in extracting the oil is this:—Two or three notches are cut into the heart of the tree; from the lower portions of these notches the wood is scooped out, forming a rude cup; fire is then applied inside the notches, the heat of which causes the oil to exude into the hollows, from which it is removed in earthen vessels or in hollow bamboos. At night, in the depths of a dark and dismal forest, it is a weird spectacle suddenly to come upon half a dozen nearly nude natives extracting the oil; their faces look distorted in the lurid light of their torches, while in silence they move round their black and gigantic victim. It deludes one into believing oneself a witness to the sacrifice of a human being to some bloodthirsty deity.

A peculiarity of these forests, which is sure to be remarked by any one who has roamed much in those of India, is their scarcity in fauna. There are a few pheasants, partridges, and jungle-fowl, some beautiful birds as the trogon and parrot, and also some gorgeous butterflies; but deer and the larger *feræ* are rarely met with to the west of the Yoma hills, although the forests on their eastern slopes have been called the homes of such animals. That elephants and wild buffalo abound on the Okhan slopes I am convinced, as I have seen numerous tracks of both animals, and have even heard the trumpetings of the former. Here I would mention that I have both seen and heard guinea-fowl in these jungles. In doing so, I am aware that it will be said I have mistaken the silver pheasant for that bird; but, as others have on several occasions recognized them too, I can only think that, if they are not indigenous to this country, they must be the descendants of birds that have escaped or been freed from captivity.

From the almost total absence of animal life in the Thonezeh forests, day is oppressive in its solitude; while to the silence of the night is added an abnormal darkness, due to the density of the undergrowth and overhanging foliage.

The Karens, the only inhabitants of these parts, are a wandering race of people, who remind one very much, from their similarity in features, clothing, and habits, of the Mechis of the Western Dooars of north-east Bengal, and the Tharoos who live in the Tarai of the Oudh forests. In passing, it may be worth remarking that "Taroo" is the name by which one of the clans of Karens are known. The men are of finer physique than the Burmans, and the Karen women more handsome than the average good looking Burman lady. I have not seen one deformed, nor even thin, person amongst them. The clothing of the men consists of a cotton garment closely woven in one piece; this is almost identical in shape with the smock-frock worn by an English farm labourer. It is usually of two colours, a dull crimson and a whitey brown, in alternate broad stripes horizontally, and reaches down to the ankles. The women besides this wear a petticoat of the same material beneath it when out of doors; but, as a rule, when at home, they discard the tunic, wearing only the petticoat, leaving the upper portions of their persons nude. The children require no clothes; their fatness keeps them warm, decency being quite a secondary consideration.

A Karen village consists of but one house built on bamboo piles from eight to ten feet above the ground, with bamboo mats for its walls, and bamboos, not grass nor leaves, for the roof. This house has a passage from one end of it to the other, into which rooms open from both sides, the number of them varying with the number of families inhabiting, or having a separate interest in the village, the size being regulated by the number of individuals in a family. Access is had to the upper part of the house by a very narrow bamboo ladder, or sometimes by a limb of a tree with a few notches cut in it to answer for steps. This is placed in so nearly an upright position that it requires some agility to be able to climb it. The space below the house, literally the ground floor, is utilized as a hen-coop, pig-sty, dog-kennel, and latrine. It is therefore fortunate, on sanitary grounds, that the Karens remove their *tays*, as these villages are called, to a more or less distant spot every year without exception. On these occasions the old house is burnt, propitiatory offerings are made to spirits, which the Karens believe may perhaps haunt the new location they have chosen; a great feast is eaten and numerous libations are poured out. The community in a body then take up their residence in the new abode. The *tay* is known by the name of its living "Sockay," as their chiefs are called. On the death of one chief, the village is renamed after his successor. This custom is common to the *Mechi*. The Karen too, like the *Mechi*, has the habit of wandering at his own sweet will from place to place in the forest. When he comes to a spot which takes his fancy, he cuts down the trees, and, after burning them and the jungle, he sows rice in the ashes, barely sufficient to yield a crop which will suffice for the yearly consumption of his family and furnish enough for the next year's sowings. He also

cultivates cotton for his clothing, a few vegetables, and some tobacco; while the small sum he realizes from the sale of betel leaves with an odd rupee or two, which some of them may occasionally earn from forest contractors, procures him his luxuries, such as "ngapee" (fish paste) and the areca-nut. In a year's time he thinks he ought to remove to another part of the forest, where he repeats the operations mentioned above. It is as well therefore that, since the formation of this forest reserve, he has been obliged to confine his timber-cutting propensities to the clearing of that land only which within certain ample limits has been set apart for him.

The Karens are filthy in their habits, dress, and persons. They are, as a rule, extremely indolent. Sowing and reaping their crops and building their houses occupy very few of the twelve months; their spare hours, when they are not drunk on liquor distilled from rice, are spent in smoking and gossip. The women weave cloth and make very neat and durable baskets, the shape and make of one kind is identical with the "kilta" made by the hill-men in the Himalayas, and resembles an exaggerated strawberry pottle. The Karens evince great curiosity on the occasion of an European encamping near their *tays*. They come over and ask all manner of questions, inspect his tent and belongings, and they will even touch one's clothes to examine and descant upon the texture and quality of the cloth. Some to whom I showed the figures of a pattern plate from the *Young Ladies' Journal* were highly amused. They are a hospitable race as far as their means will allow, but have a dislike to selling fowls or rice, probably because the supply is limited in these parts.

In religion they profess to be Buddhists, but they seem to be very lukewarm in their belief. Knowing that many Karens had become Christians, I asked some of them why they too did not change their creed. They answered that no one taught them the new religion. I have heard that many of them, who were once converted to Christianity, have since relapsed to what, owing to their ignorance of even Buddhism, may be called *nothingism*. I believe that the present of a bottle of brandy would, for a time, decide the religious belief of a whole village in favour of any proposal by the donor. The *British Burma Gazetteer* gives greater and more interesting details of the Thonezeh forests and its inhabitants than any I could collect in a short field season.

Of the difficulties in the way of surveying, sickness is the greatest—

> "For hot, cold, moist, and dry—
> Four champions fierce—
> Strive here for mastery' "

The superabundance of water in the wet and its scarcity in the dry season, and the impossibility of procuring supplies on the spot, may also be mentioned.

Not only were malarious fever and dysentery very prevalent, but the khalassies suffered much from sore eyes and swelled legs. The former is, I think, caused by the fluffy hair of the bamboos getting into the eyes, and the latter was most likely due to the scratches of poisonous thorns, drinking bad water, or perhaps to scurvy induced by the sameness of diet for months together, with not even an occasional dish of vegetables to give a relish to the monotonous meal of rice. Two of the survey khalassies lost their sight, whilst many who were hale and hearty when they joined the party returned home crippled. The want of water in the hot weather is a great hardship. It is not so much that water is scarce, as being unable to find it when it is required, that constitutes the difficulty. The time and toil spent in searching for it down the valleys, after a long and hard day's work on the hills, is very trying, and having to climb the ascent again and then cook their food robs the khalassies of hours of well deserved rest after the fatigues of the day. And often when the water is found it looks like a strong infusion of tea, and is most likely impregnated with *bacilus anthracis*, the fatal germs of splenic fever.

As regards supplies, they must all be imported from a distance. Elephants may be employed to bring them to the foot of the hills; but once arrived there, porters must be exclusively engaged; and as one man can only carry sufficient rice for the consumption of himself and two others, it follows that a surveyor's squad, which has usually eight men in it, must be increased by eight others, when started on a piece of work which it will take fifteen days to complete. This and the short period during which work can be carried on in this part of the country materially affect the season's out-turn.

Report by Major W. F. Badgley, *Deputy Superintendent, Survey of India, on the Survey of part of the Burma-Manipur boundary, dated February* 1882.

I have the honour to send the following report on the survey of part of the Burma-Manipur boundary.

Mr. Ogle (who was deputed with me for this work) and I left Shillong on the 4th of November with a sufficient number of survey khallassies to carry our instruments, and 59 Khasia coolies for the carriage of all baggage, public and private. Our intention was to have made four marches eastward from Shillong through Jowai and along the old Asalu road, and then to have turned south-east towards Cachar, by doing which we would avoid all but one march in the plains, which it is always advisable to do when travelling with hillmen as coolies. But on arrival at our fifth halting place we found that the village had certainly been moved from the place it used to occupy according to the map; and as we went farther we found on enquiry that the whole of the country south of the old Asalu

road between the meridian of 93° and the western boundary of the Cachar hills was quite deserted, all the inhabitants having moved eastward. As our supply of food depended on what we could purchase day by day, we also had to continue our march eastward through the populated country nearly to Gujong, the head-quarters of the sub-division, before we could find a path to take us to Cachar, where we arrived on the 15th November. Here we found that it would be necessary to carry our supplies with us for the seven days' march to Manipur; and as the Deputy Commissioner would supply no coolies except at the prohibitory price of Rs. 50 a load (each cooly carrying half a load and receiving Rs. 25 pay), we had to wait for men from Manipur, which delayed us just a week. We arrived at Manipur on the 27th November.

For the next eight days our men were employed in clearing and putting up signals on old stations and at points chosen by us for our triangulation; and on the 6th and 7th of December, respectively, Mr. Ogle and I left Manipur to carry forward the work.

Starting from the stations of Yongbalong-Kong and Phunan in the Manipur valley, we arranged to carry a series of triangles eastward to the neighbourhood of the Kungal thana on the disputed boundary, where Colonel Johnstone, Political Agent and Boundary Commissioner, had established his camp, Mr. Ogle taking the northern stations of the series, and myself the southern.

For the first three days after leaving Manipur I had nothing but trouble. On the morning of my start my coolies were late, as is usually the case when making a fresh departure, and we did not get off till nearly nine o'clock, which was a bad beginning, as they had a very long march of 25 miles before them. My own route led by a detour past the Phunan hill, ten miles south of Manipur, where my triangulation was to begin. After climbing Phunan to the station and setting up my theodolite I turned the telescope to search for the first of my new stations, and found that the hill had not been touched, but that, through laziness probably, my cutters must have been taken to a low hill at half the distance, on which I saw a signal put up. I arrived in camp by torchlight. My Khasias came in after nine at night, and the Naga coolies with provisions, not at all. On the two following days I was taken, much against my judgment, a long round in search of the hill I wished to put up my station on, and at last reached it to find that I was only half a march from where we had started. After this I had an explanation with Soppa *subadar*, who had been sent with me as manager of cutters, carriers, and supplies, and had very little trouble of this sort during the rest of my journey, for which, indeed, I am much indebted to him, as without his excellent management I should certainly not have accomplished so much as I have succeeded in doing.

I was much disgusted on the night of my first march, as well as on several occasions afterwards, by the conduct of the Manipuris towards coolies and their Naga tributaries generally. There is much good, no doubt, in their rule over their Nagas. They prevent them from slaughtering one another, protect them, encourage them in agriculture and trade, and employ them as auxiliaries and in repairing and opening roads; and among themselves the Nagas seem well-to-do and happy enough, but the Munipuris treat them like dogs. On this occasion the man in charge of the thana would give my coolies no fire-wood. Looking as I do on my coolies as the legs and arms of my service, on whose well-being the success of my work mainly depends, I was particularly irritated, and the more so because I could not help them, as the man said that there was no more, which I knew to be untrue. It was 10 o'clock on a pitch-dark night so there was no use in their going out to search, even if they had had no march to tire them during the day. I did what I could for them by giving them the wood that had been brought for my camp fire, but my khallassies did much more: they gave what had been given to them for cooking and went dinnerless to bed, and they did this of their own free will and without my knowing of it till I heard it casually next day. This illtreatment of coolies is not an exceptional case. It happened whenever it could happen; and it is the rule that a cooly shifts for himself in the matter of fuel and food, no matter where he may be. Towards subordinates the Manipuris are always very overbearing, and they are very inhospitable to every body. At the end of one of my last marches back to Manipur, I arrived in the evening at a thana where I was guided to halt. After a little talk with the thanadar I proposed to rest myself in the house till my camp came up. I was told that I could not do so, but that a cow-shed would be cleared out for me to sit in. I hope that all my remarks on this were faithfully translated by the interpreter; not knowing Manipuri I cannot say, but some were, as they began to bustle about and turned some of their men out of one of their houses and made me comfortable in it opposite a good fire.

At the village where I encamped on the second day of my march I saw some trophies which had been brought by men of the village who had been among the Kuki contingent which had gone with Johnstone took to relieve Kohima. They were two Naga skulls and looked particularly fantastic, as the small trees on which they were set up had, either through accident or design, been so cut that two branches only remained, and these with their twigs looked like arms and fingers stretched out and thrown up in the air.

Not having been able to do more than a little triangulation at Phunan, my work actually began on the 9th at Sanaching hill, which I made my men and the Nagas from the village near by climb that so hard, that though it was covered with forest I had it cleared and a signal put up the next day, and was afterwards able to do some good work, at the expense, however, of building again finding my way to my camp (which I had sent on) by torchlight. On the two following days I cleared some points for plane-tabling, and on the 12th and 13th

cleared, set up a signal at, and observed from a hill named Manchuibung. Up to the 18th I was engaged in having two more hills cleared for stations, and in returning to Sanaching and Manchuibung for their triangulation. As Colonel Johnstone wished me to come to his camp as soon as possible for the actual boundary work, I worked very hard here, and I think almost the hardest day's work I have ever done was in reobserving at Sanaching. I left my camp at the Turet river, went up the hill, did my triangulation and plane-tabling, and came down again. The distance was about eighteen miles, with 4,500 feet up and down again, and it took from sunrise to near nine o'clock at night. On the evening of the 18th December I arrived at the Kungal camp at the northern end of the Kabu valley, where the disputed boundary, which the Commissioner had come to settle, lay; having up to this cleared five stations, observed at three, and plane-tabled about 280 square miles of half an inch to the mile topography.

During the next few days I reconnoitred the boundary with Colonel Johnstone and sent working parties to endeavour to clear two points on the Angoching range, which lay on the eastern side of the Kabu valley opposite our camp. The range is in Burmese territory, and my men were sent merely as an experiment, and unarmed, to avoid any chance of collision. They were turned back by armed patrol parties of Burmese. Mr. Ogle came into camp on the 24th, having cleared and observed at four stations and plane-tabled about 200 square miles, which, joining on to the north of my work, completed both the triangulation and topography of the country between the Manipur valley and the disputed boundary.

These days of comparative rest were very agreeable after our hard work, and we all passed Christmas together. Besides Colonel and Mrs. Johnstone we had in our camp Mr. Phayre, Assistant Commissioner; Dr. Watt as Botanist; Mr. Oldham as Geologist; Captain Angels, of the 12th Khelat i-Ghilzaies, of which regiment we had 250 men as well as some police; Lieutenant Dun, of the Intelligence Department; and Mr. Ogle and myself, of the Survey: and with so many together, and of varied ideas, the time passed very pleasantly. Colonel Johnstone was meantime unsuccessfully trying to open negotiations with the Burmese officials, and as a last resource it was determined that Mr. Phayre should go to Samjok to see the Rajah, who seemed more obstructive than the others, and I immediately proposed to go with him, thinking that both profit and pleasure might be had from the trip.

On the 27th December Phayre and I started, making our first march to Morlung, about sixteen miles nearly south of the camp. He had written a letter to the Samjok Raja to say that he proposed to visit him to talk over matters, and on the way we met the messenger with the answer, which was conveyed in ambiguous terms, the clever use of which the Burmese rather pride themselves on, and was so very vague that we had almost turned back, as we did not know how the man might receive us, and we had no intention of allowing our dignity to suffer from want of the observation of proper etiquette. However, on arriving at Morlung, the chief man, who was a relation of the Raja, and who had come out to Thanan, about four miles, with all his armed following to meet us, received a confidential letter to say that the Raja wished to see us. At Morlung they treated us most hospitably, as they did everywhere else in Burma. We had given them no notice of our coming, or they would have built a special house for us; but they fitted up the travellers' house with cloths as curtains, and though it was a small village of merely twelve or fourteen houses, they gave us three maunds of rice, a heap of vegetables, salt, fowls, and half a gallon of honey, and would have been grievously offended if we had offered payment. Hospitality is a trait of the Burmese. In every village there is a traveller's rest-house, which is free to all, and a Burman, they say, will sell his coat to entertain a friend. In every village also there is a monastery, where, I believe, the village children are taught without fee by the priests, who are forbidden to touch money and live on what is given to them as food by the villagers, and which they beg from day to day, doing this not because of poverty, but because of religious rule; some of them always being well off, as I believe it is an institution that every young man, son of a person in good circumstances, shall pass a year or two in study among the priesthood. They shave their heads, wear saffron-coloured robes, and are not allowed to speak on public matters. Of common beggars I did not see anywhere we were in Burma.

At Thanan, which we passed through on our way to Morlung, we saw a coffin supported on stakes outside the village, and were told that it held the corpse of a very old man who had lately died, and that as his funeral ceremonies, on account of the honour due to his great age, would be very long, his relations had obtained permission to postpone them till after the harvest. The Burmese burn their dead.

On the 28th we crossed the Angoching range to Toungban, where the rest-house had been got ready for us with curtains and an awning of leaves set up in front of it. This village is on a little river, the Nat-than-yit, which being translated is "The creek of the fairy's son." We came across the fairies several times on our visit. At Morlung there is a salt spring which had burst out of the hill-side after an earthquake, and we were asked not to go too near it with our shoes on for fear of offending the resident fairy. Phayre had a pony with him, and in riding through a narrow pass was asked by our guides to dismount till we came to the other end, as they said the fairy would, if not thus propitiated, bring misfortune on their village. And again at Samjok, where the house they were building for us had not been finished when we arrived, we were asked to wait before entering it till the spiritual influences had been propitiated by music, as otherwise misfortune might ensue.

On the 29th we marched to Samjok. They sent us a message to Toungban, begging us not to come till the sun was well up, as they had had so little time to prepare that they were not ready to receive us. So we started later than usual, and dawdled away some time in seeing the view at Nat-than-yit, a village on the Kyendwen, and did not reach Samjok till noon. Even then our shed was not ready, but in about half an hour the band struck up and we entered and made ourselves comfortable. Our accommodation was a large shed about forty feet by twenty, with planks laid down as a floor, with a leaf awning about a hundred feet square in front, and sheds for the guard, servants, and kitchen. The roof of our house was, to be sure, somewhat like a sieve, and the walls rather like a bird-cage; but that was not from want of civil intention, but from want of time to do better; and considering that we were not wanted, and were looked upon more or less in the light of enemies, our treatment was very good—indeed so hospitable that we got more food than we knew what to do with, the Raja sending us a present of that sort every two hours during the day. A band had been sent to enliven us, consisting of a chime of drums, a big drum, pipes, cymbals, and bamboo castanets. The man playing on the chime sat inside a tub-like enclosure of carved wood with his drums in a circle round him—a picture, by the way, of such a band of musicians was printed in the *Illustrated London News* last year. A conjuror also was sent in the evening: one of his tricks was very cleverly done. He held a rupee on the tip of his finger and asked that some one in the crowd should try to catch it. One of our Kuki coolies who was near held out his hand, and the conjuror smacked the rupee into his palm. The Kuki closed his hand, and grasping the finger and money shouted "I have it," and was very much amused and amazed to see the man when he had succeeded in pulling out his finger hold it out with the rupee on it, and to find his hand empty when he opened it. Dancing and singing girls were provided for our entertainment at night. The dancing was posturing, more graceful and lively than that of Indian dancing-girls, and not indecent. The women pinned their dresses down the side, which was necessary, as a Burmese woman's petticoat, though it reaches her heels, is only about four feet broad. The singing was really pretty, a ballad evidently, in two voices, the tune and time changing to suit the verse. It was, I believe, about the universal melody, one verse, which we got the translation of, being apparently a description of a pair of lovers, describing her as the silver tendrilled vine clinging to him, the golden tree. The Raja had wanted to get up a play for us, but could not on account of the death of one and the sickness of another of the actors. The one who died had died of cholera, which had been very bad just before our visit. It appears to me, by the way, that new rice must have something to do with outbreaks of cholera. It invariably appears with the new rice in Sylhet, and has done so here also. The harvest here is just over, and rice is selling at three annas or less a maund. In Mandalay the price, I believe, is a rupee. Two of the Raja's ministers came to confer with Phayre, and to ask us to postpone our return till the day after next, as next day the Raja wished to pay us a visit.

The Raja, or, to give him his proper Burman title, the *Tsáwba*, came at about 11 o'clock. He fired a couple of guns (clay bombs, I suppose, they were) at starting, and then his procession appeared winding along the sand and riverside. Two lictors, armed with sword, rod, and cord, cleared the way. Nine priests, calm and slow, with shaven heads and yellow robes, headed the procession. Then followed men with pennons of white or purple with broad edgings of gold. Then the *Tsáwba* and his younger brother carried on tray-like platforms at the height of men's shoulders. Then the ministers and *pán*-bearers, &c., on either side, followed by sepoys and musicians, five gold umbrellas, two fine elephants, and about a thousand people, men, women and children, all walking except the *Tsáwba* and his brother. They were both very handsomely dressed. He had on a loose crimson velvet coat with hanging sleeves, with collar, cuffs and border about a foot broad of gold, a handsome silk nether garment, and a high white and gold conical cap. The ministers were in white, with white fillets round their heads. The [illegible] were in a uniform of black jackets, red plaid continuation, and red fillets; the sedan-[illegible]ers were also dressed uniformly, and all the people were neat and clean; and one could [illegible] noticing how different it was in this to what one sees in Indian processions where [illegible]ng and bobtail element is always so very conspicuous. It was altogether a most [illegible]e procession, the irregularity of its approach along the river bank helping to pictu[illegible] more so, and in this picturesqueness it was very much superior to such pro-make[illegible] one sees at home, which, to my mind, could not hold a candle to it. But in this cessi[illegible] peculiar ideas, as I can see no beauty, nor anything but dreary absurdity, I ma[illegible] o-military tramp of trades-people with double-poled banners following a in a [illegible]

town ba[illegible] platform had been built and roofed in, under which the priests sat. In front, A r[illegible]ng was stretched and a carpet laid down with chairs for us and the *Tsáwba*, a scarlet a[illegible] and ours were collected round. Phayre had a long talk with him and his All his peo[illegible]upshot of which was that he asked us to wait for a day for his answer as to ministers, t[illegible]rveyors might go into the Angoching hills; every other point he said he must whether the [illegible]. Seeing it from one side only perhaps, and as Phayre told him, he must not refer to Mand[illegible] territory suffered, and that though we desired to do justice, once we had be surprised [illegible]y we would not draw back or reconsider it, as we had acted all through settled the b[illegible] the usage of great nations, and the omissions had been entirely on their in conformit[illegible], the *Tsáwba* asked to see the sepoys (we had twenty-seven police) go side. Before [illegible]es, so the *havildar* put them through the manual and platoon, the latter through some [illegible] an impression, especially "fire two rounds, front rank kneeling." making, I fancy, rat[illegible]

The *Tsáwba* is a fine looking man. I noticed that he had peculiarly long untapered fingers, which made his hand seem wedge-shaped, which perhaps may be an indication of character explainable by chirosophists. He asked my age, and in return for the information told us that he was thirty-three, which I have no doubt was correct; but he looked forty.

In the afternoon we went to see the town. It was a cloudy day in December, so we lost the effect of bright light and full fresh foliage; but even as it was, it was very pretty. About the middle of the town, but more removed from the river, is the *Tsáwba's* house, with a Chinese pagoda-like wooden spire and many gables; to the south and south-west are the spur of a little hill with many pagodas; and the monastery and all, interspersed with magnificent mangoes, cocoanuts, palms, and other trees, and the view of this, with the broad-winding river seen from the monastery hill, is quite charming. The town is a single street on the river bank, and in front there is a strip of sand, with some sheds occupied by people connected with the boats which come to trade. Every place was beautifully clean. I wanted to find a memento of our visit, but there was nothing for sale except pottery, red and unglazed, but very good. It seems to be a speciality of the place, and all the boats at the landing were loading with some of it, and it is used all over the district. It is the only produce of the place I believe. There were half-a-dozen large boats at the place, and there are always some there, either going up or coming down, and in August a number of boats pass down, which have been farther up the river to the Kamti country, trading for turpentine among other things. They go up, I suppose, in the spring and return with the flood at the end of the rains. I was in treaty for an ivory-handled sword, but at the last moment the owner refused to sell it, and I afterwards heard that this was by the *Tsáwba's* order, who had ordered that nothing of the sort should be sold to us, though why I cannot say.

Samjok, which has been visited by only about half-a-dozen Europeans, has a great name in these parts; but it is only a place of sixty houses, with no fortifications, and only about thirty sepoys. There are, I was told, about three hundred houses in the district governed by Samjok, which does not extend across the river, but I think from what I saw that there may be six hundred. It is in a very defensible position, provided the hill to the south of the place were fortified, as it has the broad, deep river to the east, a stream with rotten banks and soft silty bottom to the north, and a great marsh to the west. Whoever holds the hill has the town, but there is no way of getting to the hill from the north, so far as I know, except through the town.

The Kyendwen (pronounced Chindwin) river is a fine stream about 2,000 feet across, just above Samjok, and perhaps 200 feet broader opposite the town. It is said to be fifty feet deep in the channel, and the current here was about a mile an hour. The banks are steep, about twenty feet high, with forest growing to their edges, except where there is cultivation or habitation. It is navigable for large boats (sixty feet long and flat bottomed) for two months' journey farther up, the same journey by land occupying one month.*

All this part of Burma is covered with forest, and though I did not see any good timber on our route there must be some, as the Kyendwen River Steamer Company have purchased the monopoly of the timber trade of this river for Rs. 20,000 a year, and the slabs of teak used for boat building were magnificent. About fifteen to twenty miles east of the Kyendwen is another large river, the Mu, which joins it lower down, along which there seems to be a good deal of cultivation, and where they say ponies are plentiful. Beyond the Mu I saw one or two mountain ranges.

There used to be a good deal of trade between this part of Burma and Manipur, principally of buffaloes, ponies, and lacquer oil. The so-called Manipuri pony was really a north Burma pony, and since the supply has been stopped the number and quality available in Manipur has greatly fallen off and the prices quadrupled. For the last four years there has been no trade. A body of Shans surprised the Kungal thana, killed seven Manipuries who were there, and burnt it. Burma would give no reparation, so the [illegible] were closed.

During the evening the Manipuri *subadar* with us brought up a youth, who [illegible] was the son of a Manipuri captive by a Shan mother. He was a handsome youth, while at once distinguished him from his Shan companions, for the Shans can [illegible] good looking, but the curious thing about him was that he spoke Manipuri fluently. I think it is not generally the case that the father's language is learnt in the mother's country. Another handsome fellow also came to see us, and there was no mistaking [illegible] well-cut features and thick curled moustache and whiskers (neither of which are Shan properties) for anything but Hindoo. He was a man from Goruckpore. He asked me if I could help him to get away. On questioning him I found he had been fourteen years in Samjok. He must have been quite a boy when he first came, as he did not look more than eight and twenty. He had, he said, landed at the place, and on the first night [illegible] stay all his belongings were stolen. For eight days, being unable to cook, he chewed [illegible] rice, and then gave in and turned Burman. He had since engaged in several occupations, made money and had it stolen. He at last determined to leave and invested his [illegible] in six ponies,

* There is gold in the Kyendwen. Otter skins are laid in the stream at night, dried during the day, and dusted in the evening. A family can collect a tolah in a week in this way. Old women also collect it by washing. Any lumps of gold found are thrown back into the river, for, say they, "If we take the fathers and mothers I shall not get any more of the youngsters," meaning the small grain.

but had been turned back at the Manipur frontier, and three of his beasts were now dead. He had not married, as he said, "Where a man's children are his home is," and he wanted his funeral in his own country. I was sorry for him, but could not help him. When the passes are open again, he will get away I hope.

On the 31st we made a long march of twenty-three miles to Morlung, and on the 1st of January, Phayre having gone on to Tammu to visit the Pagan Woon, I returned to the Kungal camp.

There are four routes from Manipur to the Kabu valley, but only two of those, the Inganrok-Kungal and the Imol-morch, could be used by troops, water being scarce on the others. These two also are easier, the Imol being much the easiest of the four. The Kungal and Morch thanas, at the edge of the Kabu valley, are each five marches from Manipur. From Kungal a level path leads by Thanan (12 miles, 6 houses) to Morlung (4 miles, 14 houses) at the foot of the Angoching range. Thence the path of Samjok crosses the range to Toungban (18 miles, 18 houses). The range is about 1,500 feet above the valley. To the west the ascent is steep, to the east the path follows a gently sloping spur the whole way. From Toungban to Samjok (about 5 miles) the road is level. It crosses at one mile the Nalthangit river at Tschdangon (6 houses), and at four miles passes Nalthangit village (30 houses). Between this and Samjok there are two small streams, the path following the river bank. The road from Morch thana joins the road at Morlung, the distance being about thirty-two miles. It passes near Tammu (18 houses), Koudong (8 houses), Mangsa (20 houses), Tap or old Samjok (10 houses), and Monoi (4 houses). There is water on all these routes at moderate distances, and in the dry weather room for camping in the fields near the villages, or, where they are in bearing, in the jungle, which is thin tree forest with little undergrowth. At Nalthangit there is a fine plain, half a mile square. The paths are all fit for laden animals except elephants, but would be so for them with a little improvement. The Nalthangit river was a foot deep when we crossed it. There is no ford at Samjok, and not more than a dozen boats, large and small. Rice was very cheap; but this was probably because there were no buyers, not on account of any very large supply. The whole country, except for small patches of cultivation, grass, or swamp, is covered with forest. This, when we saw it, was of small scattered trees with light undergrowth, principally of a weed called *goldfussia*. Lieutenant Dun, of the Intelligence Department, has made a careful report on the passes between Manipur and Kabu, so I need not describe them. They are included in my map.

As a route for trade the Manipur valley will, I think, be happily exempt; the road from Cachar is excellently made, but it crosses seven ranges, and the hills are tremendous, and those to the east of the valley are nearly as high. The whole journey from Samjok to Cachar, at ordinary rates of travel, would take about twenty-two days. There is some small trade between Samjok and Southern Burma in China silk handkerchiefs and English salt, which undersells the native product. A few of the handkerchiefs find their way to Manipur.

From the 1st to the 4th of January Mr. Ogle and I were engaged in computing and plotting our triangulation. On the 5th I marked out the boundary with Colonel Johnstone, and on the 6th Kungal camp broke up, our boundary work being done.

The demarcation of this part of the Manipur boundary had become necessary for several reasons, the principal being that while no definite line existed the Burmese were able to support some villages of Kukies, whom they had sent, with the intention of annoying Manipur, to settle on lands claimed by Manipur, whence they raided on and enslaved the Manipuri Naga tributaries, and whence they could not be dislodged without the probability of bringing on a war, which, as it would have involved us also, it was the policy of the Government to prevent. The trouble that Manipur has had from these Kukies is a Nemesis on their conduct to them in past time, and would be also to Government should anything more serious come of it. The Kukies originally came from the south-west, and settled in Manipur by invitation of the Raja. Some years ago the chief, while on his way to Manipur to see Colonel McCulloch, who had sent for him, was treacherously murdered by a Manipuri. Government would not interfere, and the Manipuri was not hanged, and the chief's son, now grown up, is a bitter enemy to the Manipuries. They have tried to win him over by kindness and concession, once ransoming his mother, who had been carried off by the Shans, at a heavy price, but he is not to be won. Four years ago he left Manipur territory with all his tribe, and since then has been giving a good deal of trouble.

Since the time when Manipur, much more powerful than now, made six raids upon Burma and carried their arms to the Irawadi, and Burma in retaliation made seven raids on Manipur and slaughtered men, women, children, and cattle indiscriminately, the two peoples have been bitter enemies, and the boundary that keeps them farthest apart is the best for the preserving of peace on the border. This, which is of so much importance to us as well as to them, the boundary, as now laid down, does better than any other line that could be chosen, as for nearly its whole length it follows the bases of the hills or streams in deep gorges in the hills, which are parts of the country avoided by both people; the Naga tributaries of Manipur keeping high on the ridges and spurs for their joom cultivation, and the Burmese keeping away from the hills in the flat plain for their flooded fields of rice. The only hills used as part of the boundary is the Kusom range, north of the Nampagna river. This has always been known as the boundary in that part, and serves very well, as it is not habitable more than half way up, the peaks being of the most extraordinary jaggedness, and more like those in a young lady's fancy sketch than any I have ever seen. The entire boundary, except for

about a mile near Kungal thana, is unmistakeably marked by nature, and therefore requires neither the trouble nor the expense of marking or maintaining.

From the 6th till my return I was engaged in triangulation and topography. The most southerly point which I visited was Morch thana. This is used as a penal settlement for women who have committed murder. There were about a dozen murderesses in the place, who waited on me with a present of fishes, and among them I am glad to say that there was only one moderately good looking. She had quarrelled with another girl and drowned her. Banishment is the extreme penalty which women suffer in Manipur. For offences less than murder they are cried in the marketplace, and the most severe form of this punishment is awarded to women who go wrong with men out of their caste. They are shaved and hideously painted, and so led naked up and down the marketplace for three days, a drummer going before crying their crime. They also lose their caste. Men are not hanged in Manipur, except for murdering women. For other murders they are nominally banished to a place in the south of the valley, where they are made over to the natives, who kill them. For other serious offences men are banished to the islands in the Logtak lake, where they suffer torment from mosquitoes, which are so numerous, they say, that they can be caught by handfuls.

On the 21st I returned to Manipur, and on the 25th started for Calcutta, my work in the field being finished. During January I observed at four stations and plane-tabled about 600 square miles. The total amount surveyed by me has been 900 square miles. To the end of January Mr. Ogle had finished about 450 square miles. The total area of our survey therefore on that date was about 1,350 square miles, on the half-inch scale. Besides this, I was able to get in on the same scale about 500 square miles of reconnaissance. Mr. Ogle is now continuing, by your orders, the survey in Manipur, and will bring in, I hope, some valuable information.

Extract from a Narrative Report, dated 12th January 1883, *by* J. B. N. Hennessey, Esq., M.A., *Deputy Superintendent, 1st grade, on Surveys in Dardistan and on the Kishanganga.*

There is a tract of country, horse-shoe in shape, belonging to Dardistan, with Chilás about the centre and the Indus bisecting it north and south. This tract is some 45 by 30 miles, and is edged by the territories of Kashmir, along which edge will be found Khanbari Darra, Báriben pass, Gor, Nangá Parbat, and the Indus-Kishanganga water-shed reaching to Kaghán. This horse-shoe could not be surveyed, because the ruler of Chilás refused admittance to surveyors, nor had the surrounding water-sheds been visited, so that the important passes leading across the Chilás horse-shoe were generally unknown. By visiting the water-shed, which is the boundary of Kashmir, not only could the passes be fixed, but as the country must slope from the northern and southern limiting ridges down to the Indus, it was reckoned that a valuable sketch of the horse-shoe itself may be obtained.

Ahmad Ali was despatched to carry out the foregoing plan, with directions to begin at the west end of the south edge of the horse-shoe; but owing to the delay already mentioned, he did not leave Dehra until 26th July. Further delay occurred at Srinagar, due to his own illness and the absence of the Maharaja's dewan, so that the sub-surveyor did not reach his ground and commence work until 15th September; meanwhile the winter snow had begun, and, when standing on Gamukdori pass, his foreground for some 8 or 10 miles presented merely a confused mass of white hills, bare of vegetation and otherwise very like one another. His northern aspect at the next station he visited, Hole Nár pass, was hardly more favourable, and in brief his season's work was hampered by fresh snow and by illness brought on by exposure.

Notwithstanding Ahmad Ali persevered working up the Kel Darra, across the Shochar pass into the Mir Malik Darra and up it to Rattu, and from thence down the Kamri Darra to the Kamri pass, where, with winter well on him, he ceased surveying on 12th November.

Although his field season was unavoidably short, he sketched on the ½ inch about 800 square miles of country, of which some 200 square miles to the north were never sketched before, and the remaining 600 miles had been reconnoitered rather than surveyed, the latter area, on the extreme confines of Kashmir, and part of it *at the time* utterly uninhabited, had not been *visited* by Ahmad Ali's predecessor, who appears to have sketched from a distance of 10 or 12 miles, and in fact not to have crossed even the Kishanganga.

Ahmad Ali, however, actually stood on the Kishanganga-Indus watershed, so that his survey of the 600 miles in question can be relied on; it differs considerably, as may be supposed, from the original reconnaissance. He also fixed three important passes hitherto unknown on this water-shed, viz.—

Gamukdori	...	...	...	13,400 feet
Hole Nár	...	...	...	14,700 „
Bunar	...	...	...	(Not visited)

besides other passes, &c., within Kashmir territory, and acquired experience by which it is likely he could sketch the horse-shoe in question on making a second attempt.

As regards the passes and traffic, it appears that the Babusar pass, on the confines of Kaghán, is the one mostly used, especially for traffic between the Panjab *viâ* Dardistan to Darel Tangir, &c. There is a made road from the south up to Babusar pass, which is

The luni-solar declinational semi-diurnal tide, R_2 of K, is less in proportion to the main tide than has previously been found, and is very near the theoretical value, being 0·131 against 0·127. The large proportion which the diurnal components bear to the main tide, which is the chief peculiarity at Aden, is again evident from the analysis of this year's observations.

The proportion of the solar diurnal tide, R_1 of S, is considerably larger than has been before obtained here, and very nearly equals the values obtained at Beypore and Paumben, being 7 per cent of the main tide.

The main diurnal tide, R_1 of K, is nearly the same in amplitude as in 1877-78, and but slightly less than that for 1879-80; it bears the same immense proportion to the main lunar tide, being 85 per cent of it.

The solar diurnal tide (P) is about 24 per cent of the main tide, which is much about the same as has been found in the previous years, and is greater than in any other Indian port.

The proportions of the diurnal tides, O, J, and Q, to the main tide, agree well with those found in the previous years. O is a little less than before, but is still 44 per cent of the main tide.

The proportion between P and O is within the theoretical limits; that between J and Q is again higher than the previous year, and much higher than theory gives. O to K is slightly less than the last year, and less than minimum proportion given by theory.

With regard to the long period tides. The proportions to the main tide (except in the case of the lunar monthly and lunar fortnightly) are nearly the same as last year. The lunar monthly is double the value obtained in the previous year, whilst the lunar fortnightly is one-third less.

The epoch of the solar annual agrees well with last year, but the solar semi-annual is a month later than last year.

VALUES OF THE TIDAL CONSTANTS AT ADEN, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Aden:—

Short-Period Tides

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	5·814	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·093	0·086	0·627	1·275	0·389	0·031	0·130	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	161·49	106·88	313·88	110 75	303·15	130·25	322·49	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·701	1·586	.....	0 176	.....	.....	.....	0·032	0·420	0·038	0·060	0·074	...	...	...	0·021
ϵ_2	246·32	225·48	.....	224·07	.....	.....	.....	13·43	221·66	28·39	167·82	178·25	...	...	...	115·85
R_3	.....	0·018	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	198·20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	...	...	...
R_4	0·000	0·007	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·009	...
ϵ_4	274·76	313·82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	164·15	...
R_6	0·004	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	209·58	19·60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	325·01	324·13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	.. $R = 0·026$	$\epsilon = 324°·129$
„ fortnightly „	...	... $R = 0·042$	$\epsilon = 1°·90$
Luni-solar „ „	...	... $R = 0·016$	$\epsilon = 100°·37$
Solar annual „	...	.. $R = 0·353$	$\epsilon = 1°·62$
„ semi-annual „	...	... $R = 0·093$	$\epsilon = 150°·93$

The mean level of the sea (A_0) is slightly higher than has been obtained in the preceding years.

The amplitudes of the main lunar and solar tides are almost the same as the previous year's, and therefore the proportion between them is identical with what had been found before. This is rather less than the theoretical value, being 0·444 against 0·476.

With regard to the lunar elliptic semi-diurnal tides, the smaller (L) has a proportion to the main tide slightly less than theory gives, ·020 against ·027; and this value is just the mean between the values of the two first years, but is very much less than that of the preceding year.

The proportion between the larger component (N) and the main tide is rather less than has yet been found, but is still one-third greater than is given by theory.

The proportion of the evectional semi-diurnal tide (λ) to the main tide is higher than has yet been found at Aden, being more than three times greater than the theoretical value, whilst the proportion of the other evectional tide (ν) agrees exactly with theory.

The variational tide (μ) is 5 per cent of the main tide, which agrees with the values from former years, but is double the theoretical value.

The luni-solar declinational semi-diurnal tide (R_2 of K) is rather less in proportion to the main tide than has yet been found here, and is slightly in defect of the theoretical value.

The proportion of the luni-solar compound semi-diurnal tide to the main tide is the same as was found in the two previous years.

The high proportion of the diurnal tides to the main tide at Aden is again shown this year. The chief of these, the luni-solar declinational tide (R_1 of K), is 80 per cent of the main tide. The solar declinational diurnal tide (P) is 25 per cent, and the lunar declinational diurnal (O) 40 per cent of the main tide. These proportions are the greatest found at any Indian port, Beypore having the nearest approach to such high values.

The proportions between P and O, J and Q, and O and K, are very much the same as previously obtained. The first two are greater than theory gives, and the third less.

The lunar and solar over-tides agree with the values of previous years, and are all small.

With regard to the long-period tides, their amplitudes and epochs agree fairly well with the results of preceding years. The solar-annual and semi-annual are slightly less than previously obtained, but call for no special comment.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1879-80.

The following are the amplitudes and epochs deduced from the 1879-80 observations at Kurrachee:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	N	λ	*ν*	*μ*	*R*	*T*	*MS*	2*SM*
A_0	7·308	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_1	0·086	0·082	0·707	1·867	0·306	0·110	0·106	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_1	161·33	237·30	326·61	120·60	315·06	142·27	328·07	.....	.....	.....	.....	.....	.....	.....	...	.....
R_2	0·957	2·526	.....	0·316	.....	.....	.....	0·077	0·590	0·010	0·088	0·075	.....	.....	...	0·018
ϵ_2	324·73	294·25	.....	308·22	.....	.....	.....	141·48	278·11	213·39	329·91	245·17	.....	.....	...	159·68
R_3	.....	0·041	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_3	.....	310·77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_4	0·008	0·026	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·031	.....
ϵ_4	63·09	2·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	335·45	.....
R_6	0·006	0·053	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_6	324·09	213·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_8	0·002	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_8	222·71	11·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·038$ $\epsilon = 25°·61$
,, fortnightly ,,	...	...	$R = 0·035$ $\epsilon = 307°·16$
Luni-solar ,, ,,	...	...	$R = 0·030$ $\epsilon = 320°·17$
Solar annual ,,	...	...	$R = 0·042$ $\epsilon = 86°·49$
,, semi-annual ,,	...	...	$R = 0·165$ $\epsilon = 170°·97$

The value of mean sea-level (A_0) is the highest yet obtained, except in 1878-79, which, however, having been specially treated to correct for alterations of zero, cannot be considered to have quite the same weight.

The amplitudes and epochs of the main solar and lunar tides agree well with the values of previous years. The proportion between them is likewise nearly the same as before, but is considerably less than the theoretical value, being 0·379 against 0·476.

With regard to the lunar elliptic semi-diurnal tides, the smaller (L) has a proportional value double what was found in the preceding year, and agreeing very nearly with the theoretical proportion, which on the whole is nearly approached at Kurrachee.

The larger component has a proportional value not far from the mean value of former years, and rather greater than is given by theory.

With reference to the lunar perturbational tides, the smaller evectional tide (λ) has nearly exactly the theoretical proportion to the main tide: previous years have generally given a larger value.

The larger component (ν) is also almost identical with the theoretical value, being smaller than has been generally found here.

The variational tide (μ) has a proportional value of ·030; theory gives ·022. The general mean of the previous years is ·026.

The luni-solar declinational semi-diurnal tide (R_2 of K) agrees very well with the general value at Kurrachee, and has nearly the theoretical proportion to the main tide.

The diurnal tides call for no special mention; they agree very well with the values obtained in previous years.

The same may be said of the over-tides of S and M.

With regard to the long-period tides, the lunar tides call for no special mention; they agree well with the general mean value of former years.

The solar annual is, however, abnormally small, being hardly 2 per cent of the main tide. Its epoch is the 18th June, a month earlier than in 1877-78. The epochs of this tide at Kurrachee have been variable.

The semi-annual tide has a proportional value about equal to the mean of former years; its epochs, which occur on the 18th June and December, are also unsettled at this port.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Kurrachee:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2 *SM*
A_0	7·267	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·135	0·007	0·010	1·264	0·266	0·068	0·106	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	03·61	107·83	326·90	127·95	318·51	183·19	331·43	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·969	2·536	.....	0·421	.....	.....	.....	0·148	0·581	0·020	0·169	0·037	0·049	0·094	...	0·031
ϵ_2	323·55	292·58	.....	303·79	.....	.....	.....	120·87	273·56	130·74	311·43	278·35	58·04	49·22	...	122·35
R_3	.....	0·030	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	310·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·000	0·020	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·023	...
ϵ_4	31·43	357·37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	315·35	...
R_6	0·000	0·052	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	291·83	202·19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	11·31	332·25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·036$ $\epsilon = 131°·23$
„ fortnightly „	...	...	$R = 0·021$ $\epsilon = 47°·45$
Luni-solar „ „	...	...	$R = 0·018$ $\epsilon = 304°·50$
Solar annual „	...	...	$R = 0·102$ $\epsilon = 101°·51$
„ semi-annual „	...	...	$R = 0·139$ $\epsilon = 191°·73$

The value of mean sea-level (A_0) is slightly less than last year, and agrees very well with the general mean of previous years.

The main solar and lunar tides are slightly higher than before found, but they agree well both in amplitudes and epochs with previous values.

The proportion of the main solar to the main lunar tide is 0·382, which is quite accordant with former values, and is considerably less than the value given by theory, 0·476.

The smaller lunar elliptic semi-diurnal tide (L) has a proportion to the main tide nearly double that of last year, and much larger than the usual proportion at Kurrachee, which approaches nearly to the theoretical value.

The proportion of the larger component (N) to the main tide is nearly the same as last year, and agrees well with the mean of preceding years, but is rather greater than the theoretical proportion.

With regard to the evectional tides, the smaller (λ) has the same proportion to the main tide as was found last year, and which is nearly the theoretical value.

The larger (ν) is nearly double what was found last year, when its proportional value nearly agreed with what theory assigns.

The variation tide (μ) has only half the proportional value which was obtained last year, and is considerably under the theoretical value.

The solar elliptic semi-diurnal tides are calculated this year. The smaller one (R) has a proportional value four times as great as theory assigns. This is about the mean value of this tide at Kurrachee.

The larger component (T) is about 25 per cent greater than the theoretical proportional value.

The luni-solar declinational semi-diurnal tide is larger than has ever yet been found at this port. Its proportional value is 0·166 : theory gives 0·127.

With regard to the diurnal tides, the largest (R_1 of K) is rather smaller this year than in general, R_1 of S is larger, amounting to 5 per cent of the main lunar tide.

The lunar diurnal tide on the contrary has a smaller proportion than usual. The other diurnal tides have this year smaller proportional values than the mean of former years.

The over-tides of S and M are much the same as in previous years. The over-tide, R_6 of M, at Kurrachee is double the quarter diurnal tide, a peculiarity which in the Indian tides only occurs at one other place, Elephant Point.

With regard to the long-period tides. The lunar tides are rather smaller than the mean of previous years. The solar annual tide this year is 4 per cent of the main lunar tide; last year it was hardly 2 per cent. The value of this tide has fluctuated greatly at Kurrachee, as also has the epoch, which this year is about 15 days later than last year, when the maximum occurred about the middle of June.

The solar semi-annual tide is slightly less than last year, and agrees well with the general mean value. Its times of maximum occur about ten days later this year than the last, *i.e.* about the end of June and December.

VALUES OF THE TIDAL CONSTANTS, BOMBAY, 1880.

The following are the amplitudes and epochs deduced from the 1880 observations at Bombay :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS* − 2*SM*	
A_0	10·187	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_1	0·088	0·090	0·030	1·430	0·100	0·134	0·166	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_1	182·22	225·58	327·81	126·57	313·53	139·14	335·61	.....	.....	.....	.....	.....	.....	.....	...	...
R_2	1·627	4·643	.....	0·418	.....	.....	.....	0·150	0·987	0·030	0·078	0·212	.....	.....	...	0·048
ϵ_2	3·64	327·59	.....	337·08	.....	.....	.....	141·93	313·90	335·18	266·39	309·98	.....	.....	...	114·13
R_3	.....	0·068	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_3	.....	22·14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_4	0·003	0·119	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·125	...
ϵ_4	238·96	310·23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20·60	...
R_5	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_5	140·39	72·52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_6	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_6	151·39	304·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}041$ $\epsilon = 86°{\cdot}07$
,, fortnightly ,,	...	...	$R = 0{\cdot}059$ $\epsilon = 337°{\cdot}84$
Luni-solar ,, ,,	...	...	$R = 0{\cdot}042$ $\epsilon = 186°{\cdot}09$
Solar annual ,,	...	...	$R = 0{\cdot}173$ $\epsilon = 312°{\cdot}56$
,, semi-annual ,,	...	...	$R = 0{\cdot}071$ $\epsilon = 162°{\cdot}31$

The results of the analysis of this year's observations differ but slightly from those which have been obtained from the reductions of former years, and do not call for any lengthened comment.

The value of A_0, mean level of the sea, is almost identical with that obtained last year, 80·187 instead of 80·184, above Town Hall datum; the mean value, as far as yet obtained, being 80·212 feet.

The amplitude of the main lunar tide (R_2 of S) is the largest yet obtained, being 4·05, against 3·98 in 1879 and 3·89 in 1878; the main solar tide being nearly exactly the mean of the two preceding years.

The proportion between the two main tides is slightly smaller than has yet been obtained, being 0·402; the theoretical value being 0·476.

The epochs in both cases agree well with previous years.

The smaller component (L) of the lunar elliptic tide has a proportion to the main tide much greater than has yet been obtained, being ·039, the previous year having been only ·014. The theoretical value is ·027. For the larger component (N) the proportion agrees very well with the values in former years, and is about 25 per cent greater than the theoretical value.

The perturbation tides, with the exception of ν, agree fairly in their proportions to the main tide with the values of former years. The proportion of ν approaches nearest to that obtained in 1876-77, but is not more than one-third of the value of the last two years.

The luni-solar compound declinational tide (R_2 of K) and the luni-solar compound semi-diurnal (2 SM) are fairly accordant with previous values.

The values of the diurnal tides agree well with what has been found in former years, the principal one (R_1 of K) being 35 per cent of the main tide, which is slightly less than the values previously obtained.

The proportion of the solar and lunar declinational tides, P and O, is ·59 to 1·0, which is about the value already obtained here; theory giving from ·391 : 1 to ·574 : 1.

The proportion between the two lunar elliptic tides, J and Q, is 1 to 1·25, which agrees with the value obtained in 1876; theory giving about 1 to 2·4.

The proportions of the over-tides of S and M are nearly identically the same as found in former years, as is also the proportion of the quarter diurnal luni-solar tide (MS) to the combined lunar and solar semi-diurnal tides, viz. ·022.

The proportion between the lunar ter-diurnal and the lunar semi-diurnal tide is ·017, which is almost precisely the value of former years.

With regard to the long-period tides, the reduction of this year's observations gives in several cases values diverging, both in amplitude and epoch, from those already obtained.

The solar annual has a value of 0·173, against one in 1879 of 0·137 and in 1878 of 0·254. Its epoch agrees within about 15 days with that of 1879, and more nearly with that of 1876, but differs entirely from that of 1878. From the results of 1876, 1879, and 1880, the date of maximum effect seems to be early in February, whilst 1878 gives the middle of August.

With reference to the solar semi-annual tide, the amplitude is nearly the same as in 1878, and not much more than half the value obtained in 1879. The epoch differs considerably from that found in previous years. The maxima would appear to be about the 9th June and 9th December, agreeing most closely with the 1876 values.

The lunar fortnightly and lunar monthly tides agree fairly in amplitude with the two previous years.

The luni-solar fortnightly tide is nearly three times as large as last year, but is nearly a mean between the values of 1876 and 1878.

VALUES OF THE TIDAL CONSTANTS, BOMBAY, 1881.

The following are the amplitudes and epochs deduced from the 1881 observations at Bombay:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	10·248	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·074	0·099	0·634	1·331	0·403	0·121	0·130	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	178·66	135·31	328·47	126·24	312·23	165·07	326·82	.....	.....	.....	.....	.....	...	...	...	...
R_2	1·618	4·095	.....	0·410	.....	.....	.....	0·096	0·283	0·013	0·122	0·185	0·037	0·256	...	0·038
ϵ_2	3·33	338·38	.....	334·91	.....	.....	.....	110·78	312·61	20·46	6·70	206·90	5·90	81·55	...	111·32
R_3	.....	0·056	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	7·98	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·011	0·128	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·126	...
ϵ_4	314·62	319·35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	23·30	...
R_6	0·005	0·017	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	160·35	106·63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R8	0·002	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	60·44	4·65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}048$ $\epsilon = 55°{\cdot}55$
„ fortnightly „	...	...	$R = 0{\cdot}028$ $\epsilon = 226°{\cdot}38$
Luni-solar „	...	...	$R = 0{\cdot}019$ $\epsilon = 335°{\cdot}66$
Solar annual „	...	...	$R = 0{\cdot}188$ $\epsilon = 316°{\cdot}59$
„ semi-annual „	...	...	$R = 0{\cdot}201$ $\epsilon = 232°{\cdot}34$

Analysing these observations, they will be found to give results differing but slightly from those obtained by the reductions of the observation in previous years.

A_0, the mean level of the sea, is found by this year's observations to be 80·248 above the Town Hall datum, which is ·06 feet higher than last year's value, and about the same amount higher than the mean of the four preceding years.

The amplitude of the main lunar tide (R_4 of M) is about ½-inch greater than the result of last year, and is the largest yet obtained; while the amplitude of the main solar tide is slightly less than last year, and agrees very well with the mean of the previous years.

The main solar tide is only 0·395 of the main lunar, which is the smallest proportion yet found at Bombay, where, however, the value has always been less than the theoretical one, 0·476.

The proportion of the smaller component of the lunar elliptic semi-diurnal tide (L) to the main lunar tide is ·023, which is slightly less than the theoretical one, ·027, but agrees with it much more closely than has been found in any previous year save 1876.

The larger lunar elliptic semi-diurnal (N) agrees very well with the results of former years, being about 24 per cent of the main lunar tide.

The evection and variation tides λ, *ν*, and *μ* bear about the same proportion to the main tides as had been found in previous years, λ being rather smaller, whilst the proportion of *ν* is about mean value.

With regard to the solar elliptic tides the smaller (R) is rather less than the value previously obtained, and its proportion to the main lunar tide is slightly nearer the theoretical value, but still twice as great.

The larger tide (T) is three times greater than its previous value, and its proportion to the main tide of M is more than twice as great as the value given by theory.

The luni-solar declinational semi-diurnal tide (R_4 of K) has a value slightly less than has been yet obtained, and its proportion to the main tide is less than theory assigns, ·100 against ·127; in this agreeing with the last two years, the proportion in 1877 and 1878 being greater than the theoretical value.

The luni-solar compound semi-diurnal tide (2SM) agrees well with previous years.

The proportions of the over-tides of S and M to the main lunar tide agree almost exactly with the previous values.

The proportion of the ter-diurnal lunar tide to its main tide slightly less than has been found in the previous years.

The whole of the diurnal tides agree well in value with the values obtained last year, and their proportion to the main lunar tide is very nearly a mean of the values previously found.

The proportion of the solar declinational tide (P) to the lunar declinational (O) is about 1 : 1·57, which is greater than in any previous year. The theoretical proportion is from 1 : 1·74 to 1 : 2·56.

The proportion between the two lunar elliptic tides J and Q is 1 1·07, being much the largest yet obtained at Bombay. Theory gives the proportion about 1: : 2·4.

The quarter diurnal luni-solar tide (MS) bears precisely the same proportion to the combined lunar and solar semi-diurnal tides as it did in four of the five previous years, viz. ·022; the year 1879 giving ·024.

With regard to the long-period tides, the solar annual has an amplitude a little greater than last year, and an epoch about four days later, agreeing nearly exactly with the value obtained in 1876.

Looking at the five years' values which we have obtained, it would seem that the value, both for amplitude and epoch, obtained in 1878 was abnormal; the other four years are consistent in fixing the dates of the maxima as being in the first half of February. The 1878 values gave the date as the 17th July, and the amplitude as 25 per cent greater than even this year's value, which is the highest of the other four years.

The solar semi-annual gives values, both of amplitude and epoch, divergent from those already obtained. Its amplitude, 0·201 feet, is three times as great as last year's value, ·071, and one-fifth greater than the largest previous value (·163 in 1877). Its epoch is nearly the same as in 1879, but differs from all other years.

The lunar fortnighly agrees fairly in the amplitude with the values of the last two years, but the amplitudes of the other two lunar tides differ greatly from previous values.

VALUES OF THE TIDAL CONSTANTS, KARWAR, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Karwar:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2*SM*
A_0	5·564	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·055	0·052	0·622	1·031	0·282	0·000	0·134	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	156·16	189·55	329·21	125·05	312·50	148·09	334·49	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·021	1·753	.....	0·169	.....	.....	.....	0·073	0·412	0·032	0·122	0·046	...	...	...	0·004
ϵ_2	333·08	208·41	.....	309·39	.....	.....	.....	132·38	280·33	206·51	258·46	255·73	...	...	...	16·72
R_3	.....	0·018	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	272·09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·010	0·054	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·021	...
ϵ_4	94·37	7·21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	58·50	...
R_6	0·004	0·013	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	82·24	270·70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·000	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	296·57	0·22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·048$ $\epsilon = 99°·91$
„ fortnightly „	...	...	$R = 0·036$ $\epsilon = 322°·54$
Luni-solar „ „	...	...	$R = 0·021$ $\epsilon = 224°·02$
Solar annual „	...	...	$R = 0·491$ $\epsilon = 302°·72$
„ semi-annual „	...	...	$R = 0·128$ $\epsilon = 191°·21$

The value of (A_0), mean level of the sea, is very slightly higher than in the preceding year, being 5·564 against 5·541 for 1879-80. The mean of the three years' observation gives 5·585.

The value of the main lunar tide (R_2 of M) is slightly greater in amplitude than in either of the foregoing years. The epoch agrees well with what was previously found.

The value of the main solar tide (R_2 of S) is nearly the same, both in amplitude and epoch, as in the two preceding years.

The proportion between the two main tides, which was 0·368 and 0·375 in the two last years, is 0·354 this year—all smaller than the theoretical value, though agreeing *inter se*.

The proportions of the lunar elliptic semi-diurnal tides to the main tide are slightly greater for L than in the previous years, and considerably above the theoretical value. For N the proportion of the former years is slightly diminished, but it also is greater than theory gives.

The evectional semi-diurnal tide (λ) differs both in amplitude and epoch from either of the preceding years, and is greater than theory gives. It is ·018 of the main tide; the theoretical value being ·007.

The proportion of the other evectional tide (ν) to the main tide is nearly the same as last year, and about twice the theoretical value.

The variation semi-diurnal tide (μ) has nearly the theoretical value, it being ·026 of the main tide; theory giving ·022.

The semi-diurnal component of the luni-solar declinational tide (R_2 of K) has a smaller value than yet found at this port, and its proportion to the main tide is considerably less than has been found in the previous years, when it had nearly the theoretical value.

The proportion of the luni-solar compound semi-diurnal tide to the main tide is the same as last year, and is the smallest that has been yet obtained at any Indian port; the next smallest being at Beypore and Vizagapatam.

The chief diurnal tide (R_1 of K) bears a proportion to the main tide of ·588 to 1, which is about a mean between Bombay, ·369 to 1, and Beypore, ·794 to 1, and is much the same as is found at Kurrachee.

The solar diurnal tide (R_1 of S) is about $\frac{1}{11}$th of its principal component, being about the same proportion as obtains at Bombay and Kurrachee.

The proportion of P to O is again greater than the previous years, but all these values are within the theoretical limits.

The proportion of J to Q (0·672) is again greater than in 1879-80 (0·584) and 1878-79, when it was 0·413; these values are all in excess of the maximum theoretical limit, 0·417.

The proportion of O to K is nearly the same (0·506) as was found in the two previous years (0·518 and 0·517), but all much less than the minimum proportion given by theory (0·657).

The proportions of the over-tides of S and M are all small, and agree fairly well with those of the previous years, except the solar quarter-diurnal tide (R_4 of M), which is twice as great.

The Helmholtz tide (MS) is ·009 of the main lunar tide, the same value as was obtained in 1878-79.

With regard to the long-period tides, the lunar monthly and luni-solar fortnightly agree with previous values; but the lunar fortnightly bears only about half the proportion to the main tide that it has borne in previous years.

The solar annual and semi-annual again show a considerable increase, these values being three times as large as those found for 1878-79.

The epochs of both the solar annual and semi-annual agree well with last year's dates, being about four days earlier.

VALUES OF THE TIDAL CONSTANTS, KARWAR, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Karwar:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2 *SM*
A_0	5·515	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·052	0·073	0·479	0·089	0·287	0·063	0·098	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	164·75	121·81	329·33	125·59	310·86	144·08	330·17	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·616	1·772	.....	0·164	.....	.....	.....	0·037	0·404	0·021	0·058	0·034	0·009	0·075	...	0·007
ϵ_2	333·20	298·82	.....	316·04	.....	.....	.....	95·79	279·11	158·80	230·37	240·15	330·73	19·38	...	108·50
R_3	.....	0,012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	..
ϵ_3	.....	260·62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·011	0·060	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·029	...
ϵ_4	109·65	12·28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	57·74	...
R_6	0·006	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	51·31	277·71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	282·53	59·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}045$ $\epsilon = 0°{\cdot}47$
„ fortnightly „	...	...	$R = 0{\cdot}035$ $\epsilon = 350°{\cdot}49$
Luni-solar „ „	...	...	$R = 0{\cdot}009$ $\epsilon = 91°{\cdot}27$
Solar annual „	...	...	$R = 0{\cdot}383$ $\epsilon = 302°{\cdot}56$
„ semi-annual „	...	...	$R = 0\ 053$ $\epsilon = 224°{\cdot}01$

The value of A_0, the mean level of the sea, above the zero of the gauge is slightly lower than in previous years; but all the values are very accordant, the extreme difference having been 0·135 foot. This year's value is ·05 foot below the mean value.

The main solar tide is very slightly less in amplitude than in the previous years, and the main lunar tide is a little greater; the epochs of both tides are nearly identical with last year's values.

The proportion which the main solar tide bears to the main lunar tide is rather less than has been found in the three previous years, and is considerably below the theoretical value, being 0·348 against 0·476.

With regard to the two lunar elliptic tides, the smaller (L) is only about half the value obtained last year, and is slightly less in its proportion to the main tide than its theoretical value.

The larger component (N) is slightly less than in former years, but fairly concordant; it is rather greater in proportion to the main tide than theory allows.

The smaller evectional semi-diurnal tide (λ) has a value which is nearly the mean of those obtained at this port. This tide is about half as large again here as theory gives it, agreeing exactly with Beypore, whilst at Bombay the mean value of the proportion is exactly the theoretical one.

The larger evectional tide (ν) is much smaller this year than has been before found, being only about half the value of the previous year; its proportion to the main tide approaches very nearly to the theoretical one, being ·033 against ·037.

The variational tide (μ) is rather larger than last year, but its proportion is not much greater than theory gives, being ·029 against ·022.

This being the fourth year of the observations, a second value of the solar elliptical tides (R and T) has been obtained (two years' observations being necessary for each value).

The smaller component (R) is slightly larger than before; the mean of the two gives exactly the theoretical proportion.

The larger component (T) is considerably greater than its former value, and its proportion to the main tide is 50 per cent greater than theory gives, whilst the last value at this port exactly agreed with the theoretical value.

The semi-diurnal component of the luni-solar declinational tide (R_4 of K) has nearly the same proportional value as last year, which is somewhat less than the theoretical value.

With regard to the diurnal tides, they all agree well with the values obtained in the previous years; they are on the whole a little smaller in proportion to the main tide with the exception of the diurnal lunar tide, which is about double its former value.

The proportions of P to O and J to Q both exceed the theoretical limit, while that of O to K is less than it.

The over-tides of S and M agree very well with the values of previous years, and call for no special mention.

With regard to the long-period tides, the lunar tides have all much the same proportional values as before found.

The solar annual tide is rather less than was found last year, but is about the mean of the values of the four years.

The semi-annual has a proportional value, the same as in 1877-78, but less than the two previous years. Its epoch is more than half a month later than last year.

The time of maximum of the solar annual is exactly the same as last year, viz. 23rd January.

VALUES OF THE TIDAL CONSTANTS, BEYPORE, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Beypore :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	5·412	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·003	0·056	0·329	0·078	0·197	0·063	0·091	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	187·20	142·03	339·81	135·27	327·20	161·23	340·10	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·309	0·001	.....	0·085	.....	.....	.....	0·021	0·101	0·013	0·051	0·008	...	...	...	0·034
ϵ_2	21·78	330·87	.....	355·34	.....	.....	.....	146·21	300·38	100·55	351·98	199·09	...	...	...	243·56
R_3	.....	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	196·47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·004	0·018	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·005	...
ϵ_4	132·80	49·14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	98·30	...
R_6	0·003	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	205·76	178·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ^8	45·00	131·32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	... ...	$R = 0·108$ $\epsilon = 349°·81$
„ fortnightly „	... ...	$R = 0·021$ $\epsilon = 26°·05$
Luni-solar „ „	... ...	$R = 0·017$ $\epsilon = 276°·62$
Solar annual „	... ...	$R = 0·328$ $\epsilon = 310°·74$
„ semi-annual „	... ...	$R = 0·180$ $\epsilon = 208°·39$

The mean level of the sea (A_0) from the 1880-81 observations was found to be 5·412 feet above the zero of the gauge, being ·020 higher than that obtained last year and ·027 than that of the year before.

The main lunar tide (R_2 of M) is almost identical in amplitude and epoch with the values of the two preceding years.

The amplitude of the main solar tide (R_2 of S) is almost the same as obtained last year, and its epoch differs but very slightly.

The proportion between the two main tides (R_2 of M and R_2 of S), ·342, is still less than was found in the two preceding years, and is greatly less than the theoretical value, which is ·476. With the exception of the places in the Gulf of Cutch, this is the smallest proportion yet obtained in India ; the value at Karwar being the nearest to it.

The smaller lunar elliptic semi-diurnal tide (L) has not quite half the value found last year, but agrees very fairly with the value of 1878·79 and the proportion given by theory.

The proportion of the larger component (N) to the main lunar tide is very nearly the same as was found in the two previous years, and is slightly greater than the theoretical proportion.

With regard to the two evectional tides (λ and *ν*), λ is nearly the same value as last year, *ν* is slightly greater, and both considerably exceed the theoretical proportion.

The variational tide (*μ*) is only about one-third as large as in the previous years, and its proportion to the main lunar tide is much less than what is given by theory.

The luni-solar declinational semi-diurnal tide (R_2 of K) has a value almost identical with that obtained last year ; its proportion is considerably less than the theoretical one.

With regard to the diurnal tides, the chief one (R_1 of K) is a little less than the values of the previous years, but is still greater than has been found at any port except Aden.

The proportions of the other diurnal tides to the main lunar tide do not differ much from the value obtained in the previous years, except R_1 of M, which is 6 per cent of the main tide, a proportion which has only been slightly exceeded one year at Aden.

The luni-solar compound semi-diurnal tide (2SM) agrees well with the values of previous years.

The over-tides of S and M present no remarkable features, except the rather larger proportion of the lunar quarter-diurnal to the main tide, a peculiarity noticed in the previous years.

The proportion between the solar and lunar diurnal declinational tides (P and O) is ·599, which is larger than has yet been obtained, and slightly exceeds the maximum limit given by theory.

The proportion between J and Q is much larger than in previous years, and considerably greater than the theoretical proportion.

The proportion between O and K is slightly less than in the two previous years, and is less than the theoretical minimum proportion.

With reference to the long-period sides, the lunar monthly equals 12 per cent of the main tide, which is a larger value than before obtained at any port in India.

The lunar fortnightly is only about one-fifth of the values obtained in the previous years, which, however, were two or three times as great as had been found at other Indian ports.

The luni-solar fortnightly is also much smaller than the previous years'. The values of both these lunar tides, as deduced from this year's observations, agree much better with the general values of the Indian ports than those previously obtained.

The amplitude of the solar annual tide is about a mean between the two previous values, and its epoch agrees very well with previous years, the maximum occurring same day as in 1878-79.

The solar semi-annual is rather less than last year, being 20 per cent of the main tide, instead of 28 per cent: its amplitude is still, however, much greater than at any other port on the west coast. Its epoch is about nine days earlier than in 1878-79 and a fortnight later than in 1879-80.

VALUES OF THE TIDAL CONSTANTS, PAUMBEN, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Paumben:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2 *SM*
A_0	2·759	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·038	0·018	0·116	0·294	0·108	0·014	0·023	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	153·29	190·38	323·09	120·27	315·78	114·95	12·13	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·377	0·061	.....	0·113	.....	.....	.....	0·018	0·084	0·008	0·030	0·012	...	...	...	0·012
ϵ_2	91·35	43·88	.....	70·79	.....	.....	.....	244·60	30·09	171·81	12·85	90·05	...	...	...	341·92
R_3	.....	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	161·62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·004	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·18	...
ϵ_4	261·87	194·87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	283·83	...
R_6	0·005	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	195·46	33·90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	267·20	294·83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·034$ $\epsilon = 22°·84$
„ fortnightly „	...	...	$R = 0·052$ $\epsilon = 335°·25$
Luni-solar „	„	...	...	$R = 0·027$ $\epsilon = 158°·99$
Solar annual	„	...	...	$R = 0·164$ $\epsilon = 286°·80$
„ semi-annual	„	...	...	$R = 0·184$ $\epsilon = 116°·70$

The mean level of the sea (A_0) was found to be 2·759 above the zero of the gauge, being slightly higher than the values found in the two preceding years, which were 2·666 and 2·707 respectively.

The main lunar tide (R_2 of M) is slightly larger than the values for preceding years; its epoch is the same.

The main solar side (R_2 of S) agrees extremely well both in amplitude and epoch with former values.

Resulting from this we find the proportion between the two main tides is much the same as in previous years, being ·627 as compared with ·652 and ·645 in the two preceding years. This proportion is abnormally high, Tuticorin being the only other Indian port where the theoretical proportion, 0·476, has been exceeded.

The proportion of the smaller lunar elliptic semi-diurnal tide (L) to the main tide is but very slightly in excess of the theoretical value, whilst that of the greater co-efficient (N) considerably less, being about a mean of the proportions found in the previous years.

With regard to the two lunar perturbation tides (λ and ν), λ is only one-third as large as was found last year, and approaches more nearly to the theoretical proportion than has yet been found here, but is still nearly twice as great.

The proportion of ν is nearer to that given by theory than last year's value, but is considerably in excess.

The variational semi-diurnal tide (μ) is nearly the same in value as last year, and its proportion to the main tide approaches very nearly to the theoretical value.

The luni-solar declinational semi-diurnal tide (R_4 of K) is nearly exactly the same as was found for the two preceding years, and at this port is higher in its proportion to the main tide than has been found in any Indian ports except Tuticorin.

With regard to the diurnal tides, they agree well with the results of the two previous years. The principal one (R_1 of K) is slightly less than the preceding years; its value is greater than those found at the ports of the east coast and less than those of Aden and the west coast, except Bombay.

R_1 of S is nearly identical in value and proportion to the main tide with the result of 1878-79, which agrees with the Tuticorin values.

The proportions of the other diurnal tides to the main tide agree closely with the results of the previous years.

The proportion of the solar and lunar declinational tides (P and O) is still greater than was found in the last two years, and very much greater than the maximum value assigned by theory, which is 0·572, the proportion found this year being 0·931.

The proportion of J to Q is nearly the same as last year, being greater than theory has assigned, as has generally been found, except at Tuticorin and here in 1878-79.

The proportion of O to K agrees with the former values, and is lower than is generally found.

The overtides call for no special remarks; they agree very closely with former values.

With regard to the long-period tides, the lunar monthly is only about half the amount found in the last two years.

The lunar fortnightly agrees well with the former values, whilst the luni-solar fortnightly is twice as large as the previous values.

The solar annual tide is larger than previously found, being 27 per cent of the main tide (but although it has increased, the solar semi-annual tide continues to exceed it), and is 31 per cent. of the main tide, exactly the same proportion which was found last year.

The epoch of the annual tide does not agree very well with that of last year, being more than a month earlier, occurring early in January, which was nearly the time found in 1878-79.

That of the semi-annual occurs about the middle of May and November, which is about the same date as the two previous years.

VALUES OF THE TIDAL CONSTANTS, MADRAS, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Madras:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*SM*	2*SM*
A_0	2·209	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_1	0·026	0·002	0·004	0·287	0·094	0·012	0·003	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_1	96·10	63·34	244·60	59·41	251·06	31·05	70·07	.....	.....	.....	.....	.....	.....	.....	...	.....
R_2	0·445	1·082	.....	0·113	.....	.....	.....	0·017	0·237	0·025	0·007	0·040	0·016	0·056	...	0·022
ϵ_2	274·77	244·65	.....	238·90	.....	.....	.....	138·70	238·13	100·45	285·24	163·19	204·08	336·71	...	221·90
R_3	.....	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_3	.....	52·00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_4	0·002	0·001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·001	.....
ϵ_4	168·69	110·77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	52·21	.....
R_6	0·001	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_6	98·75	142·42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_8	0·000	0·001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_8	65·44	76·24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....

Long-Period Tides.

Lunar monthly tide	$R = 0\cdot049$	$\epsilon = 130°\cdot38$
„ fortnightly „	$R = 0\cdot047$	$\epsilon = 325°\cdot25$
Luni-solar „ „	$R = 0\cdot034$	$\epsilon = 47°\cdot88$
Solar annual „	$R = 0\cdot335$	$\epsilon = 224°\cdot82$
„ semi-annual „	$R = 0\cdot383$	$\epsilon = 148°\cdot67$

The mean level of the sea (A_0) is 2·209 feet above the zero of the gauge, being 0·042 foot less than last year's value.

The main lunar tide (R_2 of M) agrees well both in amplitude and epoch with the value obtained last year.

The same remark applies to the main solar tide (R_2 of S).

As may be imagined from the foregoing, the proportion between the two main tides (R_2 of M and R_2 of S) is the same, 0·419, as was obtained last year, being less than the theoretical value.

The smaller lunar elliptic semi-diurual tide (L) has an amplitude of not much more than one-third of the amount found last year; its proportion to the main tide is considerably less (·016) than the theoretical proportion, which is ·027, and is only about half what has been found at Vizagapatam and Paumben.

With regard to the larger elliptic semi-diurnal tide (N), its proportion to the main tide is slightly less than last year, but is greater than the theoretical proportion, and very much the same as at Vizagapatam.

With reference to the two evectional tides (λ and ν), λ is nearly the same in value and proportion to the main tide as last year, the proportions being much greater than given by theory.

The value of ν is extremely small, and its proportion to the main tide is much below the theoretical value, being less than has yet been found at any Indian port.

The variational tide (μ) is nearly the same as last year, and its proportion to the main tide is about double the theoretical value, whilst at Vizagapatam and Paumben it has been found to be rather less than it.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time for Madras (two years' observations being necessary). With regard to the smaller component (R), the proportion to the main tide is nearly four times the theoretical value, and is a mean between the values of Vizagapatam and Paumben; whilst the larger component (T) is nearly twice as large as the theoretical value, and is much larger than at Vizagapatam and rather smaller than at Paumben. Both these tides approximate nearly in value to those found at Beypore.

The luni-solar declinational semi-diurnal tide (R_2 of K) is rather less than in the preceding year, and is in defect of the theoretical value. It is slightly less than at Vizagapatam, and only about half what was found at Paumben.

The luni-solar compound semi-diurnal tide (2SM) agrees nearly exactly with last year's value.

The distinctive feature of the Madras tides, viz. *the very small proportion which the diurnal tides bear to the main lunar tide*, is borne out by the result of this year's observations.

The solar diurnal tide (R_1 of S) is considerably less than last year, and agrees with the mean of the two years at Vizagapatam.

The solar declinational diurnal tide (R_1 of P) is exactly the same as last year.

The luni-solar declinational diurnal tide (R_1 of K) is slightly less than last year, and agrees well with the Vizagapatam value, but is only about half that found at Paumben.

The proportion of the lunar diurnal tide (R_1 of M) to the main tide is so small as to be barely appreciable, and is the smallest yet obtained at any Indian port.

The lunar declinational diurnal tide (R_1 of O) is slightly less than last year.

The elliptic diurnal tide (R_1 of J) is only a little more than one-third the amount that was found last year, and is only half the value at Vizagapatam and Paumben. The other elliptic diurnal tide (R_1 of Q) is the same as last year and insignificant in amount.

The lunar and solar over-tides are very small at Madras.

With regard to the long-period tides, the results of this year's observations confirm the very high value of the solar-annual and semi-annual tides, in proportion to the main tide, which was found last year, shewing that the mean level of the sea at Madras in November was 17 inches higher than in March and April.

The proportion between the solar annual tide and the main tide is slightly smaller this year than in the previous one, 0·315 against 0·356. On the other hand, the proportion of the semi-annual tide is considerably greater than last year, being 0·361 against 0·263. Thus the general effect of these tides in raising the level of the sea is nearly the same as last year.

The epoch of the solar annual tide, which last year was about the 10th October, is this year the 2nd November.

The epochs of the semi-annual tide last year were the 20th May and 20th November. This year they are the 4th June and 4th December.

Thus the maximum combined effect of the solar-annual and semi-annual tides would seem to occur in November, and this is borne out by the tidal diagrams, which give the mean sea-level in November 1·36 feet higher than in March and April.

The lunar monthly tide is slightly larger than last year, and is about a mean between Vizagapatam and Paumben.

The lunar fortnightly tide is a little greater than the last year's value, being very nearly the same as at Vizagapatam and about half the value found at Paumben.

The luni-solar fortnightly tide, which last year was hardly appreciable, is this year considerably larger, and is about the same as the mean of the last three years at Vizagapatam and Paumben.

VALUES OF THE TIDAL CONSTANTS, VIZAGAPATAM, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Vizagapatam :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2 *SM*
A_0	4·809	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·035	0·003	0·140	0·360	0·117	0·014	0·004	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	93·47	312·38	253·87	62·70	250·12	30·85	226·93	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·051	1·474	.....	0·158	.....	.....	.....	0·027	0·294	0·022	0·002	0·016	...	...	...	0·015
ϵ_2	280·00	252·38	.....	267·26	.....	.....	.....	100·82	249·20	61·98	70·14	213·49	...	...	...	252·29
R_3	.....	0·006	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	38·33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·006	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·014	...
ϵ_4	50·19	334·82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	17·75	...
R_6	0·001	0·005	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	218·09	23·57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·003	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	60·52	234·88	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}051$	$\epsilon = 104°{\cdot}02$
„ fortnightly „	...	...	$R = 0{\cdot}057$	$\epsilon = 337°{\cdot}81$
Luni-solar „ „	...	...	$R = 0{\cdot}038$	$\epsilon = 316°{\cdot}49$
Solar annual „	...	...	$R = 0{\cdot}577$	$\epsilon = 188°{\cdot}65$
„ semi-annual „	...	...	$R = 0{\cdot}458$	$\epsilon = 140°{\cdot}37$

The value of the mean level of the sea (A_0) this year is ·1 of a foot less than last year and ·2 less than that of the year before.

The proportion between the two main tides (R_2 of M and R_2 of S) agrees very well with the results of the two previous years, and is slightly less than the theoretical value, 0·442 against 0·476.

With regard to the two lunar elliptic tides, the proportion of the smaller of the two (L) to the main side is only half what has been found in the last two years, and falls as much below the theoretical proportion as it exceeded it before.

The larger component (N) has a slightly less proportion than previously obtained, and approaches very near to the proportion given by theory, being 0·199 against 0·192.

The smaller evectional semi-diurnal tide (λ) has nearly exactly the same proportion to the main tide as was found in the preceding years, about double the theoretical proportion ; whilst the larger evectional tide is hardly apparent at all this year, agreeing with Madras in this peculiarity, as this year's value of this tide at these two places is by far the smallest yet found at any Indian port.

The proportion of the variational tide (μ) to the main tide is less than in the previous years, and is exactly half the theoretical value.

The proportion of the luni-solar declinational semi-diurnal tide (R_2 of K) is also smaller than in previous years; a mean of the three values would give a value but slightly less than theory assigns.

The smallness of the diurnal tides at Vizagapatam is again shewn in the results of this year's observations. The chief of these (R_1 of K) is one-quarter of the main tide, which is the same as was found in the two preceding years.

The remaining diurnal tides do not differ much from the values of the former years, and with the exception of the solar declination diurnal (P), which is slightly larger, they are all of less amplitude than previously found.

The lunar-diurnal tide especially being almost imperceptible.

The lunar and solar over-tides are small, and call for no special mention; the lunar and solar quarter-diurnal tides are each about one per cent of the main tide.

The proportion between P and O is larger than theory assigns, but agrees well with the value found at Paumben and Madras.

The proportion between J and Q again departs entirely from the theoretical value, which gives Q about 2½ times greater than J. Here J is 3½ times greater than Q. The same or even a larger value is found at Madras and False Point, and Dublat gives nearly the same results.

The proportion between O and K is smaller than the theoretical one, and it agrees with the value at Paumben and Port Blair, and is less than at any other port except Madras.

With regard to the long-period tides, the solar-annual and semi-annual continue to shew the very high proportion to the main tide, which is a distinguishing feature of this port, and is only surpassed in India by the two riverain ports of Kidderpore and Moulmein.

The solar-annual tide indeed is less than in the two former years, but is still 39 per cent of the main tide; last year it was 57 per cent. and the year before 49. Its epoch this year is the end of September, being the same time as was found two years ago.

The solar semi-annual is greater this year than before, reaching the very large proportion of 31 per cent of the main tide, which is larger than has yet been found in any Indian port except at Madras for this same year, when it was 36 per cent. Its epoch is later than before found, occurring on the 1st June and 1st December.

The other long-period tides require no special mention.

VALUES OF THE TIDAL CONSTANTS, FALSE POINT, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at False Point:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	7·552	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·006	0·015	0·168	0·393	0·134	0·020	0·004	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	325·24	173·42	256·32	64·91	259·22	23·11	227·81	.....	.....	.....	.....	.....	...	...	...	...
R_2	1·005	2·271	.....	0·247	.....	.....	.....	0·002	0·477	0·040	0·165	0·072	...	...	...	0·019
ϵ_2	301·55	206·80	.....	279·25	.....	.....	.....	95·70	263·33	94·87	244·83	202·18	...	...	...	197·99
R_3	.....	0·012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	30·65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·007	0·030	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·039	...
ϵ_4	331·19	220·16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	270·33	...
R_6	0·003	0·000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	153·44	74·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·003	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	218·03	221·15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly	tide	...	...	$R = 0·055$ $\epsilon = 53°·15$
„ fortnightly	„	...	...	$R = 0·055$ $\epsilon = 13°·62$
Luni-solar „	„	...	...	$R = 0·042$ $\epsilon = 280°·81$
Solar annual	„	...	...	$R = 0·746$ $\epsilon = 166°·12$
„ semi-annual	„	...	...	$R = 0·364$ $\epsilon = 142°·23$

The mean level of the sea is found to be 7·552 feet above the zero of the gauge, or 12·99 feet below bench-mark A.

The main tides of S and M have amplitudes of 1·01 and 2·27 feet respectively, exemplifying the increasing amplitudes of the tides of the ports on the east coast, going north from Paumben.

The proportion between the two main tides is 0·442, which is a little less than the theoretical proportion of 0·476. This proportion is nearly exactly the same as is found at Vizagapatam, and slightly greater than at Madras.

With regard to the two lunar elliptic tides, the proportion of the smaller of the two (L) to the main tide is exactly what is given by theory ·027, and agrees well with the mean values at Vizagapatam and Madras.

The larger component (N) also agrees very fairly with the theoretical value, being 0·210 against 0·192. The Vizagapatam mean value is almost identical, and the Madras value slightly larger.

The smaller evectional semi-diurnal tide (λ) has a value about three times the theoretical one, and about a mean between the Madras and Vizagapatam values. The theoretical value of this tide has been exceeded in all the Indian ports, except the three on the west coast.

The larger evectional tide (ν) is twice the theoretical proportion, in this instance differing from the two other east coast ports, where the mean value of this tide has nearly agreed with theory.

The variational tide (μ) is about half as large again as it should be theoretically; its value being about a mean between the mean values at Madras and Vizagapatam.

The proportion of the luni-solar declinational semi-diurnal tide (R_2 of K) to the main tide is rather less than theory assigns; the value found here agrees well with the means of Madras and Vizagapatam.

One of the distinguishing features of the tides at this port, as at the other two east coast ports, is the very small proportion which the diurnal tides bear to the main lunar tide. This is more marked here than at either Madras or Vizagapatam, which may be shown by the fact that at Madras the sum of all the diurnal tides would equal 52 per cent of the main lunar tide; at Vizagapatam 49 per cent, and at False Point only 33 per cent.

The chief diurnal tide (R_1 of K) is hardly 18 per cent of the main tide. The lunar and solar diurnal tides are insignificant; as are also the two lunar elliptic diurnal tides J and Q; whilst the solar and lunar declinational diurnal tides, P and O, are only 6 and 7 per cent respectively of the main tide.

The over-tides of S and M are all insignificant in amount, and call for no special mention.

With regard to the long-period tides. The solar annual, although not so large as at Vizagapatam, amounts to 33 per cent of the main tide, which is almost the same proportion as was found at Madras.

The solar semi-annual is about half the proportional amount which was found at Madras, and two-thirds of the value at Vizagapatam.

The time of maximum of the solar-annual tide at False Point is the 4th September, and the maxima of the semi-annual tide occur on the 1st June and December.

At Vizagapatam the maximum of the solar annual tide seems to occur during the latter portion of September, and at Madras in October.

The times of maxima of the semi-annual tide seems to be nearly the same for all the three east coast ports and for Port Blair.

The lunar long period tides are smaller in proportion to the main tide than have been found either at Madras or Vizagapatam, but they call for no special comment.

VALUES OF THE TIDAL CONSTANTS, KIDDERPORE, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Kidderpore:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	10·730	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_1	0·094	0·020	0·220	0·382	0·140	0·016	0·038	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_1	196·96	221·98	302·60	138·73	311·95	72·24	278·51	.....	.....	.....	.....	.....	.....	.....	...	...
R_2	1·427	3·633	.....	0·409	.....	.....	.....	0·100	0·085	0·127	0·327	0·220	.....	.....	...	0·085
ϵ_2	101·81	50·49	.....	72·91	.....	.....	.....	250·70	45·88	308·95	365·89	109·90	.....	.....	...	356·99
R_3	.....	0·012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_3	.....	331·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_4	0·066	0·750	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·053	...
ϵ_4	120·45	34·52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	79·97	...
R_6	0·006	0·163	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_6	266·37	316·15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_8	0·006	0·077	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_8	207·56	267·68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...

Long-Period Tides.

Lunar monthly	tide	...	... $R = 0{\cdot}329$ $\epsilon = 0^{\circ}38$
„ fortnightly	„	...	... $R = 0{\cdot}278$ $\epsilon = 17^{\circ}{\cdot}18$
Luni-solar	„	„	... $R = 0{\cdot}838$ $\epsilon = 36^{\circ}{\cdot}56$
Solar-annual		„	... $R = 2{\cdot}809$ $\epsilon = 157^{\circ}{\cdot}08$
„ semi-annual	„	...	... $R = 0\,935$ $\epsilon = 204^{\circ}{\cdot}56$

The mean level of the river from this year's observations is 10·739 feet above the sill of the Kidderpore Dock. The mean value of the five former years being 10·489 feet, the present value is therefore 3 inches higher.

The tides at Kidderpore, owing to its situation high up a large river, are not comparable with those of any of the Indian ports, except Rangoon and Moulmein, whose situation is similar; and it is with the results of the observations at these ports that the comparisons are chiefly made.

The amplitudes of the main tides of S and M are slightly greater than the mean of the previous values. Their epochs are nearly identical with the value in 1877-78, but differ by 22 minutes from the mean value of the five years which had been previously used.

The proportion between the main tides is less than the mean value obtained before, and considerably less than the theoretical value, being 0·393 against 0·476; it is rather more than the value obtained at Rangoon and Moulmein, which is 0·360.

The main lunar elliptic semi-diurnal tide (R_2 of N) has a proportion to the main tide nearly exactly the same as given by theory, 0·189 against 0·192. This is identically the same proportion as was found to obtain both at Moulmein and Rangoon.

The smaller component (L) has a proportion of about twice that given by theory, but approaching it more nearly than at Moulmein and Rangoon.

The larger evectional semi-diurnal tide (ν) is 9 per cent of the main tide, the theoretical value being a little less than 4 per cent. This is the same value as found at Rangoon, but a little larger than at Moulmein.

The smaller evectional semi-diurnal tide (λ) is five times as great as the theoretical proportion; the value of this tide is very large in proportion at Dublat also, and all the stations in Burma.

The proportion of the variational semi-diurnal tide (μ) to the main tide is slightly less than before obtained, and is about three times greater than the theoretical proportion; at Moulmein and Rangoon it is found to be four times as great.

The proportion of the luni-solar declinational tide (R_2 of K) to the main tide is very nearly the theoretical one, being 0·113 against 0·127; it is higher here than at Moulmein and Rangoon.

The proportion of the luni-solar compound semi-diurnal tide to the main tide is ·023, which is nearly the same as was found at Dublat, but is one-third less than at Moulmein and Rangoon.

The proportions of the diurnal tides to the main tide are smaller than were previously found: the chief diurnal tide (R_1 of K) being only 10 per cent of the main tide, in this it agrees with the other two riverain ports, where it is 12 per cent.

All the diurnal tides in the Bay of Bengal have smaller proportions to the main tide than prevail in the Indian Ocean, and their proportion seems to be exceptionally small in the riverain ports.

With reference to the over-tides of S, the quarter-diurnal tide R_4 of S is 5 per cent of the main tide, which is the same as at Moulmein and Rangoon; the other over-tides are insignificant.

The lunar over-tides are larger in proportion than the solar, the lunar quarter diurnal being 21 per cent of the main tide—an amount which has only been equalled at Moulmein, where it is 24 per cent, whilst at Rangoon it is only 7 per cent.

The lunar sexter-diurnal over-tide (R_6 of M) is also very great in proportion, being 4½ per cent of the main tide, which is the largest proportion yet obtained in India, but which is very nearly equalled at Rangoon. The remaining over-tide R_8 of M is 2 per cent of the main tide, being the largest value yet obtained in India.

The compound luni-solar quarter diurnal tide (MS) is 13 per cent of the sum of the amplitudes of the two main tides (R_2 of S and R_2 of M) with the exception of Moulmein, where it is 14 per cent. This also is the largest value yet obtained in India.

With regard to the long-period tides, their very large proportion, compared with the main tide, is again apparent.

The chief tide of the solar annual is 77 per cent of the main tide, which is the largest value ever yet found. At Moulmein, where the next largest value was found, it was 64 per cent, and at Rangoon 29 per cent. The epoch of this tide is very nearly the mean epoch of the former years, shewing it to occur on the 28th August, and indicating that its cause may be ascribed to rainfall.

The solar semi-annual tide is 26 per cent of the main tide, which is considerably more than was found either at Moulmein or Rangoon. The epoch of this tide differs greatly from the mean, or any of the values of former years; from this year's observations its maximum should occur at the beginning of July and January, whilst the former dates were the beginning of September and March.

The next in importance is the luni-solar fortnightly tide, which is 23 per cent of the main tide, which is remarkably high, though exceeded at Moulmein, where it is 29 per cent. At Rangoon it is 9 per cent.

The lunar fortnightly tide is 8 per cent of the main tide, and the lunar monthly 9 per cent, both these proportions being considerably in excess of what has been found at any Indian port except Moulmein, Paumben, and Beypore.

VALUATION OF THE TIDAL CONSTANTS, DIAMOND HARBOUR, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Diamond Harbour:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R.*	*T*	*MS*	2*SM*
A_0	9·263	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·092	0·033	0·220	0·488	0·176	0·028	0·023	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	166·14	196·61	265·03	90·21	276·13	16·27	289·81	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·215	5·238	.....	0·619	.....	.....	.....	0·163	1·000	0·173	0·426	0·278	...	...	...	0·096
ϵ_2	26·06	342 78	.....	2·26	.....	.....	.....	161·42	337·15	196·70	291·82	75·12	...	...	...	253 37
R_3	.....	0·043	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	216·50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·117	0·774	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·695	...
ϵ_4	328·35	242·36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	283·55	...
R_6	0·013	0·161	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	266·42	109·36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·068	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	304·70	339·13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	R =	Not computed. θ =
,, fortnightly ,,	...	...	R =	ϵ =
Luni-solar ,,	,,	...	...	R =	ϵ =
Solar annual	,,	...	...	R =	ϵ =
,, semi-annual	,,	...	...	R =	ϵ =

The mean level of the river at Diamond Harbour (A_0) is 9·263 feet above the level of the zero of the gauge, which is the level of the Kidderpore Dock sill. The river-level at Kidderpore is 10·74 feet above the sill of the dock, whilst the sea-level at Dublat is approximately 8·55 above the same point.

The amplitudes of the main solar and lunar tides are greater than at Kidderpore or Dublat. The epoch of the main lunar tide differs from the mean of the previous years by about 10 minutes. The crest of this tide will reach Diamond Harbour about 1 hour 50 minutes after Dublat and 2 hours and 26 minutes before Kidderpore.

The proportion of the main solar to the main lunar tide is 0·423, which is rather less than the mean of the previous years, and somewhat in defect of the theoretical value, but is the largest found as yet at any riverain port.

The proportion of the smaller lunar elliptic semi-diurnal tide (R_2 of L) to the main tide is but slightly in excess of the theoretical value, being ·031 against ·027. This is nearly the same proportion as was found at Dublat, and considerably less than at Kidderpore.

The larger component (R_2 of N) may be said to be theoretically correct in its proportion to the main tide, which is the same result as was found at Kidderpore.

The smaller evectional tide (λ) is about five times as great as the proportional value given by theory. This is the same as at Kidderpore.

The larger component (ν) is about twice as great as theory gives, which also agrees closely with the Kidderpore value.

The proportion, of the variational semi-diurnal tide to the main tide is about twice the theoretical value. It is slightly less than at Kidderpore and little larger than at Dublat.

The proportion of the luni solar declinational tide to the main lunar tide is very nearly what is given by theory, being 0·118 against 0·127. Kidderpore and Dublat both give 0·113.

The luni-solar compound semi-diurnal tide (2 SM) is 2 per cent of the main tide, which is the same as found at Kidderpore and Dublat.

All the diurnal tides at Diamond Harbour are very small, agreeing in this with what was found at Kidderpore and Dublat. The total value of all the diurnal tides at Kidderpore is only 25 per cent of the main tide, whilst at Diamond Harbour and Dublat it is only 20 per cent, the smallest value yet found in India.

The chief diurnal tide (R_1 of K) is only 9 per cent of the main tide, which is a very small value, whilst the solar-diurnal tide is not 2 per cent and the lunar-diurnal less than 1 per cent.

The solar quarter-diurnal tide (R_4 of S) is 5 per cent of its main tide, which is the proportion which has been found at Kidderpore, and also at the other riverain ports. The other over-tides of S are insignificant.

The lunar quarter-diurnal tide (R_4 of M) is 15 per cent of the main tide, which is less than was found at Kidderpore or Moulmein, but is twice as great as at Rangoon.

The sexter-diurnal (R_6 of S) is 3 per cent of the main tide, agreeing in this with the other riverain ports.

The proportion of the amplitude of the compound luni-solar quarter-diurnal tide (MS), as compared with the sums of the amplitudes of the two main tides (R_2 of S and R_2 of M), is 0·093, which is slightly less than found at Kidderpore.

The long-period tides have not been evaluated, pending a correction in the formula for their reduction.

VALUES OF THE TIDAL CONSTANTS, DUBLAT, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Dublat :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	14·394	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·044	0·013	0·174	0·486	0·158	0·030	0·010	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	99·12	92·19	253·00	74·60	245·50	68·69	220·42	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·053	4·679	.....	0·529	.....	.....	.....	0·161	1·054	0·302	0·274	0·223	...	...	...	0·098
ϵ_2	320·81	288·08	.....	292·95	.....	.....	.....	95·23	282·84	156·99	258·92	6·07	...	...	...	196·74
R_3	.....	0·050	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	128·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·025	0·103	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·095	...
ϵ_4	202·44	139·49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	160·23	...
R_6	0·002	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	120·47	268·03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·004	0·016	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	116·94	307·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	$R = 0\,047$	$\epsilon = 29°{\cdot}34$
„ fortnightly „	$R = 0{\cdot}051$	$\epsilon = 37°{\cdot}12$
Luni-solar „ „	$R = 0\,050$	$\epsilon = 279°{\cdot}70$
Solar annual „	$R = 0{\cdot}796$	$\epsilon = 146°{\cdot}93$
„ semi-annual „	$R = 0{\cdot}234$	$\epsilon = 162°{\cdot}17$

The mean level of the sea at Dublat was found to be 14·394 feet above the zero of the gauge, and therefore 8·58 feet below bench-mark A.

The position of Dublat is on the sea near the mouth of a large river, and this situation it shares with three other tidal stations in the Bay of Bengal, viz. False Point, Elephant Point, and Amherst, and, allowing for differences of geographical position, we should expect to find the same peculiarities in the tides of all four.

The proportion of the main solar to the main lunar tide is rather less than the theoretical one, being 0·439 against 0·476. The mean proportional value of the four estuary ports is 0·434.

The smaller lunar elliptic semi-diurnal tide (L) at Dublat exceeds the theoretical proportion, as also does the larger component (N). In this also the other estuary ports shew similar values.

With regard to the evectional semi-diurnal tides, the smaller (λ) is very nearly ten times greater than the theoretical value. It is nearly the same value as found at Amherst, and these with Elephant Point give the highest proportions for this tide yet found in India.

The larger component (ν) has also a value about 50 per cent greater than theory gives, but the other estuary ports have a still higher value than this.

The variational semi-diurnal tide (μ) has more than double its theoretical proportional value.

The proportion of the luni-solar declinational semi-diurnal tide (R_2 of K) to the main tide is very slightly less than the theoretical value. In this it agrees well with False Point. One of the chief features of the Dublat tides is the exceedingly small proportion which the diurnal tides bear to the main lunar tide. This is a general feature in all the stations in the Bay of Bengal; but it is most marked at Dublat, where the sum of all the diurnal tides only equals 19¼ per cent of the main tide. The lowest value before obtained was 25 per cent at Kidderpore and Rangoon, whilst at the two other estuary stations it is 28 per cent.

The chief diurnal tide (R_1 of K) is only 10 per cent of the main tide. The lunar and solar diurnal tides are insignificant, as also the two lunar elliptic diurnal tides, J and Q, whilst the solar and lunar declinational diurnal tides (P and O) are only 3 and 4 per cent respectively of the main tide.

The over-tides of S and M call for no special remark. They are all very small; the largest, the quarter-diurnal lunar tide, being only 2 per cent of the main tide.

All the long-period tides are small at Dublat. They are nearly the same in total proportional amount as was found at Elephant Point.

The three lunar tides are each only 1 per cent of the main tide.

The solar annual tide is 17 per cent, and the semi-annual 5 per cent.

The time of the maximum of the solar annual tide was the 18th August. This tide seems to occur earlier as one goes up the Bay. At Madras it is in October, at Vizagapatam late in September, at False Point early in September, and here in the middle of August.

The times of maxima of the solar semi-annual are the 12th June and December, very nearly the same time as at False Point.

VALUES OF THE TIDAL CONSTANTS, RANGOON, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Rangoon:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	14·080	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·123	0·060	0·285	0·669	0·148	0·023	0·023	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	128·72	347·11	308·31	115·89	321·68	169·50	309·69	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·003	5·675	.....	0·639	.....	.....	.....	0·316	0·959	0·293	0·201	0·510	0·117	0·290	...	0·157
ϵ_2	170·37	129·84	.....	165·60	.....	.....	.....	322·32	117·51	1·77	72·89	290·04	167·26	207·36	...	56·33
R_3	.....	0·016	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	151·40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·098	0·433	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·419	...
ϵ_4	256·12	167·17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	210·13	...
R_6	0·009	0·234	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	39·20	82·51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·003	0·087	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	117·47	94·05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0\cdot238$ $\epsilon = 8°\cdot83$
„ fortnightly „	...	...	$R = 0\cdot208$ $\epsilon = 2°\cdot91$
Luni-solar „	...	...	$R = 0\cdot565$ $\epsilon = 54°\,21$
Solar annual „	...	...	$R = 1\cdot415$ $\epsilon = 153°\cdot23$
„ semi-annual „	...	...	$R = 0\cdot012$ $\epsilon = 314°\cdot51$

The value of mean sea-level (A_0) this year is ·094 foot lower than by last year's determination.

The main solar and lunar tides agree almost exactly in amplitudes and epochs with last year's results. The proportion between them is therefore nearly the same as last year, being 0·359 against 0·363, both values being considerably in defect of the theoretical proportion, 0·476, as has been found at all the river stations.

The smaller lunar elliptic semi-diurnal tide (L) is condiderably less than last year, but is still more than double its theoretical proportional value.

The larger component (N) is slightly smaller than last year; but approaches very nearly to the proportional value given by theory, with which it last year was almost identical.

With regard to the evectional tides, the smaller (λ) is identical with last year's value, and is about eight times larger than the theoretical value, which is the same result as was found at Moulmein.

The larger component (ν) is about one-third less than last year, but is still 50 per cent greater than the theoretical proportional value.

The variational tide (μ) is the same in value as last year, which is four times the proportional value given by theory.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time this year (two years' observations being necessary).

The smaller component (R) is about five times greater than its proper proportional value; in this it agrees well with the results obtained for this tide at Moulmein.

The larger component (T) has also the same proportional value as was obtained at Moulmein, which is nearly twice as great as theory gives.

The luni-solar declinational semi-diurnal tide (R_2 of K) is nearly identical with last year's value, as also is the luni-solar compound semi-diurnal (2SM).

The diurnal tides at Rangoon are again very small, and agree almost exactly in proportional value with last year's results. Both here and at Moulmein their total amount is only 25 per cent of the main tide, which is also the case at Kidderpore, shewing that the diurnal inequality does not greatly affect tides in rivers.

The lunar and solar over-tides are very accordant with what was found last year.

The solar quarter-diurnal is 4 per cent of the main tide, and the lunar quarter-diurnal is 8 per cent; the sexter-diurnal lunar over-tide (R_6 of M) is also 4 per cent of the main tide. The large values of these over-tides is due to the position of the place, separated from the sea by a considerable length of shallow water, and the same phenomenon is found in the Hughli and Moulmein rivers.

With regard to the long-period tides, the lunar tides have much the same proportion to the main lunar tide as was found last year. These, as well as the solar long-period tides, are considerably less in proportion than at Moulmein and Kidderpore.

The solar annual tide is 25 per cent of the main tide; last year it was 29 per cent, whilst the semi-annual tide is very small.

The epoch of the annual tide is about nine days later than last year, occurring on the 24th August.

VALUES OF THE TIDAL CONSTANTS, ELEPHANT POINT, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Elephant Point:—

Short-Period Tides.

	S	*M*	O	*K*	*P*	*J*	Q	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	16·554	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·113	0·022	0·356	0·817	0·199	0·113	0·049	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	79·37	283·05	277·14	99·13	302·52	137·78	256·34	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·337	5·870	.....	0·405	.....	.....	.....	0·413	1·546	0·660	0·692	0·357	...	...	...	0·042
ϵ_2	143·11	100·00	.....	73·24	.....	.....	.....	278·75	77·89	323·14	206·42	275·14	...	...	...	86·57
R_3	.....	0·025	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	142·80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·037	0·079	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·135	...
ϵ_4	162·30	41·90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	64·45	...
R_6	0·021	0·200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	93·61	342·71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·008	0·031	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	60·07	313·85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}145$ $\epsilon = 5°{\cdot}85$
„ fortnightly „	...	...	$R = 0{\cdot}102$ $\epsilon = 286°{\cdot}61$
Luni-solar „	„	...	... $R = 0{\cdot}059$ $\epsilon = 275°{\cdot}34$
Solar annual	„	...	... $R = 0{\cdot}930$ $\epsilon = 145°{\cdot}63$
„ semi-annual	„	...	... $R = 0{\cdot}261$ $\epsilon = 198°{\cdot}43$

The gauge at Elephant Point being situated nearly on the sea at the mouth of a large river, the tides here are comparable first with Amherst, similary situated on the opposite side of the Bay about 100 miles distant, where we should expect the same phenomena to prevail, and with Dublat and False Point, also situated at the mouths of large rivers.

The mean sea-level was found to be 16·55 feet above the zero of the gauge.

The amplitudes of the two main tides (R_2 of S and R_2 of M) are 2·3 feet and 5·9 feet respectively, the corresponding values at Amherst being 2·9 and 6·2. The proportion of the main solar to the main lunar tide is 0·398, which is less than that found at any of the other estuary ports, and considerably less than the theoretical value, 0·476.

The proportion between the smaller of the lunar elliptic semi-diurnal tides (L) and the main tide is about 2½ times that given by theory, whilst at the other estuary ports the agreement is close.

With regard to the larger component (N), it is rather greater than the theoretical proportion, being 0·263 against 0·192.

The two lunar perturbational tides (λ and ν) are very much larger than assigned by theory, and are the largest proportions yet found in India.

The variational semi-diurnal tide (μ) is about three times as great as theory allows, and is nearly the same proportion as is found at Amherst.

The luni-solar compound semi-diurnal tide (R_2 of K) has a value of only about half the theoretical one. In India this tide has generally been found to agree very well with theory.

The luni-solar compound semi-diurnal tide (2SM) is very small at Elephant Point, only about one-fourth the value found at Amherst and one-third the value at Dublat. A distinctive feature of the Elephant Point tides is the small value of the diurnal tides; in this it agrees with Amherst, Rangoon, and all the stations in Burma and the Bay of Bengal generally. The most important of the diurnal tides, the luni-solar declinational diurnal tide, is only 14 per cent of the main tide, whilst on the west coast of India it ranges from 40 to 80 per cent.

The solar diurnal is only about one-half the proportional value to the main tide that is generally found in India. R_1 of O, the lunar declinational diurnal tide, is less than one-third of the general proportional value, whilst the other diurnal tides are insignificant in their proportion to the main tide.

There is nothing to call for special remark in the over-tides either of S or M, except the rather large value of the sexter-diurnal lunar tide.

With regard to the long-period tides, they have small proportional values as compared with the other Burman ports, but agree very well with the values found at Dublat.

The lunar long-period tides are all considerably less in value than the general mean of Indian values.

The solar annual tide is 16 per cent of the main tide; at Dublat it is 17 per cent, and at Amherst 10 per cent.

Its time of maximum occurs at the middle of August, which is the same time as has been found at Rangoon.

VALUES OF THE TIDAL CONSTANTS, MOULMEIN, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Moulmein: —

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	8·659	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·099	0·032	0·242	0·437	0·144	0·018	0·052	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	154·80	209·27	330·08	121·65	331·19	124·60	335·71	.....	.....	.....	.....	.....	...	...	...	...
R_2	1·344	3·743	.....	0·261	.....	.....	.....	0·360	0·680	0·252	0·248	0·322	0·097	0·300	...	0·139
ϵ_2	148·31	110·34	.....	135·23	.....	.....	.....	310·87	104·39	0·18	89·33	254·80	170·50	189·37	...	42·27
R_3	.....	0·032	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	211·81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·060	0·092	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·710	...
ϵ_4	225·18	105·63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	206·00	...
R_5	0·006	0·111	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_5	187·13	191·99	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_6	0·001	0·038	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	251·57	132·82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}459$ $\epsilon = 17°{\cdot}43$
„ fortnightly „	...	...	$R = 0{\cdot}346$ $\epsilon = 16°{\cdot}25$
Luni-solar „ „	...	...	$R = 1{\cdot}110$ $\epsilon = 49°{\cdot}86$
Solar annual „	...	...	$R = 2{\cdot}389$ $\epsilon = 152°{\cdot}84$
„ semi-annual „	...	...	$R = 0{\cdot}653$ $\epsilon = 283°{\cdot}89$

The value of the mean sea-level (A_0) above the zero of the gauge is found to be 0·2 foot greater from this year's observations than from the last.

The amplitudes of both the main tides are slightly less this year than last. The proportion between them, 0·359, is almost identically the same as last year, and is much less than the theoretical value, 0·476. It is nearly the same proportion as is found at Rangoon.

The lesser lunar elliptic semi-diurnal tide (L) is nearly half as large again as last year, and its proportion to the main tide is nearly four times greater than assigned by theory, being rather larger than the proportion found at Rangoon, and nearly twice as great as that at Kidderpore.

The larger component (N) has nearly the same proportion as last year, and is but slightly in defect of the theoretical value, being 0·182 against 0·192; Kidderpore and Rangoon both being 0·189.

With regard to the lunar perturbational tides, the evectional tide (λ) is one-third higher in its proportion to the main tide than was found last year, being ·067 against ·041. This is very much higher than the theoretical proportion, which is only ·007, but agrees well with the values found at Dublat, Amherst, and Rangoon.

The proportion of the larger component (ν) is ·058, theory giving ·037.

The proportion of the variational tide (μ) is about four times the theoretical one, being ·086 against ·022. Rangoon gives ·090 and Kidderpore ·063.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time this year (two years' observations being necessary). With regard to the smaller component (R), its proportion to the main tide is 6¼ times the theoretical value, and is the highest value yet obtained for this tide except one year at Kurrachee, and lately at Amherst. The larger component (T) has a proportion about twice that given by theory—a result which differs little from what has been found at several of the other ports.

The luni-solar declinational semi-diurnal tide (R_2 of K) is less this year, being only 7 per cent of the main tide, or about half the theoretical proportion. The luni-solar compound semi-diurnal tide is very much the same as was found last year, and agrees well with what was found at Rangoon.

The diurnal tides are nearly identical this year with the values of the previous one, and their values are very small, as was also found at the riverain ports of Rangoon and Kidderpore.

The quarter-diurnal tides, both solar and lunar, are nearly exactly the same in amount as was found last year; the solar over-tide being 5 per cent and the lunar 24 per cent of the main tide. This very large proportion is a marked characteristic of the Moulmein tides, which has been found at no other place except at Kidderpore, where the two combined are equal to 25 per cent of the main tide.

With regard to the long-period tides at Moulmein, the solar annual tide is by far the largest, being 64 per cent of the main tide. The same value was found last year. This is the largest proportion found anywhere save at Kidderpore. Its epoch agrees very well with last year, and is about the middle of August, shewing that it has to do with the rainfall.

The solar semi-annual tide this year is 17 per cent of the main tide Its times of maximum agree exactly with those of last year—the middle of August and the middle of February.

The solar monthly tide is rather larger than last year, and is 12 per cent of the main tide, the highest value yet obtained at any Indian port.

The lunar fortnightly tide is slightly larger than last year, amounting to 9 per cent of the main tide, which is a very high value.

The luni-solar fortnightly tide is also slightly larger than last year, and is actually 30 per cent of the main tide—an abnormally high value—which is only approached by Kidderpore, where this tide was 23 per cent of the main tide.

VALUES OF THE TIDAL CONSTANTS, AMHERST, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Amherst :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*E*	*T*	*MS*	*2SM*
A_0	13·591	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·420	0·052	0·312	0·071	0·132	0·111	0·064	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	178·00	325·05	248·52	84·50	217·74	90·22	245·41	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·851	6·249	.....	1·753	.....	.....	.....	0·259	1·378	0·394	0·427	0·440	...	...	...	0·18
ϵ_2	108·69	67·81	.....	79·55	.....	.....	.....	279·85	57·48	200·70	163·39	273·70	...	...	...	347·22
R_3	.....	0·034	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	283·81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·005	0·275	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·230	...
ϵ_4	146·81	56·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	87·85	...
R_6	0·022	0·071	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	221·61	250·31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·009	0·008	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	209·25	273·74	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Nil.

The value of the mean level of the sea (A_0) above the zero of the gauge is found to be 13·59 feet.

The amplitude of the main solar tide (R_2 of S) is 2·85 feet, which is about twice the amount at Moulmein, and is larger than has been found at either Rangoon or Elephant Point.

The amplitude of the main lunar tide is 6·25 feet, which is also the highest yet obtained at any Burman port.

The proportion between the two main tides is 0·456, which is larger than has been found before in Burma, and approaches nearly to the theoretical value.

Of the two lunar elliptic semi-diurnal tides, the smaller (L) has a proportion to the main tide about 50 per cent larger than assigned by theory, but only about half the value found at Elephant Point, Moulmein, or Rangoon.

The larger (N) is not very much greater in proportion to the main tide than the theoretical value, being 0·221 against 0·192; it is slightly less than at Elephant Point.

With regard to the evectional semi-diurnal tides, the smaller (λ) is nine times greater than theory gives, but agrees with the Moulmein value.

The larger (*ν*) is not quite double the theoretical value, and also agrees with the mean value at Moulmein.

The variational tide (*μ*) is more than thrice as great as it should be according to theory,

The luni-solar declinational semi-diurnal tide (R_2 of K) is very large, being 28 per cent of the main tide, which is by far the largest value yet found at any Indian port.

The luni-solar compound semi-diurnal agrees well in value with the value found at Moulmein.

As has been found at all the Burman stations, the diurnal tides are very small at Amherst, their total amount being only 28 per cent of the main tide, which is exactly the value found at Elephant Point, and slightly greater than at Moulmein and Rangoon, where they amounted to 25 per cent.

The main diurnal tide (R_1 of K) is 11 per cent of the main tide, which is the same proportion as found at all the Burman ports

The solar diurnal tide has a large value, being 7 per cent of the main tide—a proportion only equalled at Beypore and Paumben.

The lunar diurnal tide is quite insignificant.

The proportion of P to O falls within the theoretical limits, that of J and Q greatly exceeds, and that of O to K is less than them.

The quarter-diurnal tides of S and M are respectively 3 per cent and 4 per cent of the main tide; the other over-tides call for no special comment.

The long-period tides have not been computed.

The results in this table have been deduced from the observations of eight lunations only, and have not therefore the same value as the results of a full year.

VALUES OF THE TIDAL CONSTANTS, AMHERST, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Amherst:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2*SM*
A_0	13·974	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·143	0·037	0·301	0·062	0·103	0·079	0·057	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	148·53	13·77	259·20	67·74	258·07	83·82	241·04	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·705	0·174	.....	0·771	.....	.....	.....	0·255	1·267	0·234	0·287	0·255	0·451	0·841	...	0·152
ϵ_2	101·22	65·66	.....	64·69	.....	.....	.....	287·37	40·16	243·35	265·24	295·06	353·37	222·90	...	30·30
R_3	.....	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	221·32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·118	0·437	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·412	...
ϵ_4	102·23	47·46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	77·90	...
R_6	0·004	0·153	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	221·06	242·41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·000	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	848·10	236·01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·160$ $\epsilon = 43°·45$
,, fortnightly ,,	...	...	$R = 0·054$ $\epsilon = 291°·89$
Luni-solar ,, ,,	...	...	$R = 0·081$ $\epsilon = 78°·37$
Solar annual ,,	...	...	$R = 0·638$ $\epsilon = 149°·83$
,, semi-annual ,,	...	...	$R = 0·188$ $\epsilon = 138°·72$

The value of the mean level of the sea (A_0) above the level of the zero of the gauge is 13·974 feet; the incomplete year of 1880-81 gave it 13·591.

The main solar and lunar tides agree well, both in amplitude and epoch, with last year's values; the amplitudes in both cases being slightly in defect.

The proportion between the two main tides is less than in the previous year, being 0·438 against 0·456; theory giving 0·476. This value is almost identical with that found at Dublat and False Point, and is rather greater than at Elephant Point.

The lesser lunar elliptic semi-diurnal tide (L) is identical in proportional value with the result obtained last year, about 50 per cent higher than the theoretical value.

The larger component (N) is a little smaller than last year, and approaches very nearly to the theoretical value, being 0·205 against 0·192.

Of the evectional semi-diurnal tides, the smaller (λ) is somewhat less than the value of the previous year, but is still between six and seven times the theoretical value. The mean of the two years agrees well with the mean values obtained at Moulmein and Rangoon; but is lower than at Dublat and Elephant Point, and much higher than at False Point.

The larger component (*ν*) is also less than the last year's value, and approaches nearer to the theoretical value; the mean of the two years agrees with the Dublat value, and is less than at Elephant Point and False Point.

The variational semi-diurnal tide (*μ*) has a proportional value this year not much greater than half what was obtained last year, and is about twice the theoretical proportion.

The solar elliptic semi-diurnal tides (R and T) have been deduced here for the first time this year (two years' observations being necessary). They both appear to be extremely large, R being 18 times the theoretical value and three times greater than has yet been found at any Indian port; whilst T is five times the theoretical value and twice as great as any value at any other port. These tides have not as yet been deduced for any other estuary port.

The luni-solar declinational semi-diurnal tide (R_2 of K), which last year shewed an abnormally high proportional value, has this year a proportional value nearly identical with theory, being 0·125 against 0·127.

The luni-solar compound semi-diurnal tide (2SM) is nearly the same as last year. Its proportional value agrees well with that of Dublat, but is much higher than at Elephant or False Point.

The diurnal tides, the sum of which last year only amounted to 28 per cent of the main tide, are this year only 24 per cent. All the several tides are nearly the same as last year, the reduction being in the solar diurnal tide, which last year reached the large proportion of 7 per cent of the main tide, and is this year only 2 per cent.

The proportions of P to O and J to Q are greater than theory gives, whilst that of O to K is less.

With regard to the over-tides of S and M, the quarter-diurnal of S is 4 per cent of the main tide, whilst that of M is 7 per cent, and R_6 of M is 2½ per cent. At Elephant Point it is 3½ per cent.

The quarter-diurnal Helmholtz's tide (R_4 of MS) is nearly 5 per cent of the sum of the two main tides.

The long-period tides at Amherst are all small, being the smallest in proportion to the main tides that have been found in the Bay of Bengal. Their total is only 18 per cent of the main lunar tide, agreeing in this most nearly with Port Blair, where they are 19 per cent. At Elephant Point and Dublat they are 25 per cent.

The solar annual is 10 per cent of the main tide. The epoch of its maximum effect is about the 21st August, which is the same time as has been found at Rangoon, Elephant Point, and Moulmein.

The solar semi-annual is only 3 per cent of the main tide. Its epochs are the 1st June and 1st December.

VALUES OF THE TIDAL CONSTANTS, PORT BLAIR, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Port Blair:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	4·718	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·016	0·012	0·156	0·388	0·137	0·020	0·026	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	34·94	1·69	224·46	48·38	236·79	41·23	102·77	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·978	2·038	.....	0·274	.....	.....	.....	0·000	0·397	0·047	0·130	0·091	0·020	0·009	...	0·020
ϵ_2	313·49	275·38	.....	290·57	.....	.....	.....	94·08	270·08	129·00	253·44	293·06	67·06	31·74	...	170·36
R_3	.....	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	8·17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·001	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·010	...
ϵ_4	85·60	124·12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	204·37	...
R_6	0·002	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	98·53	200·30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	87·01	61·93	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	$R = 0·018$	$\epsilon = 25°·71$
„ fortnightly „	$R = 0·061$	$\epsilon = 351°·00$
Luni-solar „ „	$R = 0·007$	$\epsilon = 6°\ 26$
Solar annual „	$R = 0·062$	$\epsilon = 132°·87$
„ semi-annual „	$R = 0·134$	$\epsilon = 196°·96$

The value of the mean level of the sea (A_0) above the zero of the gauge is rather less than last year, being 4·718 against 4·792.

The value of the amplitudes of the main tides of S and M is almost identical with what was found last year.

The proportion between the main tides is again very nearly the theoretical one, being 0·480 against 0·476 given by theory, the mean of the two years giving exactly the theoretical proportion.

The proportion between the smaller lunar elliptic semi-diurnal tide (R_2 of L) and the main tide is not so close to theory as it was last year, being ·044 against ·035; theory giving ·027.

The larger lunar elliptic tide (R_2 of N) is almost exactly the theoretical value, its proportion being 0·195; theory giving ·192.

With regard to the two lunar perturbational tides (λ and ν), they are much the same as last year; λ being about three times as great in proportion to the main tide as theory would assign, and ν nearly twice as great.

The variational semi-diurnal tide (μ) is the same as last year, and twice as great as the theoretical value.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time this year (two years' observations being necessary).

With regard to the smaller component (R), its proportion to the main tide is 2½ times the theoretical value, which agrees well with what has been found at Madras and Vizagapatam; whilst the larger component (T) is about twice the theoretical value, which is what was found at Madras, but is considerably greater than at Vizagapatam.

The luni-solar declinational semi-diurnal tide (R_2 of K) approaches very nearly to the theoretical value, being 0·134 against 0·127; whilst at Madras, Vizagapatam, and False Point the values are rather less than theory gives.

The luni-solar compound semi-diurnal tide (2SM) is the same as last year, and has a proportion to the main tide about half what was found at Madras, and nearly the same as at Vizagapatam and False Point. As was found last year, the diurnal tides bear a very small proportion to the main lunar tide.

The solar declinational diurnal tide (R_1 of P) is the only one which has a slightly larger proportion than was found last year.

The lunar elliptic diurnal (Q) and the lunar declinational diurnal (O) are the same as last year, whilst the solar diurnal (R_1 of S), the luni-solar declinational (R_1 of K), the lunar diurnal (R_1 of M), and the lunar elliptic diurnal (R_1 of J), are less than last year.

The proportions of P to O, J to Q, and O to K, differ greatly from the values assigned by theory; the two former being much greater, and the last one much less. As was found last year, the lunar and solar over-tides are insignificant.

There is a close coincidence between the amplitudes of the short-period tides evaluated from the two years' observations, as might be expected from the position of Port Blair as an ocean port; and from this cause also the proportions of the various tides to the main lunar tide are more generally agreeable to theory than is usually found.

With regard to the long-period tides, the lunar monthly is nearly the same as last year, and insignificant in amount.

The lunar fortnightly has a value of 3 per cent of the main tide, which is the same as was found last year. The luni-solar fortnightly is hardly appreciable.

In the solar annual tide there is a considerable difference both in amplitude and epoch from the values of last year. This year it is only 3 per cent of the main tide, which is nearly the smallest value which has ever been obtained for an Indian port, the only values at all approaching to it being at Kurrachee and Bombay. Its time of maximum effect is the 4th August. Last year it was early in September.

With regard to the solar semi-annual tide, its proportion to the main tide is ·066, which is about one-fifth what was found at Madras and Vizagapatam, and agrees nearly with the proportion at Dublat and Elephant Point. Its times of maximum are about the end of June and December, or about a fortnight later than was found last year.

Memorandum by Major M. W. Rogers, R.E., *Deputy Superintendent, 4th grade, on the earthquake of the 31st December* 1881 *and the great sea-waves resulting therefrom, as shown on the diagrams of the tidal observatories in the Bay of Bengal.*

Port Blair mean time is used throughout. Latitude 11°40′30″ N., longitude 92°45′ E.

The tide-wave can be traced clearly on the diagrams at seven tidal stations, viz. Port Blair, Paumben, Madras, Negapatam, Vizagapatam, False Point, Dublat, and may be suspected on an eighth, viz. Diamond Harbour, on the Hooghly.

At Port Blair, in the Andaman Islands, the first indication of the shock is at 7h. 42m. A.M., and this, I am inclined to think, is due to the earth-wave, or rather to the forced sea-wave, which is formed when the earth-wave gets into shallow water; for the tidal curve goes on undisturbed for some 30 minutes afterwards, and it is not until 8h. 10m. A.M that the first wave is recorded, followed by others in succession at about 15 minutes' interval, with a height of about 3 feet from crest to hollow. The diagram is unfortunately incomplete, for the pencil of the gauge, in its violent oscillations, caught in and tore the paper of the diagram, and the clerk, being frightened, stopped the driving clock, which was not started again until 1 P.M. There is evidence that the waves continued to follow one another with great regularity until about 3 P.M., when they became of a much smaller size, but are traceable until 9 P.M. Small shocks were felt on Ross Island all that day, and the violence of the great shock, which damaged the barracks and did other injury, seems to indicate that the centre of impulse could not have been far from the Andamans.

At Madras there is a trustworthy time for the advent of the earth-wave; it is obtained from the Telegraph Office, where the shock affected the recording instruments. It occurred at 7h. 56m. A.M (7h. 5m. 45s. Madras time), whilst the great sea-wave reached at 10h. 10m. A.M., and continued until 7 P.M., with intervals of about an hour from crest to crest, and the influence of the disturbance can be traced until 10 P.M.

At Negapatam the first and largest wave came in at 10h. 10m. A.M., with a height of nearly four feet from crest to hollow, and it was succeeded by a series at about half-hour intervals, which continued until midnight. Judging from the diagrams, the sea at this port seems to have been more affected by the earthquake than at any other.

At Paumben the first wave was registered at 11h. 35m. A.M., and was followed until midnight by a succession of waves with about two hours' interval between them.

At Vizagapatam the first wave was recorded at 10h. 48m. A.M., and from that time there was a succession of small waves at irregular intervals until past midnight.

At False Point the diagram shows the passage of the earth-wave or forced sea-wave at 7h. 54m. A.M. The pencil seems to have been moved rapidly up and down a small quantity for some minutes, and the clerk notes that the building was shaken by an earthquake. The sea-wave here is hardly indicated. Its first appearance is at 11h. 12m. A.M., and there is a second one at 1 P.M.

At Dublat the wave appears to have arrived at 1 P.M., and a second, one hour afterwards; there is also an indication of a third at 3 P.M.

At Diamond Harbour the indications of the wave are untrustworthy, and very slight. If felt at all, it was at about 3 P.M.

Looking over the data at our disposal, I find that the shock, *i.e.* the earth-wave, was recorded as felt at Madras, Coconada, Vizagapatam, Gopálpur, False Point, Calcutta, Port Blair, and Kisseraing, an island in the Mergui Archipelago in latitude 11°39′ N., longitude 90°31′ E., and also on board a ship, *The Commonwealth*, in latitude 5°55′ N., longitude 92°49′ E.

Of these the times of the shock at Madras, False Point, and Kisseraing were probably recorded correctly within a minute. Madras was recorded in the Telegraph Office, and given to the nearest second; False Point was recorded on the tidal diagram, and also by Mr. Rendell, of the Survey, who was leveling a few miles from False Point, and whose recorded notice of the time at which he felt the shock agrees to the minute with the tide gauge record.

At Kisseraing I was observing at the trigonometrical station there with a 24″ theodolite, and saw the earthquake before feeling it; the heliotrope (distant some 15 miles) to which I was observing appearing to rise and fall in the field of the telescope, and the levels of the instrument being violently agitated. The motion was, to my feeling, barely perceptible, but the recorder and other men with me said that they felt it distinctly. It was not, however, felt by several of the officers of the Indian Marine, who were on the island that morning, thus proving that it was not a severe shock, though plainly noticeable by instrumental means.

At Madras, False Point, and Kisseraing, the earth-wave was felt at about the same minute—7h. 55m. A.M. On the hypothesis that the strata between them and the centre of impulse is homogeneous, this centre was equidistant from them, and would be at a spot in the Bay of Bengal in latitude 11°55′ N. and longitude 89°33′ E.

There is no reliable evidence on the subject of the velocity of earth-waves; it varies with the nature of the strata through which it passes and the violence of the initial shock, and also on the depth of the locus of the centre of impulse.

If we assume that the centre of impluse in this case was at the point mentioned, it will be found that it, and Port Blair and Kisseraing, are almost in a straight line. The distance from Port Blair to Kisseraing is 400 miles; and if we assume that the mark on the diagram at the former place at 7h. 42m. was due to the earth-wave, it took 13 minutes to travel 400 miles, which gives a rate of 30 miles per minute—a velocity which I find mentioned in books on the subject as probable under favourable circumstances. With this velocity the central shock should have taken place at 7h. 35m., the distance to Madras, &c., being a little over 600 miles. The distance from this assumed centre of impulse to Port Blair is 218 miles, which would take seven minutes in transit and cause the shock to be felt there at 7h. 42m.

This fixing of the locality of the centre is of course merely hypothetical: the whole of the region is volcanic. Narcondam and Barren Island, to the east of the Andamans, are volcanoes, the latter having been in eruption as late as 1792; the only thing certain is that the centre must have been not far from Port Blair and Car-Nicobar, and about equidistant from the whole of the east coast of the Bay of Bengal, and also it must have been subaqueous in order to have caused such distinct tidal waves.

All the times of the earth-wave reaching places on the west side of the Bay agree very fairly; but in all the cases except those mentioned, the times are not likely to be sufficiently accurate to aid in the investigation.

The force of the earthquake was great at Port Blair, where it did damage to the barracks, &c., and at the Island of Car-Nicobar it was felt severely, the huts of the natives and many of their palm-trees being thrown down.

Several slight shocks were felt at Port Blair on the same and the two succeeding days, and *The Commonwealth*, which, as mentioned, felt the shock of the 31st, felt three shocks

again on the 1st off the Island of Car-Nicobar. All this points to there having been considerable subterranean disturbances in those regions at that time.

I can find no trustworthy indication of the direction of the motion as felt at the various places. At Madras there are three estimations of it: one north to south, and two others north-east to south-west; whilst the clerk of the tidal observatory says that there were two shocks—the first north to south and the second east to west. Mr. Rendell, at False Point, states that the direction appeared to him to be from north-west to south-east, whilst a person at Calcutta says that it appeared to go from west to east. At Kisseraing Island the motion was so slight that I could not decide on any direction. My first impression was that it came from the west, but after careful consideration I could not decide sufficiently satisfactorily to place it on record.

The great tide wave, of which we have full evidence on the tidal diagrams, was felt, as was to be expected, a considerable time after the shock, varying with the distance and other causes, such as wind and its velocity of translation, which again varies with the depth of the water at any given point.

The wave reached Port Blair first at 8h. 10m., or, if we assume the foregeing idea of the locality of the centre of disturbance and time of the original shock, in 35 minutes, with an average rate of 6·2 miles per minute. It reached Madras and Negapatam at 10h. 10m., two hours later than Port Blair. These places are 614 and 640 miles from the assumed centre, and would give a velocity of 4 miles per minute.

At Paumben the first wave came in at 11h. 35m., or more than one hour later than Negapatam; but owing to the intervening land and straits, I do not think any estimate of velocity can be made. At Vizagapatam the wave reached at 10h. 48m., about 40 minutes later than Madras, giving a velocity of 2·9 miles per minute. At False Point the wave reached at 11h. 12m., or 24 minutes later than at Vizagapatam, giving the same velocity of 2·9 miles per minute. The wave reached Dublat at 1 P.M., giving a velocity of a little over two miles per minute.

The direction of the wind all day was N.N.E., which would tend to reduce the velocity of the wave on its road to the northern ports.

Extract from the Narrative Report, dated 22nd December 1882, *of* LIEUTENANT-COLONEL W. M. CAMPBELL, R.E., *Deputy Superintendent, 2nd grade, in charge No. 1 Astronomical Party.*

I ARRIVED at Mussoorie, on return from furlough to Europe, on 15th May 1882, and took charge of No. 1 Astronomical Party in the place of Major Heaviside, who had proceeded on furlough. Major Strahan having written a general report regarding the longitude operations carried out during season 1881-82 by the two Astronomical parties combined, I need not here allude to the movements of No. 1 party, under Major Heaviside, in the field.

I found the work in a fairly forward state as regards the reduction of the observations, and it was steadily proceeded with until completed in October.

A large portion of my own time was employed in going through the reductions of the previous season's work, viz. 1880-81, with the hope of finding some source of error, the correction of which would improve the accordance of the results obtained. In this I was unsuccessful, and my investigations throw no light on the origin of the discrepancies, the magnitude of some of which had caused me much surprise and some uneasiness.

I did make some minute alterations in the method of computing the level corrections applied to the star observations, and, curiously enough these in almost every case increased the closing error of the triangular circuits, which seems to indicate that a coincidence within 0ˢ·01, or 0ˢ·02, in the values of an arc of longitude obtained by direct measurement and by the sum of two other arcs is very fortuitous. Much of my time was also occupied in supervising the printing of the results of 1880-81, which was carried on, and nearly completed, during the recess.

As regards the results obtained from the observations of 1881-82, these are, I regret to say, very unsatisfactory. The discrepancies between the individual values of each arc are generally larger than in former seasons, and two out of three circuit errors obtained are of almost incredible magnitude.

The observations taken for collimation throughout the season showed an amount of instability in that adjustment in the case of both telescopes, but more particularly with regard to No. 2, which was used by Major Strahan, which has caused me great anxiety as to the results from the time when I took charge of the reductions; but the event has far exceeded my worst anticipations.

When the bad results became apparent, suspicion was first thrown on the methods of observation and reduction; but the work has been gone through without any success in detecting mistakes of procedure, and all the evidence points out that the instruments are to blame. The instability of the collimation adjustment, already remarked upon, might perhaps be held sufficient to account for the errors found, were it not for the fact that the system of reversing the instruments, which has always been carried out, must eliminate from the resulting value of each arc the effects of all instrumental defects which are constant; and it is difficult to imagine inconstancy, in any hypothetical source of error, sufficient to leave such gross discrepancies in spite of the tendency of the system to cancel its effects.

The inconstancy of collimation pointed to the conclusion that the fault in telescope No. 2, which was successfully treated at Madras in 1875, had reappeared in that telescope, while No. 1 was affected to some degree by a similar failing; but the collimation observations recorded during the season do not suffice to enable me to speak with absolute confidence on this point. During the recess both the telescopes were examined by Mr. Bolton, who reported that there was great weakness of both in the suspected parts, viz. the junction of the object-half of the telescope tube with the flange, by which it is attached to the axis. These parts were accordingly thoroughly strengthened by the addition of internal collars and new soldering, and the same treatment was applied to the corresponding parts of the eye-end tubes. I am glad to say that both instruments have since then given satisfactory evidence of stability in the collimation adjustment, and I believe they are now in a better condition than they have been at any former time.

In case of the reappearance of any such defects as have on former occasions been found in these telescopes, it may be advisable to record here my experience in the matter, which, as regards these individual instruments, is greater than that of any one else.

In the first place, I consider that all observations for collimation should be carefully carried out in a way calculated to show up any instability which may exist in that adjustment, and so long as these observations afford no evidence of such instability the telescope may be used with confidence, but if any symptoms of inconstancy of the collimation adjustment should appear, suspicion should be at once aroused.

The most crucial test of stability in this respect of which I am aware is to obtain two determinations of collimation error; one from readings of horizontal collimators taken after the instrument has been pointed towards the zenith, and the other from similar readings after pointing towards the nadir. A slight difference between these two values may always be expected, as they are obtained after subjecting the telescope to two sets of strains of exactly opposite effects, and no instrument can be absolutely perfect and free from yield to such strains. The amount of difference in this respect which should be looked upon as sufficient to condemn the telescope must remain a matter of judgment and experience. If repeated experiments should show that, although somewhat large—say three divisions of the micrometer = 1″—it is very constant, the telescope may be continued in use, because the effects of all constant errors can be eliminated by reversing the telescope in its Y's; but as soon as irregularity in the amount, or sign, of the difference occurs in any marked degree, the telescope had better be carefully examined, and should remedies practicable on the spot—such as screwing the parts together more carefully, which I have known to be efficacious on one occasion—prove insufficient, it must be sent to an instrument-maker for repairs.

I would very strongly urge that every determination of collimation error taken during observations should show two distinct values obtained as above described, one for the zenith and the other for the nadir position, and that, if there should be a sensible constant difference between them, the former should be employed for correcting the transits of stars, and the latter should be used in combination with the mercury observations for finding the dislevelment of the instrument.

In order to afford the means of testing the constancy of the line of collimation in all positions of the telescope, I designed a frame to carry a small reflector permanently in front of the object glass, so that, by using a Bohnenberger eye-piece, a reflection of the wires might be observed in any position.

This reflector must not be large enough to interfere with the ordinary use of the telescope for star and collimation observations, because, unless it can be kept permanently in position on the telescope, its chief advantage will be lost, and from experiments already made I fear that a reflector of suitable size may not give sufficient light to afford an image fit for observation.

If a larger reflector were employed, and only applied to the telescope at certain times, when wanted for use, the difficulty of mounting and adjusting it securely would be immensely increased; and it need hardly be remarked that the slightest uncertainty in this respect would vitiate the whole principle, because if the reflector be subject to any accidental change of plane, relatively to that of the object glass, it will give false and misleading results.

On this point I feel considerable doubt as to the success of the contrivance, even in the case of a small reflector permanently in position; but as in that case its readings could be compared with those of the collimators, and of the mercury reflections, such changes would probably be detected.

If such an adjunct could be perfected, it would be a valuable addition to an astronomical instrument, even more so in the case of one for observing altitudes which is directly affected by flexure in a vertical plane, than in the case of a purely transit telescope, where such flexure is of no consequence, except in its indirect effects, which may take place in other planes.

Extract from the Narrative Report of Major G. Strahan, R.E., *Deputy Superintendent, 2nd grade, in charge No. 2 Astronomical Party, for the season ending 31st October* 1882.

In accordance with instructions received from you I proceeded to Agra, after having made over charge of the Mysore Topographical Survey to Major Thuillier, to meet Lieutenant-Colonel Campbell and Major Heaviside there, from the former of whom I was to receive charge of the instruments, office records, and camp equipment of No. 2 Astronomical party,

and to gain some further insight into the details of the longitude work before his departure on furlough. I arrived in Agra on October 27th, and spent twenty-seven days in examination of, and petty repairs to, the instruments and field equipment of the party, and some preliminary practice with the apparatus, including the determination of personal equation between myself and Major Heaviside. The charge of the party was made over to me by Colonel Campbell on November 4th.

On November 20th Major Heaviside started for Fyzabad to commence the measurement of the first arc, Fyzabad-Agra.

The arcs measured during the season were as follows :—

		Observers.	Commenced.	Completed.
1.	Fyzabad ... ... Agra	Major Heaviside ,, Strahan.	... November 25th	... December 2nd.
2.	Fyzabad ... ... Jubbulpore	Major Heaviside ,, Strahan.	... December 12th	... December 20th.
3.	Hazaribagh ... ... Fyzabad	Major Strahan ,, Heaviside.	... January 4th	... January 10th.
4.	Hazaribagh ... ... Jubbulpore	Major Strahan ,, Heaviside.	... January 19th	... January 26th.
5.	Calcutta ... ... Hazaribagh	Major Heaviside ,, Strahan.	... February 8th	... February 16th.
6.	Jalpaigori ... ... Hazaribagh	Major Heaviside ,, Strahan.	... February 25th	... March 6th.
7.	Jalpaigori ... ... Calcutta	Major Heaviside ,, Strahan.	... March 17th	... April 6th.

Observations for personal equation were taken, besides those at Agra already mentioned, at Fyzabad, Hazaribagh, and Jalpaigori, the results of the four observations being as follows :—

	By North Stars.		By South Stars.	
At Agra in November ...	S—H = —0·014	prob. error ±·012	S—H = —0·005	prob. error ±·013.
,, Fyzabad in December..	S—H = 0·000	,, ±·010	S—H = +0·037	,, ± 009.
,, Hazaribagh in January	S—H = —0·032	,, ±·006	S—H = —0·015	,, ±·007.
,, Jalpaigori in March ...	S—H = —0·006	,, ±·007	S—H = +0·027	,, ±·006

The process by which these values were obtained was the usual one in which one observer notes the transit of a star over the first 10 wires, and the other observer over the last 10; reduction to the central wire then gives the equation at once. About 80 stars were taken at each place for this purpose. The capital letters S. H. refer to the observer's initials. For the first two arcs, the mean of the November and December values was used ; for the third and fourth, the mean of the December and January values ; and the fifth, sixth, and seventh arcs, the mean of the January and March values.

It occurred to me during the work that there might possibly be an eye equation depending on whether the right or left eye was used for observing, and while at Hazaribagh I took divided transits of about 80 stars to ascertain this point. The reduction of these shows such an equation to be inappreciable, but it brought to light most unmistakably the fact that when a star is observed over a number of wires (15 or 20) there is a marked tendency to anticipate the transit over the latter half of them, *i.e.* that the mean of the former half, when reduced to the central wire, gives a later epoch than the mean of the latter half. A little consideration will show that the effects of this peculiarity are taken into account when the differences of transits by the two observers are taken out and corrected by the application to them of their relative personal equation ; for it may be considered as a personal error pecular to the individual in estimating the time of a transit. The peculiarity is brought into play exactly in a similar manner in the observations for personal equation and in star transits, and its annihilation would be theoretically perfect if the same number of wires were observed in both processes. This is not strictly the case, as ten or twelve are used in the former and any number from one to fifteen (fifteen in a large majority) in the latter. The whole effect is however so small, and was moreover recognized only by the observation of twenty wires, that this departure from theoretical accuracy may be considered as quite immaterial.

There is little to notice in the way of novelty in the procedure during the past year. One change that was discussed and sanctioned at Agra during your visit there in November was made, viz. an alteration in the system of changing pivots. Up to that time the pivots had always been similarly placed at both stations, either both I. P. E. or I. P W. (the initials I. P stand for illuminated pivot), the change from one to the other being made after the first half of the observations was completed. The new method (which was applied to alternate arcs only, viz. the 1st, 3rd, 5th, and 7th) consists in placing the pivots dissimilarly, *i.e.* I. P. E. at one station and I. P. W. at the other, both being changed as before after the first half of the observations. Theoretically one system cancels pivot error as effectually as the other, but it was hoped that some light might be thrown on some supposed pivot irregularities by this process. The number of observations, however, is not great enough for the purpose, besides the effects of any such irregularities are masked by other errors to be noticed below.

The direct comparison of clocks and deduction of the difference of their errors by the observation of what we have termed "local groups" (in contradistinction to "longitude groups," and so called on account of the local clocks being used by both observers) was never omitted, so that on every night there exist two separate methods of determining the difference of longitude; the one, by noting the time elapsed during the passage of a group of stars (the same for both observers) from the meridian of the eastern station to that of the western, by each clock alternately, and the other, by the direct comparison of clocks alluded to above. The agreement of the results of two methods is remarkably close, the mean difference being only ·012 sec. Both systems had been in use previously, but the latter had never been made an integral part of each night's programme before this season, or rather it would be more correct to say that the deductions of the latter had never been fully worked out for each night, because of so much extra labour being necessary for that purpose. The importance, however, of thus securing two partially independent values of each arc was so strongly urged by Lieutenant-Colonel Campbell that means were taken to secure them, and experience has shown that the additional labour of observing and reducing caused thereby is not so great as was anticipated.

It is with much regret that I have to report that, notwithstanding all the care that was bestowed on the work down to the minutest detail, the result of the season's work, as tested by the closing of the circuits, is not satisfactory.

In investigating the cause of these circuit errors all possible sources of error exceeding twenty in number were each discussed one by one, and a brief *resumé* of the results was submitted to you shortly after these discrepancies first came to light. The cause has been proved quite conclusively to my own mind to lie in uncertain flexure or shake of some kind in the telescope tube. This conclusion is almost forced on one by three separate considerations: first, because systematic reversal of pivots, pens, clocks, &c., makes it impossible that errors of this kind and amount can have their origin in any other source; second, because there is an *à priori* probability of its being caused by an imperfection in the tube, as a similar imperfection had been brought to light and remedied in a previous season's work; and thirdly, because there is no security that the line of collimation, when the telescope is pointed to the zenith, or near it, for the observation of transits, remains in the same relative position to the axis as when the telescope is placed horizontal or pointed to the nadir, as it unavoidably is in collimating and leveling respectively. During the recess both telescopes have been overhauled and the tubes strengthened, and various small changes, merely for the convenience of the observer, which it is unnecessary to particularize, were made.

The causes of, and remedies for, these instrumental defects have been so minutely considered and discussed by yourself and Colonel Campbell, with me in person, that it is perhaps unnecessary to enlarge upon them here, and I will only add that the repairs have been tested, as far as possible, by methods which on a previous occasion have shown similar faults to have been remedied. Some slight changes in the routine are to be adopted in future to guard, as far as is possible, against such faults coming into play again unnoticed. One suggested by Colonel Campbell seems to be an excellent safeguard, and is as follows:— In collimating, the telescope is supposed to begin from the nadir position; it is then to be raised twice to the north collimator and micrometer readings taken (suppose the mean = P). It is then raised to the zenith and twice depressed to the north collimator, giving a mean reading Q. The same process is then repeated with the south collimator giving mean readings R and S. Now if the telescope were perfect, the following equations would hold: P = Q and R = S, but practically no instrument can be made so perfect as exactly to fulfil these conditions; but the nearness or otherwise of their fulfilment is a good test of the stability of the tube. Colonel Campbell then proposes that the value of collimation $\frac{1}{2}$ (P+Q) should be used when determining the level correction by mercurial reflection, and $\frac{1}{2}$ (R+S) for computing the correction for collimation for the transits of longitude stars. The difference between the two would be quite inappreciable while the instruments were perfectly stable, whereas if they are not, the result would be more theoretically correct than by using $\frac{1}{4}$(P+Q+R+S) both for level and for longitude stars as has hitherto been the practice.

It is proposed also to change pivots each night, and also during the first arc to observe for eight nights instead of six.

The chronographic and electrical parts of the apparatus worked well, with some trifling exceptions, and seem to admit of no further improvement. Some experiments were made to ascertain how far the adjustment of the various relays and armatures affected the retardation, but no definite results were afforded by the observations, except the conclusion that any corrections due to this cause were rejectaneous; they remain, however, permanently recorded on the chronograph sheets for future reference if required.

The programme for the season 1882-83 will commence with the arc Jalpaigori–Fyzabad, which will, when completed, be approximately computed. This, with the help of all three observers, Lieutenant-Colonel Campbell, Major Heaviside, and myself, will probably not take more than two or three days. The arcs to be next undertaken will partly depend on the results of this one. Chittagong-Jalpaigori and Chittagong-Calcutta seem the most desirable, then Calcutta-Fyzabad and Calcutta-Jubbulpore, and what time then remains should be spent in revision of some of the arcs about Agra to be subsequently decided on. By leaving the western arcs to the last, it will be possible to work later in the season, as the weather up-country remains favourable for such observations long after the sky in Bengal becomes overcast.

GEOGRAPHICAL COMPILING AND DRAWING BRANCH, SURVEYOR-GENERAL'S OFFICE, CALCUTTA.

Statement showing the nature of the work performed and the progress made from 1st October 1881 to 30th September 1882.

Maps.	Scale. In. Mls.	Remarks and Progress.
India	1 = 96	Revisions, &c., on engraved proof for new edition.
India (outline map), 4 sheets ...	1 = 64	Additions, territorial names, &c. (from recent surveys), inserted for Engraving Branch.
India (with hills), do. ...	1 = 64	Hills in brush shading completed.
India (preliminary edition), 6 sheets	1 = 32	Hills completed, and additions made for second issue.
India 6 sheets engraved, final ...	1 = 32	Additions (names—Railways—new materials for Afghanistan, &c.) for engravers.
Rajputana Agency, 2 sheets ...	1 = 16	Compilation completed from surveys made up to date.
Central India Agency, 2 sheets ...	1 = 16	Compilation completed up to date.
Central Provinces, 4 sheets ...	1 = 16	Brush shading of hills completed on proof sheet for Lithographic Branch.
Bengal, Behar, Orissa, and Chota Nagpore (with hills), 2 sheets.	1 = 16	Railways inserted, names corrected, and marginal lines adjusted.
Sketch map of the Hazarajat ...	1 = 16	Hill drawing completed for photozincography.
Punjab, 4 sheets	1 = 16	New compilation, embracing all recent surveys to date. Sheet No. 4 completed.
Nizam's dominions, 2 sheets ...	1 = 16	Drawing in outline finished, printing of names, &c., in progress.
North-Western Provinces (edition of 1875), 4 sheets.	1 = 16	Revised to date.
Berar (Hyderabad Assigned Districts), 1 sheet	1 = 8	Hill drawing completed.
Pishin and Sibi	1 = 8	Compilation completed.
Punjab (edition of 1875), 8 sheets	1 = 8	Revised to date.
Bengal (edition of 1875), 16 sheets with index.	1 = 8	Ditto.
Southern Afghanistan, 2 sheets ...	1 = 8	Compilation completed.
Singhpo-Kampti country, or neutral ground between India and China, 2 sheets.	1 = 16	Prepared for Mr. C. H. Lepper. Compiled from various sources for reduction to ½ scale.
District Maps.		
Bannu	1 = 4	Compilation completed.
Dera Ishmail Khan	1 = 4	Ditto in progress.
Peshawur	1 = 4	Ditto completed.
Dera Ghazi Khan	1 = 4	Ditto ditto.
Raipur	1 = 4	Extracted from the sheets of the Atlas of India; revised and completed to date for publication.
Sibsagar	1 = 4	
Nowgong (Assam)	1 = 4	
Goalpara	1 = 4	
Sylhet	1 = 4	
Darrang	1 = 4	
Kamrup	1 = 4	Extracted from the sheets of the Atlas of India, and in course of completion.
Balaghat	1 = 4	Completed for publication of second issue of map.
Special Maps.		
District Shahjehanpore ...	1 = 8	Drawn for the Gazetteer, North-Western Provinces.
Ditto Dehra-Dun	1 = 8	
Ditto Terai	1 = 8	
Ditto Moradabad	1 = 8	
India	1 =128	Completed for Geological Survey.
Do.	1 =128	Ditto Meteorological Report.
Do.	1 = 64	Showing hot springs; names inserted.
North-Western Provinces ...	1 = 32	Tahseel boundaries and other additions inserted for Census Department.
Bengal and Assam	1 = 64	Division and district boundaries corrected and brought up to date for Census Commissioner.
Khasia and Garrow Hills Survey, Extract from Sheet No. 84.	1 = 2	Hill shading completed for Geological Survey.
Chart of the coast of India ...	.....	Coast line enlarged to double scale, and names inserted for Postal Department.
Punjab (to illustrate Administration Report for 1881-82.)	1 = 32	Revised and brought up to date for Punjab Government.
Lower Egypt. (Based on E. A. Goujon's map.)	1 = 3 1565	Blue prints outlined, and corrections made from information supplied by the Quarter-Master-General's Department for reduction to ¼ scale.
Suez Canal. (From Charts of the Suez Canal Company, 1876.)	.....	Blue prints outlined, and names, &c., typed for reduction to ⅔ scale.

GEOGRAPHICAL COMPILING AND DRAWING BRANCH, SURVEYOR-GENERAL'S OFFICE, CALCUTTA.

Sheets of the Atlas of India, 1 inch = 4 miles.

13 N.E.	Part of Junagarh	Hills drawn and footnotes completed.
14 N.E. S.E.	Part of Hazara	Compilation on dry-print in progress.
18 N.E.	Part of Bhawalpur native states	Reduction from recent surveys.
19 S.E.	Part of Rajputana	Ditto.
20 N.E. S.E.	Ditto	Ditto and hill shading by brush.
28	Hazara	Compilation on dry-print in progress.
29	Rawalpindi, &c.	Additions and large lettering completed.
30	Parts of Gujranwala and Amritsur.	Insertion of railway-station names and minor details.
31 N.W. S.E.	Part of Bickaneer	Reductions from recent surveys and additions.
32 N.W. N.E.	Ditto	
35 S.E.	Part of Indore	Hills drawn in brush for engraving.
36 N.W.	Ditto	Reductions from recent surveys.
S.W.	Rajpipla State	Correction of boundaries and names.
37 N.W.	Ditto and Khandesh ...	Ditto in progress.
N.E. S.E.	Parts of Khandesh	Insertion of boundary (Holkar concession boundary).
38 N.W. S.W.	Parts of Nasik, Ahmednugur and Poonah.	Compilation on dry-print in progress.
N.E.	Part of Hyderabad territory ...	Drawn in outline from existing materials.
39 40	Parts of Poonah, Ahmednuggur, and Puriandah, and part of Satara.	Reduction from Deccan survey.
48 N.E.	Part of British Garhwal ...	Details inserted from new survey of Dehra Dún.
S.E.	Part of Mozuffernugar, &c. ..	Reduction from surveys.
49 S.W.	Parts of Ulwar and Jaipur ...	Additions and details from recent surveys.
N.E. S.E.	Parts of Delhi	Reductions from recent surveys in progress.
50 N.E. S.E. N.W.	Parts of Mttra, Gurgaon, and Agra	Ditto ditto.
54	Part of Hyderabad	Insertion of Holkars boundary.
56	Parts of Barsi and Naldrug ...	Revision of old work according to recent surveys from Deccan Topographical survey.
67 N.E. N.W. S.W.	Parts of Bareilly, Rampur, Budaon, and Moradabad.	Heights inserted.
71 S.E.	Parts of Mandla and Seoni ...	Hills drawn in brush for engraving.
76 N.E.	Nellore Guntur	Original drawing received from Superintendent, Madras
78 N.E.	Arcot	Revenue Survey, examined.
103	Part of Behar	Corrections of the old courses of the Ganges, Gogra, and Gandak rivers.
106	Part of Vizianagram	Hill shading in brush for engraving.
112	Parts of Munghir and Patna ...	Resurveys of the Ganges and Gogra rivers, inserted in outline.
114 115	Parts of Chota Nagpore and Bengal	Inserting canals.
116	Part of Orissa	Insertion of additional details and revision.
118	Part of Darjeeling	Hill shading.
138 S.W.	Part of Eastern Frontier of Assam.	Additions in sketch work about the Nougyong Lake, Patkai range.

Standard sheets of the Topographical Branch Survey of India, drawn for reproduction.

Maps.	Scale.	Remarks and Progress.
Chota Nagpore Survey.	In. Mls.	Revising boundaries, railways, and otherwise bringing the sheets up to date for reproduction for second issue.
Sheets 39, 40, 45, 46, 47, 57, and 59	1 = 1	
Khandesh and Bombay Survey.		
Sheets 4, 14, 15, 16, and 17 ...	1 = 1	
Rewah Survey.		
Sheets 22, 23, and 24	1 = 1	
Rajputna Survey.		
Sheet 23	1 = 1	

GEOGRAPHICAL COMPILING AND DRAWING BRANCH, SURVEYOR-GENERAL'S OFFICE, CALCUTTA.

Miscellaneous Maps, Tracings, &c.

Maps.	Scale.	Remarks and Progress.
	In. Mls.	
Sadiya Cantonment ..	12 = 1	Drawn on vellum cloth for reproduction.
Plan of Calcutta	6 = 1	New buildings and names inserted.
Plan of the Sanitarium of Simla ..	3 = 1	Hill shading in vertical completed.
Plane-table sections of the Khandesh and Bombay survey ...	1 = 1	Revised boundaries inserted.
Chart of the Triangulation of the Mysore Topographical survey ...	1 = 4	Points plotted, names of stations inserted, revised and corrected, work previously plotted.
Postal map of Central India ...	1 = 32	Drawn on vellum cloth for Post-Master-General, Central India.
Map showing area occupied by Bihari dialect, Lower Provinces	.....	Insertion of boundary and names for Magistrate of Patna.

Miscellaneous Maps, &c., concluded.

	In. Mls.	
Sketch map of the country from Sherdurra to Mulka traversed by Eusofzai field force ...	1 = 2	Trace on vellum cloth prepared.
Designs of almirahs for type ...	3 copies.	Tracings prepared on vellum cloth for the use of Executive (survey) officers.
City and environs of Kandahar ...	About 6 = 1	Corrections made in original as given in proofs (by Colonel Leach).
Sketch map of the Hazarajat ...	1 = 16	Prepared according to Colonel Leach's directions.

847 sheets of various engraved, lithographed, and photozincographed proofs, examined, corrected, or added to for publication in a complete form for office use and for issue.

W. H. PATTERSON,
Surveyor, 1st grade, Survey of India, and Chief Draftsman.

JOHN O. N. JAMES,
Assistant Surveyor-General,
In charge Drawing and Geographical Compiling Branch.

WORK DONE BY THE EXAMINING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Subjects examined	Original standard sheets, large scale plans, and triangulation charts of Topographical Surveys	58
	Original compilations of parts of atlas sheets and other maps compiled in Surveyor-General's office	25
	Engraved proofs in outline and names, &c., in various stages, as well as of general and provincial maps	138
	Photographed and lithographed proofs on various scales, including maps, plans, atlas sheets, &c., together with additional work of corrections in territorial changes and public constructions, such as boundaries, canals, roads, &c.	469
Hill shading in brush and pen	Atlas sheets in brush, and maps in pen work	4
Work compiled	Portions of atlas sheets and provincial maps, &c.	2
Projection of graticule ...	Projection of atlas sheets, and district and provincial maps ...	13
Miscellaneous	Tracings of sketches, charts, and supply of geographical data to various officials, computation of graticule for the plates of the Indian Atlas and projection of the same on copper, calculation of areas, &c.	

A. CHAMARETT,
Surveyor, Examining Branch.

JOHN O. N. JAMES,
Assistant Surveyor-General,
In charge Drawing and Geographical Compiling Branch.

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

General Maps, &c.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. in.	Letters out.	Sq. in.	
Map of India, scale 1 inch = 32 miles—				
Sheet 3	.....	10,705	.....	Heavy additions to outline, railways and lettering for 2nd edition.
„ 4	... ..	5,350	.....	Revised and added to for 2nd edition; finished.
„ 5	.....	5,270	77 H.	Plate in hand; hills in progress.
„ 6	... ...	2,929	.....	Revised and added to for 2nd edition; finished.
Map of India in four sheets, scale 1 inch = 64 miles ...	.....	13,458	196 H.	Additions and corrections done; hills in progress.
Map of India in two sheets, scale 1 inch = 80 miles ...	.....	45	.....	Slight additions; plate put down.
Map of India, scale 1 inch = 96 miles	.....	40	.....	Ditto ditto.
Map of Bengal in two sheets, scale 1 inch = 16 miles ...	50	9,284	... ...	Outline taken out, corrected and engraved; plate put down.
Map of Central Provinces in two sheets, scale 1 inch = 16 miles	.....	.....	217 H.	Slight corrections to outline and writing; hills in progress.
Map of Rajputana in two sheets, scale 1 inch = 16 miles	47	1,782	66½ H. 25 S. H.	Additional outline engraved; writing in progress
Map of Central India Agency in two sheets, scale 1 inch = 16 miles	.....	.....	109 H.	Hills in progress.
Map of Assam, scale 1 inch = 16 miles	39	3,460	.....	Large portion of old work taken out; new outline engraved.
Chart of the Indian Ocean ...	.....	266	.....	Additional writing.
Map of Himalayan Routes ...	140	40	.....	New outline; plate in progress.
Map of Berar	320	288	.....	Plate projected, border cut and outline done; plate in progress.
Map of India, No. 2	.....	.....	.....	Corrections and additions done.
Index Chart to G. T. Survey	.....	340	.....	Additions and corrections done.
Strange's Zenith Sector. Frontispiece	.....	41	.....	Highly finished.
Strange's Zenith Sector, five other plates	.....	1,827	.....	Plates 3 and 5 finished; others, outline nearly finished.
Transit Telescope ...	.....	292	.....	Plate nearly finished.
Idiometer (Machine) by Colonel Campbell	.....	192	.....	Additional writing.
Chronograph	.....	441	.....	Plate nearly finished.
Commutator Board, plate 3 ...	.....	.....	.....	Outline finished.
Graticule plate (brass) ...	.....	.....	.....	Outline and writing done.
Major Waterhouse's reproduction in heliogravure 27A S.E.	.....	450	.....	Title and imprint finished.
Ile de Capraia	.....	199	.....	Plate finished.
Geological specimens, 2 plates	.....	804	.....	Finished.
Tint No. 1, 21¾″ × 13′ ...	.....	.....	.....	Ruled and finished.
Tint 22″ × 18″ ...	.....	.....	.....	Ruled in $\frac{1}{10}$″ divisions; finished.
Three imprint plates ...	.....	192	.....	Dates taken out and re-engraved for 1882.
Total ...	596	57,695	665½ H. 25 S. H.	

Indian Atlas Sheets (new) completed and published.

	Sq. in.	Letters cut.	Sq. in.	
Atlas sheets—				
31 N.W.	.....	340	7 S. H.	Completed up to margin.
32 S.W.	.....	252	172 S. H.	
53 N.W.	.....	2,215	55 H.	
66 N.W.	.....	105	131 H.	
67 S.E.	.....	4,974	.....	
77 N.E.	.....	284	21 H.	
129 S.E.	.....	517	3 H.	
130 S.E.	.....	305	17 H.	Ditto up to limits of survey.
138 N.W.	.....	1,594	98 H.	Ditto up to margin.
Total 9 plates ...		10,586	325 H. 179 S. H.	

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Indian Atlas Sheets (new) in progress.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. in.	Letters cut.	Sq. in.	
Atlas sheets—				
8 N.E.	168	17,132	.....	New border cut; plate projected; outline done; writing nearly done as far as drawing.
13 N.E.	29	2,048	.....	Outline and writing completed up to border.
18 N.E.	24	624	.....	Heavy additions of new survey, outline done; writing in progress.
18 S.E.	.....	297	36 S. H.	Completed as far as drawing.
19 N.E.	.....	.....	40 S. H.	Completed as far as survey; plate put down.
19 S.E.	40	578	.....	Reprojected; new border cut; outline and writing in progress.
20 N.E.	40	1,143	.....	Reprojected; new border cut; outline and writing in progress.
20 S.E.	40	3,386	.....	Reprojected; new border cut; writing nearly finished; in progress.
22 N.W.	.....	47	.....	Slight additions; plate again put down.
22 N.E.	72	825	.....	Writing in progress.
22 S.E.	96	.....	.....	Plate put down for fresh drawing.
23 N.E.	40	1,392	.....	Additional outline; lakes shaded and sand banks done; writing in progress.
23 S.E.	30	56	.....	Reprojected; new border cut; outline in progress.
31 S.W.	191	4,756	62 S. H.	Outline and writing finished; sand hills in progress.
31 S.E.	.....	1,603	.....	Writing almost done; in progress.
32 N.W.	225	3,777	.....	Projected; new border cut; outline finished up to margin; writing in progress.
35 N.W.	.....	.....	84 H.	Slight correction to outline and writing, done.
35 S.W.	.....	.....	.....	Slight correction to outline, done.
36 N.W.	.....	647	.....	Reprojected; new border cut.
36 N.E.	46	4,040	37 H.	Completed as far as drawing; plate put down.
37 S.W.	55	400	.....	Writing in progress.
37 S.E	104	3,939	.....	Plate in hand.
38 N.E.	.....	919	.....	New border cut; writing in progress.
38 S.E.	.....	3,511	.....	New border, scale cut; and writing finished as far as drawing
40 N.E.	48	336	.....	New border, scale and outside figures cut; outline in progress.
48 N.E.	79	1,629	.....	New border cut and outline repaired; writing in progress.
48 S.E.	81	14,330	.....	New outline cut; writing in progress.
49 N.E.	114	.....	.....	Outline very intricate; in progress.
57 N.W.	.....	.....	.....	New border cut; outline just commenced.
66 S.W.	.....	.....	145 H.	Hills almost finished; in progress.
67 N.W.	2	11,737	4½ H. 1. S. H.	Finished as far as drawing; plate put down.
67 N.E.	12	13,552	.....	Outline and writing, done as far as drawing; hills just commenced.
67 S.W.	68	7,326	.....	Outline and writing, done as far as survey; plate put down.
69 N.E.	97	4,171	.....	New scale cut; writing in progress.
69 S.E.	185	12,708	.....	Outline and writing, done as far as drawing; plate in hand for corrections.
71 S.E.	.....	.....	21 H.	Hills in progress; nearly finished.
76 N.E.	231	502	.....	New border and scale, cut; outline done; writing in progress.
76 S.W.	231	.....	.....	New border cut; outline done; writing just commenced.
76 S.E.	178	7,202	.....	New border cut; outline completed; writing in progress.
77 S.E.	172	1,250	.....	Outline completed; writing just commenced.
78 N.E.	198	950	.....	New border cut; under examination for outline.
138 S.W.	.....	1,014	35 H.	Outside, district names, and note, cut; hills in progress.
Total ...	2,896	127,816	326½ H. 1393 S.H.	

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Additions and Corrections to Indian Atlas Sheets.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
Atlas sheets—	Sq. in.	Letters cut.	Sq. in.	
1 N.E.	.....	54	.....	Slight additions, finished.
1 S.E.	.....	94	.....	Ditto ditto.
2 N.E.	10	.....	.....	Alterations to outline done.
3 N.E.	.....	.....	.....	Slight corrections to outline and writing.
8 S.E.	9	349	100 S. H.	Heavy additions; plate completed up to margin.
12 N.E.	.....	20	2 H.	Slight additions completed.
32 N.E.	.....	381	.....	Corrections to outline and writing completed.
35 S.E.	57	4,592	.....	New outline and heavy additions in progress.
36 S.E.	.....	.....	.....	Slight corrections to writing done.
37 N.E.	.....	194	.....	Additional roads; district names and boundaries altered; completed.
45 N.W.	.....	351	.....	Slight additions completed.
45 N.E.	.....	277	.....	Ditto ditto.
45 S.W.	.....	377	.....	Ditto ditto.
52 S.W.	.....	200	1 H.	Slight correction to boundary and hills completed.
53 N.E.	.....	76	.....	Slight additions to writing done.
53 S.W.	.....	166	.....	Ditto ditto.
63A. N.W.	.....	27	.....	Ditto ditto.
64 N.W.	.....	550	.....	Additions to outline and writing done.
64 S.W.	.....	162	.....	Slight additions to outline and writing done.
66 S.E.	.....	.....	1 H.	Slight corrections done.
69 N.W.	.....	1,162	.....	Additions to writing done.
86 S.W.	.....	.....	.....	Slight corrections, done.
86 S.E.	.....	90	.....	Ditto ditto.
87 S.W.	.....	419	.....	Corrections to outline and writing done.
124 S.W.	.....	206	.....	Additional writing and slight corrections to outline and hills done.
124 S.E.	.....	436	.....	Additional writing done.
125 N.W.	.....	84	.....	Ditto ditto.
125 N.E.	.....	244	.....	Ditto ditto.
126 N.E.	.....	.....	18 H.	New hill work done; adjoining hills touched up.
126 S.E.	.....	371	2 H.	Additional writing; boundaries and hills corrected.
127 N.E.	.....	323	3 H.	Additional writing; outline and hills corrected.
127 S.E.	.....	395	4 H.	Additional writing; outline and hills corrected.
128 N.E.	.....	231	.....	Additional writing; boundaries corrected.
129 N.W.	.....	.....	24 H.	Additional hills completed.
129 N.E.	66	1,015	.....	Additional outline and writing done.
130 N.E.	.....	.....	6 H.	Hills re-etched, slight.
130 S.W.	.....	72	.....	Slight additions done.
131 N.W.	.....	88	.....	Slight additions to writing and boundaries, done.
2 S.E., 8 S.W., 9 N.W., 18 N.W., 22 S.W., 23 N.W., 33 S.E., 72 N.E., 72 S.W., 72 S.E., 91 S.W., 34 N.W., 34 N.E., 34 S.W., 34 S.E., and 35 N.E.	12	4,639	.....	Corrections and additions to railways and names done.
Total ...	154	17,645	61 H. 100 S.H.	

Repairs and Additions to Old Plates of the Indian Atlas.

14	.....	326	.....	Additional names done; plate put down.
15	.....	215	.....	Additional names done; plate put down.
16	.....	.....	.....	Outside figures corrected.
17	.....	50	.....	Railway and names cut.
28	.....	260	.....	Additional names and boundaries done.

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Repairs and Additions to Old Plates of the Indian Atlas—concluded.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
Atlas sheets—	Sq. in.	Letters cut.	Sq. in.	
29	.....	239	.....	Corrections and additions to railways done.
30	.....	.....	.....	Slight corrections done.
38	39	60	.....	Additional outline and writing done.
39	.....	300	.....	Additional outline and writing done.
46	.....	394	50 H.	Additional outline and writing done; hills, part repaired; plate put down for more urgent work.
54	48	2,755	.....	Heavy additions; writing in progress.
55	43	1,580	.....	Heavy additions; outline cut; border repaired; writing in progress.
65	.....	21	32 H.	Additional hills etched and portion of old hill work repaired; finished.
68	16	64	.....	Additional outline and writing done.
102	.....	126	.....	Embankments and canals cut; completed.
108	.....	.....	15 H.	Heavy additions; hills just commenced; in progress.
111	.....	.....	.....	Slight additions; border repaired.
112	.....	89	.....	Embankments and boundaries cut; completed.
115	.....	62	.....	Slight corrections to outline and writing done.
116	.....	.....	.....	Slight additions done.
118	.....	52	49 H.	New hill work done; small portion of old hills repaired; completed.
119	.....	276	.....	Slight additions to outline and writing done.
121	.....	216	.....	Slight additions to writing, done.
Total ...	146	7,185	146 H.	

New Plates projected and Borders cut.

12 S.W.	.....	.....	Reprojected; new border cut.
13 N.W.	.....	830	Ditto ditto ditto.
13 S.W. and S.E. ...	.....	.....	Ditto ditto ditto.
14 Four qaurters ...	.....	208	Projected; new borders and scales cut.
37 N.W.	.....	.....	Projected; new border cut.
39 N.W.	.....	340	Ditto ditto ditto; scale and outside figures cut.
39 N.E.	.....	.....	New border cut.
40 N.W., S.W. and S.E.	.....	.....	Ditto ditto.
50 Four quarters ...	.....	208	Projected and new borders cut.
59 Ditto	.....	430	New borders and scales cut.
62 Ditto	.....	.....	Ditto ditto ditto.
76 N.W.	.....	.....	New scale cut.
80 Four quarters ...	.....	208	Projected; new borders and scales cut.
94 N.W.	.....	52	Projected.
94 N.E. and S.W. ...	.....	104	Projected and new borders cut.
94 S.E.	.....	52	Outside figures cut.
135 N.W. and N.E. ...	.....	.....	Reprojected.
144 Four quarters ...	.....	1,816	New borders, scales, and outside figures cut.
145 Ditto	.....	.....	New borders and scales cut.
153 N.E.	.....	371	Outside figures cut.
153 S.W.	.....	.....	New scale cut.
Total ...	.....	4,649	.....

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Abstract of Work Completed and in Progress.

Engraving.

	Plates.
Atlas sheets completed	9
Ditto in progress in various stages	42
General maps, plans, &c.	46
Repairs, corrections, and additions.	77
Projections and engraved borders cut, &c.	47
Total ...	221

Copperplate-printing.

Impressions taken	7,573
Proofs pulled	1,053
Transfers pulled	341
Total ...	8,967

Steel-facing.

	Plates.
Double elephant plates, steel-faced	14
Ditto ditto re-steeled...	12
Quarter plates steel-faced ...	25
Ditto re-steeled ...	35
Miscellaneous plates steel-faced ...	11
Ditto re-steeled ...	2
Total ...	99

Square inches of hill-etching ...	2,069
Ditto of jungle etched ...	362
Ditto of outlines ...	3,792
Number of letters engraved ...	225,576

C. W. COARD,

Superintendent, Engraving Branch.

JOHN O. N. JAMES,

Assistant Surveyor-General, in charge Engraving Branch.

Table A.

Tabulated Statement of the principal records prepared in the several Executive Offices of the Revenue Branch for the year ending 30th September 1882.

Province and District.	Survey party.	Mapping.						Traverses.		Field Books.		Area Books.		For Settlement Department.		
		Original field sections.	Cadastral 16-inch sheets.	Sheets 4 inch = 1 mile.	Quarter sheets 2 inch = 1 mile 15′ × 7½′.	Index maps.	Triangulation charts.	Main circuit with azimuth computation.	Village or sub-circuit.	Main circuit.	Village or sub-circuit.	Villages.	Fields.	Sheets or traces.	Village areas or khasras.	
						Cadastral Surveys.										
N.-W. Provinces.																
Ghazipur	No. 4	486	486	.....	.....	.....	.....	.....	1	.....	5	664	309,611	.....	.....	
Ballia	Ditto	815	815	.....	6	1	.....	1	3	1	11	1,177	678,546	.....	.....	
		22 on 32″	22 on 32″						1 of Benares	1 of Benares	1 of Benares					
Mirzapur	No. 5	955	955	.....	26	.....	2	9	11	10	30	.....	.....	.....	525 villages.	
Tarai	Ditto	22	22	.....	.....	.....	.....	.....	3	.....	3	.....	.....	.....	19 do.	
British Burma.																
Hanthawaddy	No. 2	860	860	.....	14	2	.....	3	12	4	22	418	509,763	.....	.....	
Tharrawaddy	No. 7	16 of forest	860	6 of forest	13	1	.....	3	3	3	5	.....	.....	670 traces 1 on 4″ (forest).	230 villages.	
Bassein	No. 8	.....	1,031	.....	22	.....	.....	.....	.....	.....	.....	519	349,790	.....	.....	
		Village and Topographical Surveys.														
Punjab.																
Rawalpindi	No. 1	35 of Murree Sanitarium on 40″. 53 of Kala Chitta on 4″.	.....	14 of Kala Chitta.	.....	1 of Murree Sanitarium.	2 of Kala Chitta. 3	.....	1 Murree Sanitarium. 2	.....	1 Murree Triangulation. 1 Murree Sanitarium. 2	.....	55	.....	.....	1 alphabetical index supplied to Settlement Officer.
Dera Ismail Khan ...	Ditto	.....*	.....	49	.....	1	.....	2	2	2	2	31 areas of all Dehra Ismail Khan and Bannu.		.....	.....	* The field sheets have been submitted as final sheets recorded in fourth column.
Muzaffargarh	Ditto	.....*	.....	69	.....	1	.....	1	1	1	1	20	42	.....	.....	
N.-W. Provinces.																
Meerut, Bulandshahr, Jumna, and Ganges River Survey.	No. 3	23 Meerut 60 Bulandshahr.	.....	13 of Jumna river. 14 of Ganges river.	21 fine 21 exaggerated.	3 reduction for Atlas of India.	.....	1 of Aligarh	1 of Bulandshahr. 2 of Aligarh 1 Jumna river. 1 Ganges river.	1 of Aligarh	1 of Bulandshahr. 3 of Aligarh 2 Jumna river. 1 Ganges river.	.....	.....	.....	.....	5 traces of Patri forest for Superintendent, Forest Surveys. 1 trace of Ganges river for Collector. 1 trace of Jumna river for Commissioner of Umballa.
Bombay.																
Thana	No. 10	48	.....	24	8	2	.....	1	.....	1	2	.....	.....	.....	.....	
Sholapur, Satara, Kolhapur, Nizam's dominions.	No. 11	37 on 2″ scale	.....	.....	25	3 of traverse	3	.....	3	.....	3	.....	.....	.....	.....	
Bengal.																
Hooghly River Survey...	No. 6	78 on 16″ 5 on 6″	57 on 16″	.....	.....	2	.....	1	.....	1	3	.....	.....	.....	.....	The Marine Department have been supplied with plots on 16″ scale from Kashipore to Garden Reach, thence on 6″ scale to Diamond Harbour.
Shahabad	No. 4	6 on 4″	.....	9	.....	2	.....	1	1	.....	2	.....	.....	.....	.....	

Deputy Surveyor-General's Office,
Calcutta, the 1st October 1882.

J. E. SANDEMAN, *Major*,
Deputy Superintendent at Headquarters.

Table B.

Statement of work performed in the Drawing and Compiling Branch of the Deputy Surveyor-General's Office during the year ending 30th September 1882.

Title of Maps.	Scale.	Remarks.
Punjab.	Inch. Mile.	
Districts Bannu, Dera Ismail Khan, and Thal of Muzaffargarh, in 44 standard sheets, 30′ × 15′.	1 = 1	Geographical lines have been inserted on 132 of the 4-inch maps, comprising standard sheets 18, 19, 22, 23, 26, 27, 30, 31, and sent to press for photo. reduction to half scale. The 2-inch blue prints of sheets 19, 23, 30, and 31 have been typed and drawn; the drawing of sheets 36 and 39 has also been completed; and sheets 18, 22, 26, and 27 are well advanced, leaving 9 sheets to be taken up to complete these districts. Number of sheets published up to date, 25.
District Rawalpindi, Kala Chitta Pahar, in 27 sheets, 7′ 30″ × 3′ 45″.	4 = 1	The original maps drawn in the Executive's office and received up to date, viz. 13 out of 27, have been examined and completed for press. Number of sheets published up to date, 13.
Punjab and Kashmir boundary, on district Sialkot along the Chenab river and Tawi Nadi.	4 = 1	Original maps prepared by the Executive were examined, completed, and sent to press for publication for the use of the Punjab Government.
North-Western Provinces.		
Districts Moradabad, Budaon, Tarai (part of), and Rampur state, in 22 standard sheets, 30′ × 15′.	.....	The typing and drawing of the remaining 6 two-inch blue prints completed. During the year 20 sheets have been examined and sent to press for reduction and publication on 1-inch scale. Only sheets 63 and 64 now remain to be sent to press. Only one sheet has yet been published.
District Banda, in 16 standard sheets, 30′ × 15′.	1 = 1	Geographical lines inserted on 82 of the original 4-inch maps, comprising standard sheets 112, 112A, 127, 128, 142, 143, 155, 156, for reduction to half scale. Blue prints awaited. The blue prints of the 8 standard sheets mentioned in last year's return have all been typed, drawn, and examined for press.
Meerut Division, districts Shaharunpur, Muzaffarnagar, and Meerut. Fine set showing village boundaries for reproduction to scale in ¼ sheets, 15′ × 7½′.	2 = 1	The originals of 16 sheets drawn in the Executive's office have been received, viz Nos. 1, 2, 3, 4, 13, 14, 15, 16, 17, 18, 27, 27A, 28, 29, 30, and 31; they have been minutely examined in the head office, corrected, rendered suitable for photography, and sent to press for publication. Number of sheets published up to date, 8.

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
North-Western Provinces—concld.	Inch. Mile.	
Coarse set, without village boundaries, for reduction to half scale, 30′ × 15′.	1 = 1	The 19 sheets received to date, viz. Nos. 1 to 7, 13 to 18, 27A, 27 to 31 (19 in all), have been examined, corrected, and sent to press for publication. Number of sheets published up to date, 19.
Reduction for Atlas of India, sheets 48 SE and 49 NE, containing parts of districts Muzaffarnagar and Meerut.	$\frac{1}{4}$ = 1	Prepared in Executive's office. Re-examined in head office with 1-inch sheets, corrected, and sent to Surveyor-General's office for engraving.
Oudh (new edition), in 65 sheets standard size, 30′ × 15′.	1 = 1	The original maps, with graticule lines inserted, comprising 18 standard sheets, Nos. 105, 106, 121, 122, 123, 135, 136, 137, 150, 151, 163, 164, 165, 166, 167, 176, 177, and 178, have been sent to press for lithography. Since last report sheets Nos. 139 and 140 have been published. Number of sheets printed to date, 6.
Bengal.		
District Midnapore, in 18 sheets 30′ × 15′.	1 = 1	The proof sheet No. 17 has been passed through press, and the publication of the entire district is completed.
Do. do. . .	$\frac{1}{4}$ = 1	The map of the district begun last year has been completed and submitted to the Surveyor-General's office for engraving.
District Noakholly, in 12 sheets, 30′ × 15′.	1 = 1	All the sheets were published during the year, excepting sheet No. 12, which is now under correction at press.
District Jalpaiguri, in 13 sheets, 30′ × 15′.	1 = 1	Lithographic proofs returned by the Deputy Commissioner have been completed to show thana boundaries, which, however, still await the final sanction of Government. Press order is deferred pending above sanction.
District Mymensing, in 23 sheets, 30′ × 15′.	1 = 1	Geographical lines have been inserted on the main circuit maps, comprising sheets Nos. 240 and 254, and skeleton standards of these sheets, showing the limits of main circuits, &c., have been projected for the guidance of lithographic branch in preparing the transfer drawings to be put down on stone.
District Pooree, Killa Khorda, in 40 imperial sheets.	4 = 1	Examined, touched up, and adapted for photography, hills added, and sent to press.
District Patna, Patna City . .	10 = 1	The original maps have been examined and revised for a second edition, showing additions and alterations supplied by the Superintendent of Works. Sent to press for publication.
Bankipore Civil Station . .	10 = 1	.....

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
Assam.	Inch. Mile.	
District Darrang, sheets 3, 5, 8, 9.	1 = 1	Sheets examined for a second edition and sent to press.
Burma.		
District Hanthawaddy, sheets 115, 116, 124, 125, in 11 sections, 15′ longitude × 7½′ latitude, containing the Syrian township.	2 = 1	The original sheets drawn in the Executive's office were carefully re-examined in the head office and sent to press for publication on full scale for the use of the local Government.
Bombay.		
Deccan Topographical Survey, including the Konkan, in 123 sheets, 30′ × 15′, to latitude 16°.	1 = 1	Since last report the 2-inch standard sheets 61, 62, 68, 75, 76, 77, 84, 85, 86, have been examined, corrected, completed for publication, and sent to press, making 72 sheets sent to press to date, including survey up to 1880-81.
Ditto ditto ditto. Quarter sheets, each 15′ × 7½′. Six sheets complete, and portions of seven sheets published on full scale of survey to meet special demands, as noted.	2 = 1	Sheets 75, 76, 77, 84, 85, 86, have been sent to press for reproduction to full scale for Forest Department; also sheets 30 SE, 31 SE & SW, and 35 NE for Executive Engineer, Poona Division; sheets 14 NW, 18 complete, 22 NW & SW, and 26 NW for Collector of Thana. Sheets 30, 31, 35, 14, 18, 22, and 26, had previously been published, in the usual course, on the 1-inch scale.
Index Maps.		
Districts Dera Ismail Khan, Bannu, Rawalpindi, the Meerut Division, districts Ghazipur, Ballia, Benares, Mirzapur, Hanthawaddy, Bassein, Tharrawaddy, the Deccan, and Konkan	On various scales.	The index maps of the Meerut Division and the Deccan have been re-drawn; the others have been revised and brought up to date for the annual report of 1881-82.
Miscellaneous Traces, &c.		
Boundary between districts Jhang and Dera Ismail Khan.	4 = 1	Traced for Deputy Superintendent of Survey.
Boundary between district Shahpur and districts Bannu and Dera Ismail Khan.	4 & 2 = 1	Do. do. do.
Boundary between Nepal and districts Bhagulpore, Durbhanga, and Mozufferpore.	4 = 1	Do. do. do.
Boundary between Nepal and district Chumparun.	2 = 1	Do. do. do.
53 village plans of districts Shahabad and Ghazipur.	4 = 1	Do. do. do.
Hooghly river and one mile of adjoining country on both banks from Phulouria Semaphore to Sola Mohan Creek.	4 = 1	Do. do. do.
Inserted village boundaries on Hooghly river sheets from Kanchrapara to Calcutta.	4 = 1	Do. do. do.
A line of villages along left bank of Hooghly river from Atcheepore to Brool Semaphore.	4 = 1	Do. do. do.
Plan of jungle block comprising 29 villages of district 24-Pergunnahs.	4 = 1	Do. do. do.

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
Miscellaneous Traces, &c. - continued.	Inch. Mile.	
Plans of two French settlements in district Balasore.	8 = 1	Prepared for Collector.
Completed boundaries of waste land blocks on the Deputy Commissioner's copies of atlas sheets.	4 = 1	For Deputy Commissioner.
Sheets containing Jalpaiguri Station and Environs.	4 = 1	Traced for Mr. Bond, Assistant, Great Trigonometrical Survey.
Boundary common to Sind and Khelat.	4 = 1	Traced for Agent, Governor-General, Khelat.
13 old mehalwar maps of district Sylhet, in duplicate.	16 = 1	Traced to illustrate report on Sylhet Test Survey.
Several Deccan triangulation charts.	½ = 1	Traced for Deputy Superintendent.
Ditto ditto ditto .	1 = 4	Do. do. do.
Inserted course of Megna river as surveyed by Deputy Collectors under orders of the Board of Revenue, Lower Provinces, on the survey atlas sheets in this office.	4 = 1	For office record.
Prepared a plot of portion of Sarun river.	32 = 1	For Settlement Officer, Khorda.
Extract from plan of mouzah Jujhursing.	32 = 1	Do. do. do.
Boundary of 3 villages of district Azamgarh, touching on Ghazipur.	16 = 1	Traced for Deputy Superintendent.
Sheets comprising the Eta Hills, district Sylhet.	4 = 1	Do. do. do.
Several board plans of Hooghly river survey by Colonel Leach.	16 = 1	Traced for comparison with previous surveys.
Prepared a plot of Rathamati river.	8 = 1	For Settlement Officer, Khorda.
Ditto 2 villages, district Jaunpur.	16 = 1	For Settlement Commissioner, Punjab.
40 village plans and grants . .	4 = 1	Copied for Deputy Commissioner and others.
1 sheet Punchunnogram . .	150ft. = 1in	Traced for Deputy Collector.
Typed title pages (24 sheets) . .	.....	For volumes of Burma published cadastral plans.
Inserted 1″ sheet numbers and limits on several copies of Burma map.	.....	For office record and use of executives.
	Inch. Mile.	
Inserted boundary as surveyed by Messrs. Shaw and Smart between Goalpara and Garo Hills on 2 copies.	½ = 1	For Deputy Commissioner and office use.
Completed maps of districts Agra and Muttra to show numbers and limits of 4″ sheets.	¼ = 1	For Executive Engineer.
Completed set of sheets of district Lakhimpur to show the boundary adjoining Seebsagore, as shown in the 4″ sheets of the latter district.	1 = 1	For Deputy Commissioner.
Completed all the printed copies in stock of sheet No. 11, Deccan series, to show the portion of district Thana surveyed in 1879-80.	1 = 1	For office use and issue.
Completed all the printed copies in stock of sheet No. 10, Deccan series, to show boundaries that were not available at time of publication.	1 & 2 = 1	Do. do. do.
Prepared new index to the 1″ sheets of Bengal.	1 = 16	For office use.
Prepared diagrams showing the average heights of 5 minute compartments in the several districts of the Punjab and N.-W. Provinces, as far as available in this office.	.....	For Surveyor-General's Office.

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
Miscellaneous Traces, &c.—concluded.	Inch. Mile.	
Coloured a set of sheets of district Chumparun to show latest thana and subdivision boundaries.	1 = 1	For Surveyor-General's Office.
Coloured a set of sheets of districts Hooghly and Howrah.	1 = 1	Do. do.
Map-colouring.	*No. of Maps.*	
Maps on various scales . . .	109	For Surveyor-General's Office.
Do. do. . . .	109	For Deputy Surveyor-General's office.
Do. do. . . .	610	For the India Office.
Do. do. . . .	1,044	For Government officials.
Total .	1,872	
Examination of Proof Sheets.		
Photozincograph maps . . .	282	
Lithograph maps	34	

Description of Work.	Remarks.
Traverse Data, &c., supplied.	
Of 50 villages of Moradabad along Ganges river.	For Deputy Superintendent.
Of Hooghly villages from Botanic Garden to Chandernagore (60 pages).	,, Assistant ditto.
Of Eta Hills, district Sylhet, with co-ordinates of village trijunctions.	,, Ditto ditto.
Of Cachar grants (17 pages)	,, Deputy Commissioner.
Of Jaunpur, along Benares, with co-ordinates of Pargana trijunctions.	,, Ditto Superintendent.
Of Captain Samuell's Nepal boundary, along Purneah and Bhagalpur.	,, Assistant ditto.
Of districts Tirhoot and Sarun, along Nepal...	,, Ditto ditto.
Of M. C. 11, 12, and 13 of Moradabad, along Ganges river.	,, Deputy ditto.
Of Agra and Muttra, along Aligarh ...	,, Ditto ditto.
Of Sirsa and Rohtak, along Hissar ...	,, Ditto ditto.
Triangulation values of three charts of Deccan Topographical Survey.	,, Ditto ditto.
Alphabetical indexes of district Hanthawaddy (four copies).	,, Settlement Officer.

Table B—*concluded.*

Description of Works.	Remarks.
Computations examined.	
District Jaunpur 1878-80	Final examination.
Ditto Banda 1877-78	
Districts Saharanpur and Muzaffarnagar 1878-79	
Miscellaneous Work.	
Calculation of areas of Hill Tipperah and Gurjat states, also Thana areas of districts Chittagong, Sonthal Pergunnahs, Singbhoom, Hazaribagh, Lohardugga, and Darjeeling.	For Bengal Government.
Preparation of area statement of district Noakhally by summation of villages.	„ publication with sheets.
Calculation of co-ordinates for the projection of districts Banda, Tarai, Dera Ismail Khan, Bannu, and Mymensing, and of Patna City.	„ office use.
Calculation of areas of districts Goalpara and Garo Hills according to revised boundaries.	„ Deputy Commissioner.
Entering of heights of 5′ compartments for the districts of the Punjab, North-Western Provinces, Oudh, Bengal, and Central Provinces.	„ Surveyor-General's Office.
Preparation of a statement showing scale and character of survey of the districts in Central Provinces.	„ Government Central Provinces.

Deputy Surveyor-General's Office,
Calcutta, 1st October 1882.

F. W. KELLY, *Surveyor.*
J. E. SANDEMAN, *Major, Dy. Supdt. at Headquarters.*

Table C.

State of Publication of Cadastral Maps on the 30th September 1882.

Districts.	Number of Sheets. Maps prepared. Up to 30th September 1881.	Added during past 12 months.	Total up to 30th September 1882.	Published. Up to 30th September 1881.	During 1882. By Surveyor-General's Office.	Total to 30th September 1882.	Remaining to be published.	Remarks.
N.-W. Provinces.								
Agra	2,024	.....	2,024	2,024	.....	2,024	.....	(a) Figures of previous return have been changed to agree with final results. (b) These figures are liable to alteration until publication has been completed.
Azamgarh	930	.....	930	930	.....	930	.....	
Banda	(a)3,317	.....	3,317	2,953	364	3,317	.....	
Bijnour	31	.....	31	31	.....	31	.....	
Ghazipur and Ballia ...	(a)2,695	1,323	(b)4,018	2,094	994	3,028	990	
Hamirpur	2,926	.....	2,926	2,926	.....	2,926	.....	
Jaunpur	(a)3,434	.....	3,434	2,889	545	3,434	.....	
Moradabad and Terai ...	4,023	.....	4,023	4,023	.....	4,023	.....	
Muttra	1,058	.....	1,058	1,058	.....	1,058	.....	
Mirzapur	(a)1,906	955	(b)2,861	1,129	622	1,751	1,110	
Terai	39	22	(b)61	.....	15	15	46	
Total ...	23,883	2,300	26,183	21,497	2,540	24,037	2,146	
British Burma.								
Bassein	1,125	1,031	(b)2,156	110	840	950	1,197	
Hanthawaddy	2,203	860	(b)3,063	843	1,281	2,124	939	
Tharrawaddy	481	660	(b)1,141	.....	309	309	832	
Total ...	3,809	2,551	6,360	952	2,430	3,382	2,968	
Bengal.								
Patna and Gya	3,054	.....	3,054	3,054	.....	3,054	.....	
Shahabad	4,924	.....	4,924	4,924	.....	4,924	.....	
Pooree (Khorda estate)...	3,311	673	(b)3,984	1,010	104	1,114	2,870	
Total ...	11,289	673	11,962	8,988	104	9,092	2,870	
Assam.								
Sylhet	.....	61	(b)61	.....	16	16	45	
Total ...	.....	61	61	.....	16	16	45	
Grand Total, N.-W. Provinces, Burma, Bengal, and Assam	38,981	5,585	44,566	31,447	5,090	36,537	8,029	

Detail of Examination in connection with Publication.

Provinces.	Number of Sheets. Examined and rendered suitable for photozincography.	Traced and examined for zincography.	Proof copies examined previous to press order.	Coloured and subsequently examined.	Remarks.
North-Western Provinces	1,881	710	2,503	2,540	Scale 16 inches to a mile.
British Burma	1,371	705	2,284	2,430	Ditto ditto.
Bengal	266	1	104	104	Scale 32 ditto.
Assam	16	.....	16	16	Scale 16 ditto.
Total ...	3,534	1,417	4,907	5,090	

Deputy Surveyor-General's Office,
Calcutta, 1st October 1882.

J. E. SANDEMAN, *Major*,
Deputy Superintendent at Headquarters.

CADASTRAL SURVEY.—DISTRICT MIRZAPUR.—SEASON 1881-82.

Specimen of Khusrah.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of the fields.	Name of thok or patti.*	Name of proprietor, with name of father, his caste and place of residence.	Name of cultivator, with name of father and caste, and how many years he has been cultivating.	Name of under-cultivator, with name of father and his caste.	Total area.		Barren waste.	Cultivable waste.		Cultivation.		Nature of crop.	Remarks.
					Acres.	Sirkari bighs.		Lately thrown out of cultivation.	Fit for cultivation.	Irrigated.	Non-irrigated.		
					B. B.	B. D.				D. D.	B. D.		
1	Patti Gobardhan.	Gunpat, son of Gonesh; caste Kurmi; place of residence, Daudpur; 4 annas.	Nur Ali, son of Pir Buksh: caste Sheikh; residing in the village; cultivating for 10 years.	.....	2 41	3 14	...	...	...	...	2 41	Til ...	Non-irrigated.
2	Patti Dindayal.	Rambuksh, son of Sita Ram; caste Thakur; residing in the village; 8 annas.	Data Ram, son of Gonesh Misser, caste Brahman; residing in the village; cultivating for 14 years.	Debi, son of Dina; caste Kewat; residing in the village.	1 89	2 18	...	...	...	...	1 89	Do.	
3	Patti Dayaram.	Jafer Ali, son of Baker Ali; caste Syud; place of residence Mohulla Targhat, Mirzapur: 4 annas.	Raghubar Singh; son of Rameshur Singh; caste Thakur; residing in the village; cultivating for 24 years.	.....	2 78	4 7	...	...	...	2 78	...	Wheat	There is a pucca well for irrigation.
4	Patti Gobardhan.	Gunpat, of patti No. 1 ...	Nur Ali, of patti No. 1 ...	Gauri, son of Jamna Dass; caste Bania; residing in the village.	2 63	4 1	...	...	...	2 63	...	Jow ...	Irrigated from well in No. 3.
5	Patti Dayaram.	Jafer Ali, of patti No. 3...	Ramkumar, son of Dayakumar; caste Brahman; residing in the village, cultivating for 10 years.	.....	5 40	8 0	...	...	...	...	5 40	Tisi ...	Five mango-trees belonging to Ramkumar, son of Dayakumar; caste Brahman; residing in the village.

* Note.—On the first division of the lands of a village between the several proprietors, the divisions are called patties. When any of the patties are again subdivided between proprietors, the original divisions or patties are called thoks and the subdivisions are called patties; so that the thok is the larger or more important division of a village, and patti is the minor, provided both exist in a village.

CADASTRAL SURVEY.—DISTRICT MIRZAPUR.—SEASON 1881-82.

Specimen of Jummabundi Slips.

1	2	3	4	5	6	7	8	9	10	11	12	13
Name of thok or patti and of zemindar.	Serial number of cultivators.	Name of cultivator, his father's name, his caste and place of residence, and how many years he has been cultivating.	Name of mortgagee, his father's name, his caste and place of residence.	Name of sub-cultivator, his father's name, his caste and place of residence.	Khusrah field numbers.	Area in sirkari bighas.	Area of bighas, sirkari, on which no rent is paid to zemindar.	Area on which rent is paid in money.		Area on which rent is paid in kind.		Remarks.
								Area of bighas, sirkari, on which rent is paid to the zemindar in money.	Amount of rent paid in money.	Area in bighas on which rent is paid in kind (standing crop).	Amount taken by zemindar in kind per maund of 40 seers.	
						B. D.		B. D.				
	1	Dabu Lal, son of Brij Lal; caste Bund; residing in the village.	Shewshankar, son of Harshankar; caste Gharwar; residing in the village.	Gujadhar Singh, son of Bisheshar Singh; caste Thakur; place of residence, Rampur.	27	4 10	.....	4 10	.....	.....	.....	
					32	0 11	.....	0 11	.....	.....	.....	
				Total ...	2	14 1	.....	14 1	.....	.....	.....	
	2	Sukhnandan, son of Bukhtawar; caste Kurmi; residing in the village. Proprietor; ditto; cultivating for 10 years.	Shewsambat, son of Ganpat Singh; caste Bahman; residing in the village.	Raghubar Singh, son of Ruchmanar Singh; caste Bahman; place of residence, Obhapri.	5	10 12	3 0	7 13	.....	.....	.....	
					12	7 19	.....	7 19	.....	.....	.....	
					15	11 18	.....	11 18	.....	.....	.....	
				Total ...	3	30 0	3 0	27 0	.....	.....	.....	

Extract from Report of J. O. N. JAMES, Esq., *Assistant Surveyor-General, in charge Lithographic Branch, Surveyor-General's Office.—Season* 1881-82.

THE number of maps, plans, drawings, &c., printed during the year amounts to 157,440 copies. Of these 121,353, or more than ¾ths, were for other departments. During the same period 10 sheets of the Oudh Revenue Survey of the year 1860 to 1871, and 2 sheets of the Julpaiguri district, each comprising 30′ of longitude by 15′ of latitude, and an Index map to the sheets of the Noakholly district, besides 337 subjects of all sorts and sizes (chiefly small) for other departments, were newly drawn either on stone direct, or on paper and transferred to stone.

The first edition of the map of India in 6 sheets, scale 1 inch = 32 miles, transferred to stone in 1881, was completed and printed in December of the same year; a second issue, in which many additions and corrections were made on the stones, was also published during the year under review (1881-82).

The outline of the new map of Bengal, scale 1 inch = 16 miles, was obtained from transfers from the engraved plates, in 4 sections; the hills were drawn direct on stone with corrections and additions. The frequent changes in the district boundaries in Bengal have necessitated the lithography of this map in two sets of stones,—one to shew in black the topographical and other permanent details, and the other to shew in red the varying district boundaries and names. This map is now nearly ready for publication.

The outline and part of the engraved hill work of a preliminary map of the Central Provinces, scale 1 inch = 16 miles, was transferred to stone from the incomplete engraved plates, and the incomplete portions of the hills were drawn on stone, and the map was nearly in a fit state for publication by the end of September 1882.

Eleven sheets of the 1-inch maps of the Noakholly district, drawn during the preceding year, have been printed and published during the year; also two sheets of the new edition of Oudh, Nos. 139 and 140.

The total number of subjects printed in the lithographic printing room was 393, of which 26 were printed in two colours, 28 in three colours, 6 in four colours, 2 in five colours, and 1 in six colours, and the remainder in black only. These required 182,091 pulls or impressions.

Four engraved sheets of the Indian Atlas (Nos. 30, 67, 112, and 119) were in a damaged condition and past repair. Transfers to stone were made from these plates, and many additions and corrections were then made on the stone to furnish a stock of the sheets for issue pending the preparation of new copperplates. The following district maps were published from material obtained by transfers from the engraved Atlas plates, with additions and alterations on stone, viz. Seebsangar, Dacca, Sylhet, Beerbhoom, Balaghat, Kamroop, and Sonthal Pergunnahs. Maps of the following districts, obtained in a similar manner, will be published shortly, viz. Goalpara, Kulnah, and Durrang.

The statement L. 1 shews the detail of the departmental work completed during the year, amounting in value to Rs. 25,830. Statement L. 2 shews the amount and value of work done for other departments, amounting to Rs. 20,111. Statement L. 3 shews the amount and value of work done in the type department, amounting to Rs. 8,317, exclusive of the value of transfers included in the cost of the several lithographic maps. Statement L. 4 is the abstract of the whole work completed during the year, as well as the outlay in salaries and contingent charges.

Mr. Lepage, who had been officiating as Head Assistant, was permanently appointed to the post in December 1881. He obtained leave for three months, and during his absence Mr. A. G. Palmer, Engraver, officiated and conducted the duties of head assistant very satisfactorily.

Mr. Niven, Head Printer, obtained leave on medical certificate for one year, from 11th April 1882, and during his absence Mr. Watson, of the Photographic Branch, has officiated as Printer. Mr. Ferns, Draftsman, was transferred to the Guzerat Survey Party on the 1st December 1881.

Messrs. Lepage and Watson have performed their duties zealously, and have done their utmost to keep pace with the heavy demands made on the office from numerous Government departments. The draftsmen and clerks have given satisfaction.

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC BRANCH, SURVEYOR-GENERAL'S OFFICE, BETWEEN THE 1st OCTOBER 1881 AND 30th SEPTEMBER 1882.

L. 1.

Work done for the Survey Department.

Description of Maps.	Scale of maps.	Size of each sheet.	Number of sheets.	Number of coloured copies.	Number of uncoloured copies.	Total number of copies printed.	Number of impressions.	Value.	Remarks.
								Rs. A. P.	
New maps, &c., drawn during the year.									
INDEX MAP.									
Index to the sheets of district Noakholly.	Drawn on transfer paper.	.....	Half-sheet, super royal.	1	...	302	302	302	99 12 2	
REVENUE SURVEY MAPS.									
Map of Oudh Revenue Survey, sheets Nos. 105, 106, 122, 123, 138, 152, 165, 166, 167, and 178, 2nd edition.	Drawn on transfer paper.	1 inch = 1 mile	Double royal ..	10	...	.....	.....	.....	5,673 7 8	Not yet printed.
Map of district Julpaiguri in 13 sheets, sheets Nos. 1 and 2,	Re-drawn on transfer paper.	1 inch = 1 mile	Ditto ...	2	...	.....	.....	.....	429 3 2	Ditto.
General maps transferred from engraved plates.										
Outline map of Bengal, Behar, Orissa and Chota Nagpore, in 2 sheets.	Ditto ditto	1 inch = 16 miles	Ditto ...	2	...	100	100	200	321 10 8	
Map of Central Provinces, in 2 sections.	Slight corrections made and portions of hills drawn on stone.	1 inch = 16 miles	Double elephant.	2	...	.....	.....	.....	145 9 3	Ditto.
Outline Map of India, in 2 sheets	Additions and corrections made.	1 inch = 64 miles	Ditto ...	2	...	.....	.....	.....	443 0 4	Ditto.
Map of the Provinces of Bengal, Behar, Chota Nagpore and Orissa, in 4 sections.	Corrections and additions made and hills drawn on stone.	1 inch = 16 miles	Atlas ...	4	...	.....	.....	.....	1,023 7 3	Ditto.
DISTRICT MAPS.										
Map of district Seebsaugor ...	Corrections and additions made.	1 inch = 4 miles	Double royal...	1	...	251	251	251	215 5 7	
Do. of ditto Gonlpara ...	Ditto ditto	1 inch = 4 miles	Antiquarian ...	1	...	.....	.....	.....	90 7 9	Ditto.
Do. of ditto Kulnah	Ditto ditto	1 inch = 4 miles	Atlas ...	1	...	.....	.....	.....	70 13 6	Ditto.
Maps, &c., drawn previously, but printed during the present year.										
DISTRICT MAP.										
Map of district Hoshiarpore, in 4 sheets.	Corrections and additions made and hills drawn on transfer paper.	1 inch = 2 miles	Ditto ...	4	...	104	104	416	575 3 11	
REVENUE SURVEY MAPS.										
Map of district Noakholly, in 12 sheets, sheets Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11.	Corrections made	1 inch = 1 mile	Double royal...	11	...	3,102	3,102	3,102	1,766 10 9	
Map of Oudh, Revenue Survey, sheets Nos. 139 and 140, 2nd edition.	Ditto ditto	1 inch = 1 mile	Ditto ...	2	...	504	504	504	404 12 0	
Maps transferred previously from the engraved sheets, but printed during the present year.										
ATLAS SHEETS BY TRANSFERS FROM PLATES.										
Map of Indian Atlas, full sheet, No. 40.	Further additions and corrections made and colour stones prepared.	1 inch = 4 miles	Antiquarian ...	1	152	50	202	500	283 15 5	
Ditto ditto, ditto, No. 48	Further additions and corrections made.	1 inch = 4 miles	Ditto ...	1	...	152	152	152	267 10 8	
Map of India, in 6 sheets, 1st issue	Ditto ditto	1 inch = 32 miles	Double elephant.	6	...	3,597	3,597	3,597	3,401 14 6	
Ditto ditto, ditto, 2nd issue	Additions and corrections, &c., made and transfers taken.	1 inch = 32 miles	Ditto ...	6	...	1,032	1,032	1,032	2,427 5 4	
Map of Indian Atlas, full sheets, Nos. 30 and 119.	Corrections and additions made and colour stones prepared.	1 inch = 4 miles	Antiquarian ...	2	300	200	500	800	587 0 3	
Ditto ditto ditto, No. 67 ...	Corrections and additions made.	1 inch = 4 miles	Ditto ...	1	...	.....	.....	.....	63 9 3	Ditto.
Ditto ditto ditto, No. 112 ...	Ditto ditto	1 inch = 4 miles	Ditto ...	1	...	152	152	152	261 12 6	
DISTRICT MAPS.										
Map of district Dacca	Further corrections made and colour stones prepared.	1 inch = 4 miles	Atlas ...	1	100	100	200	300	113 10 8	
Carried over ...	.....	.....	.....	62	552	10,606	11,158	12,274	18,667 7	

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC BRANCH, SURVEYOR-GENERAL'S OFFICE, BETWEEN THE 1st OCTOBER 1881 AND 30th SEPTEMBER 1882.

Work done for the Survey Department—continued.

Description of Maps.		Scale of maps.	Size of each sheet.	Number of sheets.	Number of coloured copies.	Number of uncoloured copies.	Total number of copies printed.	Number of impressions.	Value.	Remarks.
									Rs. A. P.	
Brought forward ...	.....	.....	.....	62	552	10,606	11,158	12,274	18,667 5 7	
District Maps—*continued.*										
Map of district Sylhet	Further corrections, &c., made.	1 inch=4 miles	Atlas ...	1	...	356	356	356	307 5 11	
Do. of ditto Beerbhoom ...	Further corrections made and colour stone prepared.	1 inch=4 miles	Super royal ...	1	104	100	204	308	93 15 4	
Do. of ditto Balaghat ...	Further corrections, &c., made.	1 inch=4 miles	Atlas ...	1	...	250	250	250	138 15 5	
Do. of ditto Sonthal Pergunnahs	Further corrections, &c., made and colour stone prepared.	1 inch=4 miles	Double royal...	1	102	102	204	306	240 5 8	
Do. of ditto Kamroop ...	Corrections and additions made.	1 inch=4 miles	Atlas ...	1	...	252	252	252	101 3 2	
Do. of ditto Raepore	Ditto ditto	1 inch=4 miles	Antiquarian ...	2	...	.....	.....	.....	63 1 0	Not yet printed.
Reprints.										
General Maps.										
Map of Southern Afghanistan, in 4 sheets.	.....	1 inch=4 miles	Ditto ...	4	...	400	400	800	367 0 0	
Map of Punjab Provinces, in 8 sheets, sheets Nos. 1, 4, 6, and 7.	.....	1 inch=8 miles	Double elephant.	4	...	170	170	170	97 1 8	
Map of India, No. 2, 8th edition...	.....	1 inch=128 miles	Imperial ...	1	100	25	125	525	69 0 0	
Ditto in 2 sheets	.....	1 inch=64 miles	Double elephant.	2	...	25	25	50	25 5 10	
Map of British Burma, Pegu division, sheets Nos. 3 and 4.	Corrections and additions made.	1 inch=4 miles	Antiquarian	2	...	240	240	240	227 5 4	
Map of Eastern Bengal, Assam, Burma, and part of China and Siam, in 4 sheets.	.....	1 inch=32 miles	Imperial ...	4	...	50	50	400	88 0 6	
Map of North-Western Provinces and Oudh, in 4 sections.	.....	1 inch=16 miles	Ditto ...	4	...	50	50	400	106 2 8	
Map of Eastern and Western Bengal, sheets Nos. 8, 11, 13, 19, and 20.	.....	1 inch=8 miles	Ditto ...	5	100	115	215	315	92 4 5	
Map of Eastern Bengal, sheet No. 10.	Corrections made and colour stones prepared.	1 inch=8 miles	Ditto ...	1	100	50	150	250	91 11 7	
Map of Assam, in 9 sheets, sheets Nos. 3, 5, 7, and 8.	Corrections made and colour stones prepared of No. 3 only.	1 inch=8 miles	Ditto ...	3	275	100	375	975	215 14 0	
Map of Bengal, Behar, and Orissa	.....	1 inch=32 miles	Double elephant.	1	...	75	75	75	42 3 8	
District Map.										
Map of district Mymensingh ...	.....	1 inch=4 miles	40 × 40 paper	1	...	100	100	100	51 15 4	
Index Maps.										
Index Maps, Nos. 1, 2, 5, 7, 8, and 9 parties, to accompany annual report.	Corrections, &c., made and colour stones prepared.	...	Foolscap ...	5	2,500	250	2,750	7,700	472 2 10	
Index to the Survey of South Sylhet and Tipperah hills, to accompany annual report.	Corrections made and colour stones prepared.	.....	Ditto ...	1	500	65	565	1,565	90 9 6	
Index to the sheets of Baluchistan Survey, to accompany annual report.	Ditto ditto	.....	Ditto ...	1	450	50	500	650	113 10 0	
Index to the Indian Atlas shewing the state of the engraving to 1st October 1881, to accompany annual report.	Ditto ditto	.....	Ditto ...	1	600	.....	600	1,200	88 1 7	
Map of India, shewing the progress of the Imperial Survey to 1st October 1881, to accompany annual report.	Ditto ditto	1 inch=128 miles	Imperial ...	1	400	.....	400	1,600	102 1 10	
Index to the topographical survey, district Kohat.	.....	.....	Half-sheet foolscap.	1	...	105	105	105	0 7 8	
Small Index to the sheets of Indian Atlas.	Colour stone prepared.	.....	Foolscap ...	1	500	25	525	1,025	84 4 11	
Plans.										
Plan of Calcutta, in 2 sheets ...	.....	6 inches=1 mile	Double elephant.	2	...	107	107	428	132 14 6	
Guide plan of Simla and Jutog ...	.....	4 inches=1 mile	Atlas ...	1	...	108	108	108	54 3 6	
Total ...	.....	.....		115	6,283	13,776	20,059	32,727	22,476 13 5	
Miscellaneous maps, &c.	.....	.....		18	...	.....	1,578	1,926	846 14 11	
Cadastral maps	.....	.....		21	...	.....	234	234	211 15 2	
Departmental forms	.....	.....	Items ...	27	...	.....	14,216	17,877	2,294 13 6	
Grand Total ...	.....	.....	.....	181	6,283	13,776	36,087	52,764	25,830 9 0	

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC BRANCH, SURVEYOR-GENERAL'S OFFICE, BETWEEN THE 1st OCTOBER 1881 AND 30th SEPTEMBER 1882.

L. 2.

Work done for other Departments.

Names of Departments.	Number of maps.	Number of sheets.	Number of sheets coloured.	Number of sheets uncoloured.	Number of copies.	Number of impressions.	Value.
							Rs. A. P.
Foreign Department	28	29	... ..	29	1,711	1,731	941 10 2
Military Department	44	52	1	51	10,563	12,016	2,477 14 10
Home, Revenue, and Agricultural Department	4	4	3	1	3,268	5,738	518 8 2
Telegraph Department	6	6	.....	6	4,633	5,531	694 11 1
Bengal Office	34	34	11	23	31,069	33,094	2,128 2 4
Marine Survey Department	1	1	1	.... ..	240	720	221 8 8
Sanitary Commissioner	1	1	1	.....	1,075	3,205	481 12 6
North-Western Provinces *Gazetteer*	4	4	.....	4	2,319	2,319	515 11 1)
Public Works Department, Government of India and Bengal.	9	9	1	8	2,137	2,239	946 0 5
Punjab Government	3	3	1	2	1,542	2,832	478 11 5
Quarter-Master-General	4	4	....	4	1,105	1,855	59 15 10
Office of the Superintendent, Census Operations, in Bengal	5	5	4	1	5,052	10,377	1,326 9 10
Meteorological Reporter to the Government of India	7	7	3	4	2,639	4,239	514 3 0
Archæological Survey of India	24	24	.....	24	13,560	3,955	1,029 9 0
Geological Survey of India	10	10	4	6	6,769	12,873	1,588 12 11
Miscellaneous drawings	83	83	8	75	30,677	26,571	3,089 10 10
Maps, &c., drawn but not printed	70	70	4	66	.....	.....	2,317 13 3
Total	337	346	42	304	1,21,353	1,29,295	20,111 0 10

L. 3.

Statement of type-work executed, exclusive of transfers, &c., already included in the cost of the several Lithographic Maps, &c.

Subject.	Items.	No. of copies.	No. of impressions.	Value.
				Rs. A. P.
Circular Orders	8	1,025	1,225	55 5 0
Memorandum, &c.	413	2,00,297	2,73,279	5,066 9 0
Forms, &c., for Survey Department	42	30,201	1,17,036	1,867 0 0
Transfers of headings, footnotes, references to published maps for Photographic Branch	925	8,562	8,562	1,329 8 0
Total	1,388	2,40,085	4,00,102	8,317 6 0

L. 4.

General Abstract of Out-turn and Value of Work performed.

Description of Maps.	No. of sheets.	No. of copies.	No. of impressions.	Value.
Departmental Work.				Rs. A. P.
General and district maps, &c.	63	10,431	14,078	10,864 14 0
Index maps	12	5,747	14,447	1,150 2 6
Revenue Survey sheet maps, scale 1"=1 mile	13	3,666	3,666	2,171 6 9
Plans	3	215	536	187 2 0
Miscellaneous maps, &c.	18	1,578	1,938	846 14 11
Cadastral maps	21	234	234	211 15 2
Departmental forms	27	14,316	17,877	2,294 13 6
Maps, &c., drawn but not printed	24	.....	.....	8,903 4 2
Total	181	30,087	52,776	25,830 9 0
Work done for other departments	346	1,21,353	1,29,295	20,111 0 10
Total of drawing and printing in Lithographic Department	527	1,57,440	1,82,071	45,941 9 10
Work done in Type Department	1,388	2,40,085	4,00,102	8,317 6 0
Total value	.....	.....	.....	54,258 15 10

Statement of Expenditure.

	Rs. A. P.
Establishment	29,919 6 9
Contingent charges	4,659 10 10
Total	34,579 1 7

Surveyor-General's Office,
Lithographic Branch,
Calcutta, 22nd December 1882.

JOHN O. N. JAMES,
Asst. Surveyor-General,
in charge, Lithographic Branch,
Surveyor-General's Office.

Extract from Report of MAJOR J. WATERHOUSE, *Assistant Surveyor-General, in charge Photographic Branch, Surveyor-General's Office.—Season* 1881-82.

I HAVE the honour to submit the usual tabular statements of work done, expenditure, &c., in this branch of your office during the survey year from 1st October 1881 to 30th September 1882, viz.—

(*A*) Abstract of work performed during 1881-82. (Printed in Part II.)
(*B*) Comparative statement of the out-turn of 1880-81 and 1881-82.
(*C*) Statement showing the value of work done for other departments.
(*D*) Statement of expenditure and value of work done.

OUT-TURN.—*Ordinary.*—The out-turn of ordinary departmental and extra-departmental work shows a considerable increase in negatives, transfers, and press pulls, though the number of printed sheets, both single and combined, is less.

The work passing through the office during the year has been of the usual miscellaneous character, as will be seen from the return of work done for other departments, which shows a steady increase in this direction. The Egyptian campaign caused a great demand for reproductions of charts of the Suez Canal, Red Sea, ports of Alexandria, Port Said, and Suez; also for maps of Egypt. The total number of these maps printed was about 4,430.

Cadastral.—On the cadastral side also there has been a considerable increase in the number of sheets photographed and transferred to zinc, the total number amounting to about 5,000 sheets, which is the highest figure yet reached. The out-turn in pulls and printed sheets is not so great, owing chiefly to the reduction in the number of copies printed off for the North-Western Provinces from 25 to 10, which entails loss of time in constantly changing plates.

Arrangements have now been made for a steady out-turn of 20 to 22 sheets a day, or about 6,000 sheets in the year, part being done by photography and part by tracings prepared for zincography in the Deputy Surveyor-General's office; and this is about the full extent to which we can work with the present staff and accommodation. The number of sheets a year that can be turned out depends, however, upon the number of copies printed of each sheet; and as this varies for each province—thus for North-Western Provinces 10, for Burmah 34, for Bengal (Khurda) 43—it is difficult to make any close estimate of probable out-turn.

EXPENDITURE.—As will be seen from Table D, the expenditure of the office, including establishment and stores, has been Rs. 93,146, as against Rs. 89,560 of the previous year. The value of work done for which credit is taken, as calculated by the scale drawn up by me in 1879, has been Rs. 1,14,795, showing a balance in favour of the department for the year of Rs. 21,648. The value of the whole work done during the year is Rs. 1,25,260. From this it appears that the rates laid down in the scale are more than amply sufficient to cover the cost of the work done, and I propose to take an early opportunity of going into this question again, to see whether the rates can be reduced.

PERSONNEL.—I returned from furlough and relieved Major Cowan on the 26th December 1881. There have been few changes in the establishment during the year, the principal one being Mr. Caddy's resignation in February of his post of storekeeper. Mr. Dempster has since had charge of the stores and making up collodion, &c. Mr. J. Harrold returned from furlough and resumed charge of the photo-transfer printing branch on the 21st June. In the zinc-printing branch Mr. E. A. LeFranc has been superintending the cadastral work during Mr. Watson's deputation to lithographic branch since 10th April; and during Mr. B. Mackenzie's absence on privilege leave from July to October he took charge of the office presses, Mr. A. P. DaCosta taking charge temporarily of the cadastral presses.

The establishment of the office was generally reorganised and arranged from the commencement of the current financial year, as reported to Government in your No. 1146, dated 19th April 1882. The changes, however, were chiefly in designation and pay of the different posts. I have not yet been able to fill the post of head assistant, but hope to find a suitable incumbent in the course of the current year.

PROCESSES.—There have been no changes of special importance in the processes worked in the office beyond that in intensifying negatives we seem at last to have succeeded in doing away with the bad-smelling hydro-sulphate of ammonia for intensifying, and have replaced it by a solution of—

	Parts.
Hyposulphite of soda	30
Liquor ammonia	60
Glycerine	20
Water	1,000

This change will effect a very considerable saving in expense, the full amount of which cannot yet be estimated.

The method has the defect that the films become very tender when dry, and will not bear handling; but this appears to be obviated by coating them with a mixture of albumen and gelatine—

	Parts.
Gelatine	20
Water	500

and the whites of two eggs.

I have also found a method of intensifying which appears likely to be useful for special half-tone work.

The collodion plate, after exposure and development, is intensified slightly with pyro-gallic acid and silver or iron and silver, and, after washing, plunged into a solution of bromide of copper at 10%, which at once changes the colour of the film to a light canary yellow. It is then placed in a bath containing the ordinary ferrous-oxalate developer. This speedily darkens the colour of the film to a dark olive green, which becomes darker and darker up to a certain point by leaving the plate immersed in the solution. It is then taken out, washed, and dried. If not intense enough, the operation may be repeated, but the colour of the image is much more non-actinic than it appears. I have since found that instead of the bromide of copper, Carey Lea's solution of—

	Parts.
Saturated solution of bichromate of potash...	3
Hydrochloric acid	1
Water	48

may be used: it is almost equally effective, and much cheaper.

In the photo-transfer printing some exceedingly good results have been obtained by using an enamelled paper highly glazed with gelatine as the basis of the transfer prints. The paper is sold by the Autotype Company as a transfer paper for pigment printing. It can either be sensitised as it is in a bath of bichromate of potash, or be coated with a thin solution of gelatine and bichromate. In some cases the best results are obtained by inking in with a roller on the damped gelatine surface, but on the whole the usual method of inking in and washing seems to answer best. A small supply of this paper has lately been received from England; but being more thickly coated with gelatine than that I brought out with me, has not given very good results for large maps, where the sections have to be joined, though for work within the limit of a single negative it will be very useful.

We have made several trials of inking in the transfers with velvet rollers, as done at Vienna and Woolwich, but have not been able to obtain better results than we usually get either by washing or by rolling up with an ordinary lithographic roller. The latter, in cases where the work is very fine, is exceedingly useful.

Collotype.—I should have been glad to have been able to start this process again, but we have had few subjects for which it could be used with advantage, and more attention has been paid to heliogravure. The press obtained from M. Poirier seems exceedingly good for the purpose, and as soon as opportunity offers I hope to return to this process.

Heliogravure.—During the year I have given as much attention to this process as other demands on my time allowed. Two plates taken from original drawings in Indian ink of trap crystals have been reproduced by the process, and upwards of 800 copies of each printed for publication in the Records of the Geological Survey of India; four other similar plates are in hand. A plate of coins was reproduced for the Asiatic Society, but not published. A reduction of a sheet of the Atlas of India was also done as an experiment.

More might have been done, but, apart from interruptions from other work, I have been trying to perfect an improvement which I found resulted from using tissue glazed with collodion. Owing to the fine smooth surface of this tissue the gelatine reliefs obtained with it are very much sharper in the details, and develop much clearer than they do with unglazed tissue; and this is particularly important in map and other line work, where absolute sharpness of the lines and a clean ground are imperative. Unfortunately, the collodion surface is apt to split away from the copper in drying; and in the electrotyping bath the copper solution gets underneath it and forms irregular deposits.

I have tried a great many ways of overcoming this difficulty and of obtaining the same advantages in some other manner, but the results as yet are not altogether satisfactory.

Substantially, the process is the same as I was working before I went on furlough; but the experience gained during my stay in Europe, from what I saw at Vienna and Florence, and from independent work at the Autotype Works at Ealing, has been of immense use, and the improvements I have now introduced seem to have put the process on a practical footing, though it still requires perfection in certain points. It appears therefore desirable to give a full description of the whole process, as I am now working it.

Before going into details, it may be briefly stated that the process consists in obtaining by the ordinary pigment-printing process a photographic image in relief on a polished and silvered copperplate. This relief is formed of insoluble gelatine, and, if it is of a half-tone subject, has its surface roughened or grained while wet by means of waxed sand or emery, which is removed when the relief is dry. It is then black-leaded, and copper is deposited on it by the electrotyping process, so as to produce a copperplate,

on which the design is reproduced in intaglio, with lights and shades of varying depths, corresponding to the gradations of tint in the original.

The pigment tissue.—The pigment tissue consists of paper evenly coated with a mixture of gelatine and any suitable pigment. As a rule, it is purchased ready prepared from the Autotype Company. Their engraving black, warm black, and standard brown tissues, all answer well.

The prepared tissue keeps fairly well, but it is an advantage to have it as fresh as possible, otherwise the gelatine surface becomes more or less insoluble by keeping, especially in damp weather, and forms a dark scum over the picture.

Sensitising.—The tissue is sensitised by immersing it in a solution of—

Bichromate of potash	1 ounce.
Alcohol	5 „
Liquor ammonia	½ drachm.
Water	25 ounces.

In the hot weather this solution must be cooled with ice.

The bath keeps well, but should not be used if it appears at all brown.

The tissue is laid in this for a minute or two, till it softens, and is then taken out and laid evenly down on a glass plate, and the excess of moisture removed with a squeegee or glass rod. It is then lifted off the glass and placed in the drying-box to dry.

To obtain the most perfect sharpness in the reliefs, it is desirable that the tissue should be dried so as to have a very highly polished surface, which will lie in perfectly close contact with the negative. This is best obtained by drying it in contact with a plate of glass, but the latter must be coated with some substance which will permit the tissue to be readily stripped off when dry; and in this there is a good deal of difficulty.

In Vienna the glass plate is rubbed with powdered French chalk, but this I have found very uncertain in its action when used with tissue sensitised as above: so are wax, stearine, and paraffin. Linseed oil varnish answers well, so does cocoanut oil; but a certain amount of the fatty substance is taken up by the tissue and diminishes its adherence to the copperplate support, so that it is liable to lift and blister in the after processes.

The substance I have found answer best in many ways is collodion, which has very distinctive advantages in the sharpness and cleanness of the images developed upon it; but on the other hand, it also has the grave defect noticed above of splitting on the plate, and the grain in half-tone subjects is not so well brought out as on uncollodionised tissues, collodion being one of the best preventatives of reticulation or the natural graining of the gelatine which occurs in hot weather.

The best way of using collodion is to thoroughly clean a piece of patent plate glass, rub it with a little powdered French chalk, then coat it with a moderately thin and absorbent collodion containing—

Pyroxyline	1 part
Alcohol	50 „
Ether	50 „

and allow this to become perfectly dry.

The collodion being dry, the glass plate is immersed in the sensitising bath along with the tissue, and the latter is drawn out with the gelatine side in contact with the collodionised surface and pressed closely down to it with an Indian rubber squeegee, which removes all excess of fluid. The plate is put into a drying-box, which may be moderately heated, till the tissue is dry. This generally takes two or three hours.

Some writers recommend that the collodionised glass should be put in water as soon as the collodion has set, and washed till all appearance of greasiness is gone, and the wet sensitised tissue applied to the wet surface of the collodion. I have not found this answer so well as allowing the collodion to dry thoroughly. It may, however, answer with suitable collodion.

The tissue being dry the edges are cut round, and it should readily leave the glass plate and show an evenly smooth and brilliant surface. Pieces of the required size are cut from it with the aid of a properly squared glass plate.

The varnish prepared by the Autotype Company for the transfer of pigment prints also answers very well in giving a good glazed surface and allowing the dry tissue to be easily removed, though the image does not develop so clearly as with collodion, and the varnish is rather brittle and liable to crack in removing the tissue, the cracks showing on the finished plate. The way of applying the varnish is much the same as with the collodion, the glass plate being coated with the varnish, allowed to dry, and the wet tissue squeegeed down upon it.

Exposure to light.—The tissue being cut of the proper size is laid on the negative in the printing-frame, so that the image may be square and correctly centered on it, and is exposed to light in the usual way under a *reversed* negative; the time varying in diffused light from about 5 to 10 minutes for line subjects, to 10, 15, or 20 minutes, or longer, for half-tone subjects, according to the density of the negative, strength of light, &c. An actinometer may be usefully employed, as in ordinary pigment-printing; but the light in this country being generally bright, time is a sufficiently near guide to the proper exposure.

Development of the image.—The exposed tissue is taken out of the printing-frame and immersed in perfectly cold water (in hot weather ice must be used to cool it), drawn out again

quickly in contact with and squeegeed well down to a polished copperplate which has been lightly silvered with a solution of nitrate of silver in cyanide of potassium, the object of the silvering being to prevent the adherence of the deposit of copper in the subsequent operation of electrotyping. Care must be taken to lay the tissue down squarely and in its proper place on the copperplate, and the squeegeeing is best performed by laying the plate and tissue down on a wooden support standing in a trough.

The superfluous moisture being wiped off the back of the tissue and edges of the plate, they are set aside for about 10 minutes, and then placed in clean warm water, just about as hot as the hand can bear it comfortably. After a few minutes the paper support of the pigmented tissue will be loosened, and may be removed, leaving a black, slimy-looking mass on the plate. By leaving the plate to soak a little longer in the water, gently moving it from time to time to wash away the dissolved gelatine, the image will gradually appear and the development may be finished by dashing the warm water over its face with the hand till the details all appear clear and the soluble gelatine is all removed. Should the image be too dark from overprinting, the use of warmer water in the later stages will lighten it up. In any case it is desirable that the ground of a line drawing or the highest lights of a half-tone subject should appear in bare copper ; but in this country there is great difficulty in avoiding a slight scum of gelatine.

After development the plate is rinsed in cold water, and may sometimes be lightly brushed over with a soft brush to remove any loose soluble gelatine or pigment still adhering to the plate. If a line subject, the plate is now drained and wiped at the back and along the borders to remove as much water as possible, and then plunged into a bath of strong spirit of wine. This at once contracts the gelatine forming the lines, and gives the latter a crispness it is difficult to obtain in any other way.

With some tissues the use of alcohol will also give a rough velvety surface and a certain amount of grain. Three or four years ago I found an alcoholic solution of tannin most useful in giving grain and the required hardness to the film ; but with the tissues now manufactured by the Autotype Company, I find it of no use at all in graining, though it tans the gelatine and hardens it. It causes, however, scummy markings which are difficult to remove, and on the whole I do not now recommend its use.

At Vienna, line subjects are first dried off and then soaked in a solution of bichromate of potash at 5% for about half an hour; they are then rinsed in water and dried slowly without heat. This is a very good plan, but in the hot weather I find that the reliefs run if left to dry slowly, and therefore quick drying off with spirit is better. The bichromate bath may, however, be used with advantage after the drying off with spirit.

For half-tone subjects, the treatment is quite different. After rinsing in cold water, the developed picture is first placed in a bath of bichromate of potash at 5% and allowed to remain for about half an hour. The superfluous bichromate is then washed out under the tap, so as only to leave that absorbed by the gelatine.

The object of the bichromate bath is to harden the gelatine relief and render it less liable to injury in the after process of graining, without at the same time making it too tough to receive the grain, as alum or chrome alum would do. The bichromate also seems to aid in the production of a good grain, either by a slight crystallisation in the gelatine or by some repulsive action exerted on the greasy graining powder.

Graining.—In order to produce proper prints of half-tone subjects in the copperplate press, it is essential that the different gradations of shade should be broken up into a grain consisting of a multitude of little points, which will ensure the hollows in the plate holding the proper amount of ink ; and it should therefore be comparatively coarse in the shadows, gradually becoming finer, in proportion as the tints become lighter, till it disappears entirely in the high lights. The obtaining of such a grain in a simple way has been the great difficulty in the way of photographic engraving processes for many years past, and various methods have been proposed from time to time to overcome it. In most of these methods the grain obtained is uniform throughout, monotonous and unduly prominent, while others more successful are trade secrets.

Whilst working at the Autotype Works at Ealing in 1881, I had the good fortune to hit upon a method of giving the gelatine reliefs a graduated grain, which is quite novel and seems very efficient. It consists in sprinkling over the surface of the gelatine relief, while still wet and soft after development, a granular powder, such as fine sand, emery, or glass powder, previously coated with some greasy material, such as wax, paraffin, or stearine, to prevent its ultimate adherence to the gelatine. As the gelatine dries, the powder is drawn into it, and naturally sinks deepest into the darkest parts, where there is most gelatine; less into the half-tones, where there is less gelatine; and not at all in the lights, where there is no gelatine. In this way the surface of the gelatine image on the copperplate is pitted all over, and takes a fine granular texture, following exactly the lights and shades of the picture.

Were plain sand or emery used, it would stick to the gelatine and it would be impossible to remove it. In the course of experiments at Ealing, I found that these granular powders could be coated with sufficient greasy or insulating material to enable them to be easily removed from the gelatine without in any way interfering with their granular character. Paraffin and wax answer well, but I have generally used stearine. Cocoanut oil would probably do equally well.

The choice of granular material depends very much upon the kind of grain required Graining sand of 160 holes to the inch gives a very clean open grain, rather too coarse for very fine subjects. Emery powder, 160 holes, gives also a good grain, but flatter, and not

so clean cut as the sand. Oakey's glass powder No. 1 gives a delicate, clean-cut grain suitable for very fine work. On the whole for general purposes I prefer the grain given by Oakey's coarse flour emery well washed to remove all dust.

The washing is done by placing a quantity of the powder in a long glass jar, which is filled up with water; the powder is well stirred up and allowed to settle for a minute or two, till all the coarser grains are precipitated; the dirty water is poured off, and the process continued till the water remains fairly clear. The coarse flour emery requires about 20 washings of 1 to 1½ minutes each to clear it; glass powder requires about 12 washings of 1 minute each; fine graining sand also requires several washings to take out the dust.

The powders washed as above are dried with heat in an iron or copper bowl, and when perfectly dry and still hot are stearined by shredding a little stearine into them and stirring well until it is melted and thoroughly incorporated with the powder. The pot is then taken off the fire, and the powder kept well stirred till cold. The grains should then be perfectly separate, and to all appearance the same as before being stearined.

The proportion of stearine is not of much consequence; from 4 to 6 or 8 grains to the ounce of powder are sufficient. The coarse flour emery takes about 4 or 5 grains to the ounce; 160 holes sand, rather more.

The washing of the granular powder is a very essential point in getting a clear sharp grain. I found that the dust confused the image in a very peculiar manner, and was very difficult to remove.

The graining powder is most conveniently applied with a small tin pepper-box, the lid of which is covered with fine wire gauze, instead of the usual perforated plate. The powder is well sprinkled all over the image, and the plate is set aside to dry in a horizontal position, being left for some hours, in order that the bichromate in the film may thoroughly harden it. The loose powder is then brushed off with a stiffish small paint-brush, and being returned to its receptacle can be used over and over again. The plate is now placed in a dish of cold water, and the remaining powder is removed by very gentle rubbing with a soft brush or the finger, till all feeling of grit has gone. The presence of powder will also be easily seen by reflected light. The powder should come away quite easily, and if it does not, more stearine must be added to it.

The plate is then well rinsed in cold water and gently brushed with a soft brush to remove all loose grains of powder, and set aside to dry. When dry, the margins are cleaned and the plate is ready to be electrotyped.

The plate should now show a finely-grained image in very low relief, and this image should as nearly as possible be an exact reproduction of the original in depth of light and shade and general appearance, while there should be sufficient gelatine to give an image of the proper depth when slightly swollen in the electrotyping bath.

Electrotyping.—The first thing to be done is to give the gelatine a conducting surface by brushing it over with plumbago. This must be done very thoroughly, and the plumbago must be good; otherwise there may be difficulty in getting a deposit of copper on the deep shadows. Gilt or silvered plumbago are useful; and it is a good plan to facilitate the adherence of the plumbago by breathing on the image. Where the shadows are very heavy, the relief may be rubbed over very lightly with a greasy pad; but this treatment is apt to give flat images by the grease preventing the slight rising of the gelatine relief in the battery.

The form of battery I have found most useful for electrotyping these reliefs is the single cell arrangement used in the Military Geographical Institute at Vienna, and also at Florence. While on furlough I worked up the use of this battery, particularly as to the best material for the porous diaphragm, and found that leather may be advantageously used to replace the paper parchment used at Vienna, which is easily liable to damage and not always procurable.

The battery consists of two wooden troughs fitting into one another. The inner has a porous bottom, and contains a zinc or iron plate lying in dilute sulphuric acid; the outer contains a saturated solution of sulphate of copper, and in it is placed the plate bearing the gelatine relief. This is suitably connected with the zinc or iron plate in the inner trough above it, and receives a deposit of copper, which being removed when of the proper thickness forms the printing plate.

The inner trough is a tray with wooden sides about 4 inches deep. Over the bottom of it a piece of leather is stretched tightly and nailed down with copper nails. The edges of the leather and the corners of the trough are painted over with electrical cement, so as to prevent leakage except by permeation through the leather. For the starting trough with zinc, I use kid skin, and for ordinary deposition with iron, sheep's skin. Along the ends of the trough, inside, are ledges about *half an inch thick for the zinc or iron plates to rest on.*

The outer trough is about 5 or 6 inches deep, and I prefer to make it long enough to permit the plate bearing the relief to be passed underneath the inner trough without the latter being lifted up. This enables the state of deposition to be easily examined at any time. The trough is best lined with lead, well pitched over; but good cementing with electrical cement answers well for small troughs. The solution of sulphate of copper contained in the trough is kept at saturation by crystals of sulphate of copper placed in a perforated box at one end of the trough. This box should be lined with flannel or cotton cloth to prevent dirt going into the trough.

The plate bearing the gelatine relief is supported on a copperplate coated with electrical cement on both sides, but furnished on the upper side with studs about ¼ inch long, the points of which are kept bright in order to produce electrical contact with the under side

of the relief plate. One side of the supporting plate has a stout copper band about 8 inches long riveted to it and carrying at the other end a connecting screw.

In this manner the plate bearing the gelatine relief is left quite free, and can easily be removed for examination or cleaning, while the electrical contact is quite sufficient for all purposes.

Before starting a plate, the solution of sulphate of copper is carefully filtered into the outer trough. A zinc plate, about the same size as the plate to be copied, and having a copper band soldered to one side of it, having been amalgamated in the usual way, is wrapped up in thin cotton cloth and laid in its place in the inner trough with kid skin bottom. All being ready, the supporting plate is laid in its place at the bottom of the outer trough, the plate bearing the black-leaded gelatine relief is laid upon it and just allowed to soak in the solution of sulphate of copper, while the inner trough with plate is placed in position and filled with the proper quantity of dilute sulphuric acid, containing one part of acid to 60 of water, so as to cover the zinc to a depth of about one-fourth inch. The copper band attached to the zinc is then fastened in the connecting clamp attached to the supporting plate in the lower trough, and the electrical circuit being complete the deposition should begin at once.

All working well, the gelatine relief should be completely covered with copper in the course of an hour or two, and may then be changed into the ordinary depositing trough, which is exactly the same thing, but with an iron plate instead of zinc, and sulphuric acid one part to 40 of water. I generally allow the plate to remain in the zinc battery all night, and then change to the iron battery in the morning. While depositing, the plate is washed every morning to remove dirt; and if any lumpy nodules or other irregular deposits should form on the face of the deposited copper, they are removed by filing. The iron plate is washed, and the acid renewed every other morning. As a rule, the deposition proceeds very evenly and regularly, at the rate of from 1½ to 2 ounces a day on a 10 × 8 plate; so that a plate of this size, weighing 1½lb, takes from 12 to 18 days to deposit. The whole arrangement is exceedingly simple and easily worked by a native assistant. I find it a great improvement over the Smee's battery I formerly used.

When the deposited copper is sufficiently thick, the outer surface is smoothed with a rubber file, and the edges being filed round, the deposited plate can easily be removed from the relief plate. Any gelatine adhering to the plate is washed out, the edges are trimmed, and the surface being polished with a little of the finest washed emery, or oil-rubbed, is ready for printing.

These plates generally require a little brightening up of the high lights with a burnisher, and, if necessary, deep shadows may be brought out by rebiting, or worked up with a roulette. At Vienna tints are sometimes deepened by applying a mixture of sulphur and olive oil with a brush. If due care is taken throughout, the original and negative good, and the tissue fresh, very little retouching should be required.

Before printing it is essential that the plates should be steel-faced, otherwise the fine parts will soon wear out.

Arrangements have been made for working larger sized plates, and I hope to report further progress during the ensuing year. The work is very much facilitated by the ease with which we now obtain reversed negatives by means of a silvered glass mirror placed behind the lens; and the new lenses and apparatus I obtained from Messrs. Ross & Co. while in England have proved very useful.

I have also given attention to other processes of photographic engraving in which the image is obtained by biting. These methods are quicker and more economical than electrotyping, but require more skill. Some of my experiments have shown fair promise of success, and I hope to find a method that shall be as far as possible automatic and require little aid from the skilled engraver.

Photographing on Copper.—An occasion having arisen when photographs of a drawing were required to be made on a copperplate as a guide to the engravers, I found a new way of photographing either line or half-tone subjects on copper, which is simple and likely to be useful.

The copperplate being cleaned and polished ready for engraving upon is dipped for a minute or two in a bath containing a ten per cent solution of bromide of copper; it is washed and allowed to dry, then exposed to diffused light for a second or two under a reversed negative or under the drawing itself, if suitable, and developed with the ordinary ferrous-oxalate developer used for gelatine dry plates and made by adding one part of a saturated solution of ferrous sulphate to three parts of a saturated solution of neutral potassic oxalate. The image soon develops in red on a greenish yellow ground. The plate is washed and the image fixed in a weak solution of cyanide of potassium, which clears and brightens the yellow ground. The resulting images are of a rich brownish purple on a canary-coloured ground.

It is in some ways an advantage to lightly silver the copperplates before sensitising them. The coating of bromide of silver is more sensitive, and develops better. The silvered plates should, however, be fixed with hyposulphite of soda.

Some of these plates, when etched with perchloride of iron, gave very distinct images, the perchloride attacking the shadows; but there is a difficulty in biting sufficiently deeply.

Gelatino-bromide plates and paper.—During the year I have worked a good deal with the new gelatine dry plates, with a view to see whether they could be usefully employed in the office in supersession of the wet collodion process. With some plates I have found no difficulty in working through the hottest weather, but the images obtained are not so

clear as with wet collodion; and I do not think that the gelatine would suit us so well as collodion, though it has many advantages in greater sensitiveness and convenience in manipulation.

Some of Morgan's argentic-gelatino bromide paper was obtained from England for trial, with the idea that it might be useful for reproducing cadastral maps. I found that it might be used very well for taking negatives in the camera, but the density was insufficient for photo-transfer printing. The paper might very usefully be used for making direct negatives by contact from originals drawn on fine tracing-paper, but not with our present originals, drawn on thick paper, and many of them dirty and stained. I drew the attention of the Meteorological Department to the paper as likely to be useful for the self-recording instruments. It was tried in the Observatory at Alipore, and found to answer so well that it has been definitely adopted in preference to the old waxed paper process. It saves a great deal of trouble and gives clearer results.

NEW BUILDINGS.—A great deal of my time has been taken up during the year with the preparation of rough plans and drawings of the new buildings for the accommodation of the office, so very urgently required. A set of plans was made by Mr. E. J. Martin, the Government Architect, but they required considerable alterations, and there is still a good deal of work to be done in connection with the fittings and special appliances of a photographic office.

B

Comparative Statement of the Out-turn of 1881-82 *with that of the previous year.*

	Ordinary Work.				Cadastral Maps.			
	1st October 1881 to 30th September 1882.	1st October 1880 to 30th September 1881.	Difference.	Difference in square inches.	1st October 1881 to 30th September 1882.	1st October 1880 to 30th September 1881.	Difference.	Difference in square inches.
Originals...	1,260	961	+299	.....	4,981	4,591	+390	.....
Negatives	1,848	1,278	+570	.....	3,624	3,576	+48	.....
Ditto square inches	607,890	376,960	.....	+230,930	2,783,232	2,741,776	.....	+41,456
Photographic transfers	1,818	1,273	+545	.....	3,655	3,762	−107	.....
Ditto square inches ...	600,254	391,808	.....	+214,446	2,807,040	3,192,816	.....	−385,776
Silver prints	533	558	−25	.....	.....	.....	.....	.....
Ditto square inches ...	59,792	97,418	.....	−37,626	.....	.....	.....	.....
Transfer to zinc (number of plates)	800	807	−7	.....	5,000	4,705	+295	.....
Number of pulls	99,047	84,546	+14,501	.....	109,900	127,424	−17,434	.....
Ditto of printed sheets (single)	125,218	225,076	−99,858	.....	109,990	127,424	−17,434	.....
Ditto ditto (combined) ...	107,329	2 9,444	−102,115	.....	49,579	83,102	−33,523	.....
Proofs	1,366	927	+439	.....	4,753	4,723	+30	.....
Transfers	1,089	890	+199	.....	4,922	4,760	+162	.....

C.

Statement showing the Amount and Value of the work done for other Departments and despatched between 1st *October* 1881 *and* 30th *September* 1882.

Names of Departments.	Number of sections.	Number of negatives.	Number of pulls.	Number of complete copies.	Number of silver prints.	Price.
						Rs. A. P.
Asiatic Society	4	5	1,125	1,500	.....	144 6 0
Agent and Chief Engineer, Bengal Central Railway Company, Limited	22	21	900	2,300	.....	402 11 0
Chief Commissioner, Assam	.....	.....	200	200	.....	60 0 3
Calcutta Municipality	6	2	350	1,000	.....	94 0 3
Director of Public Instruction, British Burma	3	6	3,015	1,000	.....	073 0 6
Director-General of Railways	5	8	2,403	778	.....	791 12 5
Deputy Superintendent, Census, Burma	.....	.....	500	500	.....	58 15 6
Geological Survey of India*	6	6	1,690	1,604	.....	394 12 1
Government of India, Foreign Department	7	20	1,030	484	.....	693 10 7
Ditto ditto, Public Works Department, Irrigation	20	31	1,275	2,775	.....	627 6 5
Ditto ditto, Military Department	27	27	736	1,222	.....	640 2 0
Government of Bengal Public Works Department ...	64	125	7,454	7,555	6	3,438 11 11
Ditto ditto, ditto ditto, Railway ...	4	7	280	320	.....	142 9 6
Government, N.-W. P. and Oudh, Public Works Dept., Irrigation	23	23	1,200	4,000	.....	451 13 3
Inspector-General of Military Works	123	21	6,880	5,105	.....	3,106 8 0

* Two heliogravure plates not charged, printing being done in Copperplate Printing Branch.

Statement showing the Amount and Value of the work done for other Departments and despatched between 1st October 1881 and 30th September 1882—continued.

Names of Departments.	Number of sections.	Number of negatives.	Number of pulls.	Number of complete copies.	Number of silver prints.	Price. Rs. A. P.
Indian Museum	.....	.....	.....	.....	61	19 1 0
Secretary to the Chief Commissioner, British Burma ...	4	22	1,030	400	.....	583 13 9
Meteorological Reporter to the Government of India ...	6	4	405	405	.....	125 11 6
Marine Survey Department	10	27	3,395	2,350	.....	1,179 14 8
Manager, Tirhoot State Railway	7	8	200	350	.....	154 5 6
Ditto, Indus Valley State Railway	3	.....	600	600	.....	180 7 6
Ditto, Rajputana-Malwa ditto	2	2	220	220	.....	72 9 9
Ditto, Northern Bengal State ditto	2	.....	250	500	.....	51 2 0
Officer Commanding Darjeeling Depôt	1	1	.....	.....	21	41 8 0
Port Officer	5	0	630	330	.....	201 4 0
Quarter-Master-General in India	5	11	2,785	1,935	.....	664 4 9
Secretary to the Defence Committee	5	20	250	250	.....	401 6 6
Ditto to the Port Commissioners	4	14	510	500	.....	325 8 6
Superintending Engineer, Mysore	1	9	300	70	.....	204 3 9
Ditto ditto, on special duty, Bengal	2	7	250	150	.....	109 2 6
Sanitary Commissioner, Assam	1	2	170	170	.....	54 12 3
Colonel A. A. Kinloch	.....	.....	.....	.....	4	6 0 0
T. Bolton, Esq.	1	1	605	900	.....	66 8 9
Total ...	392	438	40,716	40,223	92	16,531 4 4
Cadastral North-Western Provinces (Photo-zincographs) ...	1,748	1,748	17,580	11,990	.....	20,795 0 0
Ditto ditto (Zincographs)	551	.....	5,525	5,895	.....	5,683 2 0
Ditto Burma (Photo-zincographs)	1,611	1,611	54,774	20,356	.....	20,103 14 6
Ditto ditto (Zincographs)	825	.....	28,050	9,022	.....	9,310 3 0
Ditto Bengal (Photo-zincographs)	104	104	3,782	955	.....	1,086 8 0
Ditto ditto (Zincographs)	1	.....	50	50	.....	13 4 0
Ditto Assam (Photo-zincographs)	16	16	400	325	.....	244 0 0
Total Cadastral ...	4,856	3,479	110,161	49,103	.....	69,835 15 0
Grand Total ...	5,238	3,917	160,877	89,416	2	

D.

Statement of Expenditure of the Photographic branch and of the Value of the work done and issued during the survey year from 1st October 1881 to 30th September 1882.

Normal Establishment.	Rs. A. P.	Rs. A. P.
Superintendent's salary	13,577 9 1	
Establishment	19,070 7 11	
House rent and taxes	4,483 8 0	
Contingencies	1,628 3 10	
		30,305 12 10
Cadastral Establishment.		
Establishment	10,304 7 1	
Contingencies	6,301 6 4	
		25,605 13 5
Chemicals and stores received from England	13,048 9 7	
Paper received from England	9,353 7 3	
		22,402 0 10
Paper and map cloth from the Stationery Office	432 8 0	
Stores and materials from the Stationery and other Government Offices	220 14 2	
		653 6 2
Stores received from the Mathematical Instrument Department	254 15 0	
Cost of repairs of articles at ditto ...	289 1 0	
		544 0 0
Miscellaneous stores received from other branches	20 8 4	
Printing paper received from Lithographic branch	4,464 7 2	4,484 15 6
Balance in favour of the Department ...	.....	21,648 11 1
Grand Total ...	.....	1,14,794 12 7

	Rs. A. P.	Rs. A. P.
Topographical and Revenue maps and other maps and plans issued to the Surveyor-General's and the Deputy Surveyor-General's Offices	28,300 7 6	
Miscellaneous work done for the other branches of the head-quarters office	127 1 9	
Miscellaneous extra-departmental maps and plans	16,631 4 4	
		44,058 13
Cadastral maps, North-Western Provinces	32,478 2 0	
Ditto British Burma ...	35,414 1 0	
Ditto Bengal	1,099 12 0	
Ditto Assam or Sylhet ...	244 0 0	
		69,835 15 0
Grand Total ...	.....	1,14,794 12 7

J. WATERHOUSE, *Major*, S.C.,
Asst. Survr.-Genl., in charge Photographic Branch.

Extract from the Narrative Report of J. B. N. HENNESSEY, Esq., M.A., *Deputy Superintendent, 1st grade, in charge Head-Quarters Offices, Trigonometrical Branch, Dehra Dún, for* 1881-82.

COMPUTING BRANCH.

Computing Branch.

THE following cost table of work done in this Branch is similar to the corresponding tables exhibited in the reports for previous years:—

Cost Tables in Rupees.

CLASS.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Average per cent.
1. Records, Library	24	46	54	23	22	25	65	22	21	30	27	32	1½
2. Computations	371	571	602	531	664	748	484	520	718	585	423	419	26
3. Accounts, returns, correspondence	483	322	261	238	230	254	360	382	403	467	543	509	17½
4. Supply	83	35	46	38	18	45	24	54	68	75	19	42	3
5. Press copy	236	228	210	235	330	424	224	167	167	311	257	140	12
6. Press proofs	213	101	167	190	146	251	195	160	221	176	214	207	9
7. Charts	14	9	47	28	14	59	34	9	34	53	38	11	1
8. Stations	90	52	63	127	171	64	74	105	196	89	59	91	4½
9. Leave and vacations	183	286	575	472	337	64	268	176	9	61	147	84	10½
10. Miscellaneous	...	...	...	...	...	...	...	...	92	89	173	184	5½
11. Meteorology and General Science {	445	402	108	210	201	208	384	547	...	...	...	...	10½
... ...	...	...	...	...	...	...	...	...	109	200	245	414	
TOTAL ...	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	10

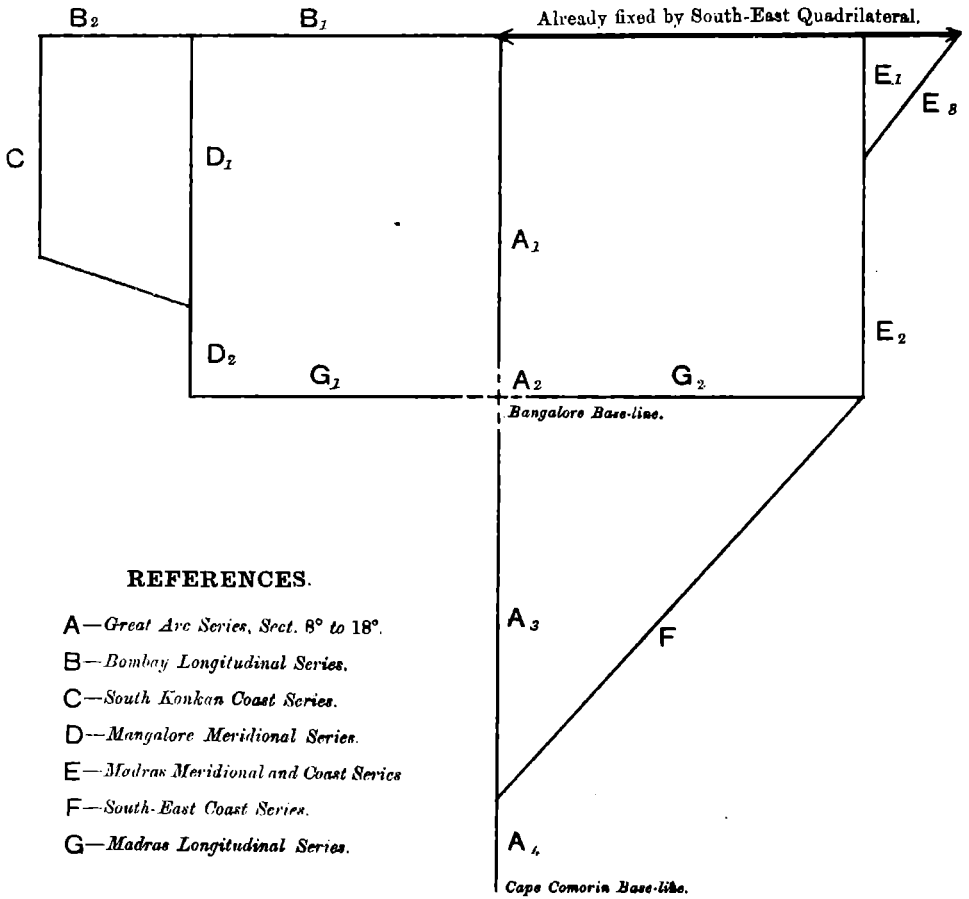
These percentages call for little remark, being about the same as in previous years, excepting in the case of class 6, which in the present return shows an average of about half the usual amount. It is also to be noticed that an additional class, viz. 11, has been introduced for the first time, it having hitherto been included in class 10—Miscellaneous. The average of the new class is unavoidably approximate on the present occasion, for the subdivision was adopted only in June. The percentage, however, is now seen to be sufficiently large to make the change desirable.

The particulars of the work done, indicated in a general manner in the preceding table, are given hereafter in such detail as appears desirable.

CLASS 2.—COMPUTATIONS (IN DUPLICATE).

Southern Trigon.—The simultaneous reduction was continued without interruption from the stages reported on last year as finished, and was concluded satisfactorily in due course. The following table states the 22 equations of condition, which may be followed with the help of the diagram, and the errors as given and as found after elimination. It will be seen that the residuals are very small.

SOUTHERN TRIGON.



REFERENCES.

A—*Great Arc Series, Sect. 8° to 18°.*
B—*Bombay Longitudinal Series.*
C—*South Konkan Coast Series.*
D—*Mangalore Meridional Series.*
E—*Madras Meridional and Coast Series*
F—*South-East Coast Series.*
G—*Madras Longitudinal Series.*

Error Table.

Number of equation.	Triangulation involved.	Value of Errors.				Residuals after computation with corrected angles.
		Given.	By substitution of "Indeterminate factors."	By substitution of deduced angular errors.		
				As computed to four decimals.	On contraction to three decimals.	
1	in side $(B_2 + C) - D_1$	+ 136·6	+ 136·600	+ 136·6044	+ 136·601	— ·3
2	„ λ Ditto	+ 0·022	+ 0·0220	+ 0·0213	+ 0·0218	— ·002
3	„ L Ditto	+ 0·078	+ 0·0780	+ 0·0773	+ 0·0778	+ ·002
4	„ A Ditto	— 0·251	— 0·2508	— 0·2506	— 0·2507	— ·002
5	„ λ $[B_1 + (D_1 + D_2) + G_1] - (A_1 + A_2)$	— 0·001	— 0·0010	— 0·0009	— 0·0008	+ ·005
6	„ L Ditto ditto	+ 0·288	+ 0·2880	+ 0·2864	+ 0·2878	+ ·003
7	„ A Ditto ditto	— 3·080	— 3·0800	— 3·0877	— 3·0805	+ ·003
8	„ side Ditto $+ A_2$	— 22·7	— 22·703	— 22·6551	— 22·700	+ ·3
9	„ „ $A_1 + A_2$	+ 20·0	+ 19·990	+ 19·9929	+ 19·998	+ ·3
10	„ λ $A_1 + A_2 + G_2 - (E_1 + E_2)$	0·000	0·0000	— 0·0035	— 0·0003	+ ·004
11	„ L Ditto ditto	— 0·174	— 0·1740	— 0·1711	— 0·1737	+ ·001
12	„ A Ditto ditto	+ 4·303	+ 4·3037	+ 4·2845	+ 4·3029	·000
13	„ side $(E_1 + E_2) + G_2 + A_2$	+ 39·9	+ 39·901	+ 40·2144	+ 39·900	+ ·3
14	„ „ $A_2 + G_2 + F + A_4$	+ 21·5	+ 21·498	+ 21·3059	+ 21·503	·0
15	„ „ $(A_2 + A_3 + A_4)$	+ 1·1	+ 1·094	+ 1·0225	+ 1·097	— ·1
16	„ λ $(A_2 + A_3) - (G_2 + F)$	— 0·273	— 0·2720	— 0·2719	— 0·2728	— ·005
17	„ L Ditto ditto	+ 0·424	+ 0·4240	+ 0·4234	+ 0·4238	— ·004
18	„ A Ditto ditto	— 9·040	— 9·0393	— 9·0211	— 9·0404	·000
19	„ side $E_1 - E_3$	+ 11·7	+ 11·700	+ 11·6165	+ 11·698	·0
20	„ λ Ditto	— 0·043	— 0·0418	— 0·0462	— 0·0419	·000
21	„ L Ditto	— 0·001	— 0·0011	+ 0·0029	— 0·0007	+ ·002
22	„ A Ditto	— 0·319	— 0·3195	— 0·3283	— 0·3189	+ ·003

NOTE.—The units of this table are—in side, the seventh place of logarithms; and in λ, L, and A, a second of arc.

The exhibits of this table assume the completion of the usual after-computations of triangles λ, L, and A, which are included in the following statement:—

Triangles up to log feet	350
Auxiliary figures	7
Second deductions of λ, L, and A	200
First deductions of latitudes and longitudes (chiefly for supplying data for longitude work)	30
Compound figure, Ceylon Series	1

The compound figure last mentioned presented some peculiar features. It was originally ground in the ordinary way as *two* figures, *i.e.* a quadrilateral and a hexagon, of which only some triangles presented unusually large errors, amounting to over 6 inches; but it could be seen that the whole of these errors may be accounted for by assuming the displacement of a single ray at but one of the two stations *common* to the two figures. Moreover, these two stations were unavoidably only $\frac{3}{4}$th mile apart; and as the sites were subject to high winds while the drops for the plumb-lines were considerable, there was every reason to suppose that improved results would be secured by rejecting the ray in question. This was verified by actual computation, and the displacement detected; but the reduction of a compound figure of the kind, it will be found, presents some special difficulties.

Observed Latitudes.—The amount of progress has unavoidably been less than desirable, though quite commensurate with the working power available. On the one hand the mass of observations is considerable: there are 906 stars in all, and several pairs of these

have been observed at 117 stations (including revisits). On the other, the nature of the work has not hitherto admitted of employing more than one pair of computers: even these two were required for still more pressing computations, so that their services have been diverted from the latitudes for five months out of the past twelve. In fact, two computers have been on loan to field parties for three-fourths of the year.

Notwithstanding interruptions, sensible progress has been made. Having exhausted the information in all available catalogues, (provisional) places and variables were adopted for the remaining 106 stars (epoch 1850), and from these the required sub-epochal values for years of observation were found. The facts of the place-table, *i.e.* N. P. D., procession, secular variation, and proper motion, were then suitably abstracted for the whole of the 906 stars. This enabled the computers to enter on the next stage, *i.e.* finding the latitude from each concluded zenith distance (or Z). In arranging for this end, every advantage will be taken of the components already computed by the field parties, as reduction to *apparent* N. P. D. (or Δ), refraction, collimation, &c., &c. Though, however, these components are mostly forthcoming, it is necessary that they should first be suitably combined before the successive values of Δ and Z can be exhibited. This, with entries of results, comparison against duplicate records, correction of mistakes discovered, &c., require great care and circumspection, which are not compatible with rapid execution. Notwithstanding, the required entries have been deduced and made for some 40 stations, and are now under comparison.

Besides foregoing, a table has been put in hand by which the adopted values of Δ (or provisional place) may be checked hereafter.

N.-E. Quadrilateral.—North-East Longitudinal Series, Assam Valley Triangulation, and Ganges River Triangulation between Mirzapur and Chunar.

Main Series	Triangles computed	18
	Deductions of latitude, longitude, and azimuth computed	24
	Weights of angles, computed	54
Secondary	Triangles, adjusted and computed	477
	Traverse of 57 triangles, computed and adjusted	1
	Deductions of latitude, longitude, and azimuth, computed or corrected	660
	Extra azimuths, computed	92
	Heights, corrected	325

Volume VII.—Various tables prepared for incorporation in the sections of this volume.

Computations for Colonel Tanner of work in and around Gilgit.—Computed 448 secondary triangles; 310 deductions of latitudes, longitudes, and azimuths; and 110 deductions of heights; 15 deductions of azimuth and side from given latitude and longitude; besides a variety of miscellaneous work in the way of examining angle books, preparing abstracts and synopses, &c. (Occupied a pair of computers, 3½ months.)

Computations for Colonel Branfill, Colonel Campbell, Majors Rogers and Hill, in connection with the Mergui base line, and latitude and azimuth observations, the Eastern Frontier Series and Burmah Party operations, and the electro-telegraphic longitude work.—The calculations, &c., are of so very miscellaneous a character that it would be tedious to detail them. They occupied a pair of computers five months in all.

Incidental computations.—Connected chiefly with supplying of data called for by various officers, including the calculation of 65 deductions of side and azimuth from given latitude and longitude (for Major Holdich), the calculation of 26 deductions of principal latitudes and longitudes for Mr. Beverley, &c., &c. (Occupied a pair of computers half a month.)

The amount of assistance in computations and otherwise necessarily required by field parties was considerable: it is approximately indicated in foregoing. Notwithstanding this help, various field operations unavoidably remain to be reduced, including the measured length of the Mergui base line.

Class 3.—Accounts, Returns, Correspondence.

As mentioned in last year's report, the designation of this class is more general than special, to avoid undesirable increase in the adopted number of classes. Briefly, a considerable portion of the work embraced in this class is of a purely professional nature, presenting much variety in kind.

Class 4.—Supply.

Requisitions from over thirty officers for data of various kinds have been complied with. Amongst the officers so supplied were Major Bailey, R.E., Superintendent of Forest Surveys, and Mr. J. H. Fisher, in charge Provincial Gazetteer, North-West Provinces. 1,135 despatches of maps, charts, books, &c., were made during the year.

Class 5.—Press Copy.

Southern Trigon.—The compilation of Descriptions of Stations (Principal) for publication has been gone on with so far as practicable. The abstracts of angles have been finally compared and now stand complete. In the reduction of figures some further recomputation was necessary, and this has been done.

Electro-longitude, or Volume IX.—Certain portions of tabular matter have been transcribed and compared; also the press copy as received has been examined generally.

Latitude Volume, or Volume X.—Major G. Strahan prepared various drawings of Strange's Zenith Sector, and Colonel Campbell wrote an account describing the instrument

and how to use it. These were examined and discussed. Subsequently, the drawings were placed in the hands of the engravers (Surveyor-General's Office, Calcutta), and of the letter-press a few Provisional Prints were struck off in this office.

N.-E. Quadrilateral, Volumes VII and VIII.—Introductions to seven of the sixteen series forming this Quadrilateral were reported last year as passed to press: those to eight more have during the present year been completed, and considerable progress has been made with the only remaining introduction (viz. to the Assam Longitudinal Series). The tables of non-circuit triangles and of the final figural adjustments have been fully compared. Vocabulary of native words prepared. Addendum to Descriptions of Principal Stations compared for 10 series. Rough draft prepared of section 19, volume VII, describing and comparing certain differences in details of processes adopted in the reductions of the several quadrilaterals. Volume VII completed in all respects, and sent on to binder.

Synoptical Volume of Assam Longitudinal Series.—Azimuth table extended to include work of 1876–78 (wants recomparison); Co-ordinate list extended so as to include *part* of work of 1876–78 (wants completion and comparison).

Synoptical Volume of the Gurwani Series.—Extended Co-ordinate list to include Ganges River Triangulation between Mirzapur and Chunar.

Eastern Sind Series.—Partly abstracted, and compared observed angles and reduction of figures. Prepared letter-press of Eastern Sind Series, Preliminary Chart (seasons 1879–81); this needs comparison in part Prepared and compared letter-press of Sehwan Series, Preliminary Chart (season 1880-81).

Assam Valley Triangulation.—Compiling letter-press for Preliminary Chart of seasons 1876-78.

Bangkok Triangulation.—Prepared and compared tabular portion of letter-press for Preliminary Chart.

Spirit-leveled Pamphlet No. 4, Southern India.—Examined generally and corrected orthography; addendum prepared, giving a *précis* of the reduction by minimum squares of the levels between Bombay, Karwar, and Madras; and the corrections required by this reduction introduced into the press copy (wants comparison before publication).

Route Book, 3rd edition.—Examined the additions and corrections to former edition.

Miscellaneous.—Arranged (alphabetically, a list of names for Mussooree cemetery plan, and checked it against the inscriptions.

Class 7.—Charts.

Final	...	Compared Calcutta Meridional Series and addendum to Gurwani Series. Corrections examined in Hurilaong Series.
Preliminary	...	Compared Assam Valley triangulation, season 1876-78. Ditto Eastern Sind Series, season 1879-81. Ditto Sehwan Series, ,, 1880-81.

Miscellaneous.—Assisted Colonel Branfill in plotting Preliminary Charts of Eastern Sind Series (1879-81) and Sehwan Series (1880-81). Examined generally diagrams for level sheet No. 82, and fair drawing to illustrate Pamphlet of Spirit-levels No. 4, Southern India. Examined and corrected orthography in a list of names occurring in Atlas Reduction of sheet No. 2, Dehra Dún survey. Examined chart of portion of the North-East Longitudinal Series, prepared for Captain Harman's use. Examined delineation (on Preliminary Chart of Pegu, Rangoon, and Coast Series) of coast line along the Irrawaddy delta, and of the traverse from below Rangoon to connect the Krishna shoals with the triangulation. Compared two charts, showing portions of the triangulation in Burma, prepared for the Marine Survey. Examined several diagrams for volume of Electro-Longitudinal Operations; Skeleton Chart of Principal Chains of Triangles, and the frontispiece for volume VII. Entered correct values of Spirit-leveled and Railway Heights on several sheets of the Kattywar Survey for second edition. Examined Plan of the Mussooree cemetery. Prepared rough working-charts of Ganges River Triangulation from Mirzapur to Chunar, and of two minor series emanating from the Assam Valley Triangulation.

Class 8.—Stations.

The increased percentage for this class makes it desirable to give a few particulars as in the following table, indicating the amount of work annually devolving on this office in carrying out the important duty of protecting our principal stations for the benefit of all future surveys: the table also shows what has been done in past years towards enabling the local officers to recognize the stations in question:—

Number of stations.	Number of districts in which stations occur.	Number of lists in which the stations are included.	Duplicate (*i.e.*, finally disposed of) lists.		Number of lists sent out from this Office during this year.		Number of Local Officers who have—		Number of stations protected during the year.	Number of bills audited and passed.	Total cost.	Average cost per station.	Number of letters, dockets, &c., issued.
			Number of lists.	Number of stations included.	New.	Supplementary.	Reported during the year.	Not reported during the year.					
											Rs.	Rs.	
3,472	338	317	310	3,458	.....	8 descriptive of 27 stations.	203	54	764	216	3,435	4-8	About 800

Under existing orders, District Officers and Political Agents are authorized to expend for the protection of each station a sum not exceeding on an average Rs. 4 per annum; any outlay in excess of this amount cannot be incurred by them without special authority from this office. The officers are also required to report annually on the condition of the stations, and as a rule this duty is discharged efficiently: on the present occasion it will be seen that there are 54* exceptions, or about 17 per cent.

Class 10.—Miscellaneous.

Volumes of the G. T. Survey.—Volume VII, pages examined, sorted, and despatched to Calcutta for binding. Synoptical Volumes VII, X, XI, XII, and XIII, distributed.

Examination papers.—Six sets prepared for examination of candidates for Junior branch of the Department, and the workings of four candidates examined.

Time observations.—Forty-two sets of observations to the sun (on 14 days) for time taken, and reduced in duplicate.

Examined and reported on the Annual Report (MS.) of the Kattywar Party for 1880-81.

Examined and reported on Mr. Rendell's account of the crossing of the line of spirit-levels over the Hooghly by simultaneous observations of Tide heights on both banks.

Examined and reported on Major C. Strahan's form for the calculation of Interpolated points.

Reported on (and corrected in some cases) heights on certain 5-minute compartments of India sent in by field parties.

Examined and reported on (1) Crellin's Traverse tables; and (2) Mackesy's tables for the calculation of Barometric heights.

Devised and prepared specimen forms for reduction of Southern Trigon.

Cost table prepared for the several scales of survey on the Kashmir, the Kumaun, and Garhwal, the Dehra Dún, and the Jaunsar-Bawar Survey operations.

Discussion of assimilation of certain office forms for the three branches of the survey.

Examined proposed symbols for maps.

Deduced Telegraphic longitudes of seven stations for comparison with Geodetic.

Set up stage at Mussooree Observatory for new large Anemometer, and mounted the instrument.

Mergui base line.—The preparations for this base line, measured in 1881-82 under the supervision of Colonel Branfill, necessarily caused a considerable amount of care and labour to this office in general. The apparatus had not been used for twelve years, so that the whole of the instruments required at least cleaning and adjusting, while several needed repairs; and other portions, as trestles, had mostly to be constructed anew for the occasion. It was also necessary to revive recollections of the art, which, like others, does not improve with disuse; nor were the difficulties diminished by the fact that the old base line *native* establishment, if not officers, had of course become very scarce. In addition to the arrangements above briefly indicated, provision was also made, by preparation of suitable books, for the field records of the measurement.

Class 11.—Meteorology and General Science.

Meteorological Observations.—Taken at Dehra twice on every day of the year, and at Mussooree during about seven months. The results for Dehra have been supplied month by month to the Meteorological Reporter to Government, North-Western Provinces and Oudh; and daily weather telegrams from Mussooree (for some seven months), as well as the anemograms for both Dehra and Mussooree, have been supplied to the Meteorological Reporter to Government of India. The usual tables of monthly results and of the mean velocity of the winds at Dehra are appended.

Earth temperatures.—These observations are briefly introduced in the report for 1880-81, and further particulars as to procedure would be redundant or out of place here. The series, moreover, has as yet been continued for only one and a half years, so that detailed discussion

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* Note.—Of these there are—

In the Punjab	4	In Bombay	5
,, North-Western Provinces ...	12	,, Madras	5
,, Bengal...	2	,, Central Provinces	2
,, Sind	1	,, Native States	23

would be premature. It may, however, prove useful to give the monthly mean temperatures obtained, and these are accordingly exhibited in the following table:—

Mean Monthly Readings of Deep-sunk Earth Thermometers.

Year and Month.	Depths in feet of thermometer bulbs below surface of ground.					Thermometer in shade.
	25·0	12·8	6·4	3·2	1·1	
1881.						
June	73°·55	74°·87	80°·06	85°·93	89°·16	87°·68
July	73°·90	76°·47	81°·01	83° 20	84°·14	82°·84
August	75°·02	77°·88	80°·75	82°·03	82°·55	81°·00
September	76°·07	78°·93	81°·24	82°·40	83°·19	82°·86
October	76°·69	79°·26	80°·33	79° 67	77°·81	82° 72
November	76°·98	77°·71	75°·80	72°·20	67°·91	75°·28
December	76°·71	74°·80	70°·58	65°·63	60°·72	71°·19
1882.						
January	76°·91	72°·83	67°·17	62°·57	58°·01	66°·77
February	76°·13	76°·79	68°·08	62°·31	59°·41	66°·61
March	74°·52	70°·47	67°·75	67°·01	66°·60	81°·36
April	74°·11	71°·70	72°·20	76°·49	78°·88	88°·72
May	73°·07	71°·37	76°·47	80°·66	84°·09	91°·04
June	74°·05	75°·23	80°·01	84°·77	88°·24	86°·11
July	74°·31	76°·57	80°·78	82°·71	83°·48	81°·61
August	74°·05	78°·20	81°·30	83°·04	84°·08	82°·40
September	75°·69	78°·88	81°·32	82°·20	82°·89	84°·02
October	76°·14	79°·02	80°·16	79°·21	77°·85	83°·47
November	76°·30	77°·64	75°·78	71°·73	67°·96	75°·04
December	76°·37	74°·89	71°·03	66°·14	62°·17	72°·36

Note.—The second places of decimals are purely arithmetical outcomes.

Contrasting to the following extent the Dehra results for 1882 with the means for Greenwich 1847–1873:—

Depth.—Feet.	1882 Dehra (or D) ... ... Lat. ... 30° 19′ Long. ... 78° 3′ Height ... 2,200 ft.				1847–1873 Greenwich (or G) ... ... Lat. ... 51° 29′ Long. ... 0° 0′ Height ... 200 ft.			D—G.		
	Minimum.	Maximum.	Range.	Minimum.	Maximum.	Range.	Minimum.	Maximum.	Range.
6·4	Feb. ... 66°·06	Sept. ... 81°·32	15°·26	Feb. ... 44°·81	Aug. ... 59°·05	14°·85	21°·26	21°·67	0°·41
				March ... 44°·80					
12·8	March ... 70°·47	Sept. ... 78°·98	8°·65	March ... 40°·47	Sept. ... 55°·77	9°·34	24°·04	23°·25	− 0°·79
		Oct. ... 79°·02		April ... 40°·43					
25·6	May ... 73°·07	Nov. ... 76°·39	2°·42	May ... 48°·06	Nov. ... 52°·22	3°·27	25°·02	24°·17	− 0°·85
		Dec. ... 76°·37		June ... 48°·05					

So far as it goes, the result is curious. It may be added that the two greater depths at Dehra indicate lower maximum temperatures in 1882 than in 1881.

Actinometry.—The necessity for this work, and the eligibility of certain localities in India as stations of observation, are now so fully recognised, that the Secretary of State, co-operating with the Solar Physics Committee, South Kensington, has sent out Sergeant Rowland, R.E., in order that he may be instructed to take a series of observations, extending over at least two years, at Leh, in Kashmir. Sergeant Rowland landed in India on 1st November 1882, so that it is anticipating events to allude to him before next report. The allusion, however, is necessary in order to explain briefly my connection with actinometry, and that the Meteorological Reporter to Government, H. F. Blanford, Esq., F.R.S., has found it convenient to place the Sergeant under my orders here pending his departure to Leh.

Some 15 years ago the Royal Society placed certain instruments suited for high altitude at my disposal, for use in my leisure hours, including two of Hodgkinson's actinometers. I commenced using these in 1869 at Mussooree, where the brilliant weather, especially in autumn, admits of excellent work. Subsequent observations with these instruments, and recently with a Stewart's actinometer, were made from time to time and published in the Proceedings of the Royal Society,* together with my discussions of the results and earnest representations that the most important work of actinometry should be vigorously prosecuted. The work performed by "a sunbeam," at any rate on this globe, from "propelling a locomotive" to governing the commonest events of life, is of vital importance to us all; and it is certainly a matter for astonishment that one of the most powerful of solar forces, radiation, should remain so little measured as it is.

* No. 125 of 1870.
,, 208 of 1880.
,, 220 of 1882.

In consequence of these actinometric observations, I have acquired familiarity with the work, which at first was *all* done entirely in leisure hours; but as the subject became more attractive and appreciated, it was necessary to obtain some help from my assistants, and hence to show, as has been done in the cost table, the percentage due to this, as well as to kindred scientific duties in which the office is called on to co-operate. My opportunities for using the actinometer are necessarily limited to the fine weather which may occur during my residence at Mussooree in summer. The work is still done largely in leisure hours, but the opportunities are only few in number under the circumstances. The results, however, help to indicate what should and may be done, and are likely to prove useful guides. Apart from

this, the proceedings of the Royal Society also show what facts have been elicited, but their repetition here would be out of place. The actinometer was used a few days last summer and again in autumn ; but I have had no leisure as yet to discuss the results.

Solar eclipse, 1882, *May* 16-17.—This happened at Mussooree to the considerable extent of about eight digits. It occurred to me that with the help of a *continuous* actinometrical series an attempt may be made to measure *variations* of radiation in *different* parts of the sun's surface. The project was carried out, but the sky and sun were covered with light clouds throughout, so that the results are vitiated. The negatives taken with the photo-heliograph at Dehra present a complete and interesting series.

Exploration.—After an absence from India of about three years, explorer M— S— returned with a valuable traverse of various routes in and around Badakhshan. His journal and itinerary were arranged and translated in this office, and passed on for printing orders. Under the circumstances, a description is unnecessary here. The sketch map illustrating these travels was taken from a more comprehensive compilation prepared by Colonel Tanner : the sketch was examined and made consistent with the translation on which it depended.

TYPOGRAPHIC BRANCH.

The usual table showing the work annually performed by this branch during the past five years is given below, the unit (a page of foolscap) being the same throughout :—

	1877-78.	1878-79.	1879-80.	1880-81.	1881-82.
Pages composed	2,050	1,844	1,421	1,363	1,283
„ printed	630,894	590,043	494,136	480,672	471,616

An analysis of the pages composed furnishes the following :—

	Pages.
For Professional Volumes VII and VIII	444
„ „ „ IX (Longitude Volume)	290
„ „ „ X (Latitude „ Provisional)	24
„ „ „ Southern Trigon	177
Total ...	935
For Volume of Kandahar and Khakrez Triangulation	12
„ Auxiliary Tables	9
„ Spirit-leveled Heights, No. 4, Southern India (since superseded for re-printing)	57
„ charts, orders, memoranda, forms, &c.	270
Total ...	348

PHOTOZINCOGRAPHIC BRANCH.

The following are the particulars of the work executed by the Photozincographing Branch during the year :—

Maps.

Subjects.	When published.	Number of parts.	Number of sheets printed.
Prints of maps published in former years	.....	39	3,870
Reserved forests, Bahraich *(for Forest Department)* ...	October 1881	1	300
Guzerat Survey, sheet No. 5	„ „	1	194
Sketch of Lower Dawar Valley	„ „	1	65
Ditto the Khaisor Pass Waziristan	„ „	1	65
Ditto the Waziristan Defile	„ „	1	65
Spirit-leveled heights, sheet No. 75	„ „	1	207
Index to the Darjeeling Survey	„ „	1	200
Reserved forests, Kumaon and Garhwal Division *(for Forest Department)*	„ „	1	322
Reserved and protected forests, Kumaon and Garhwal Division *(for Forest Department)*	November „	1	322
Reserved forests, British Burma *(for Forest Department)* ...	December „	1	453
Guzerat Survey, sheet No. 16	„ „	1	187
Cutch Survey, sheet No. 5	January 1882	1	142
Index to the Cutch Survey	„ „	1	463
Index to the Level Charts	„ „	1	466
Kumaon and Garhwal forest map, sheet No. XLVIII *(for Forest Department)* ...	„ „	1	67
Ditto ditto, No. XLVII *(ditto)* ...	„ „	1	69
Ditto ditto, No. LXVII *(ditto)* ...	„ „	1	69
Ditto ditto, No. XIII *(ditto)* ...	„ „	1	67
Ditto ditto, No. LXIII *(ditto)* ...	„ „	1	70

Subjects.	When published.	Number of parts.	Number of sheets printed.
Index to the Guzerat Survey	January 1882	1	495
The Russo-Persian Frontier	,, ,,	1	156
Dehra Dún Cemetery	February ,,	1	22
Kumaon and Garhwal forest map, sheet No. XLVI *(for Forest Department)*	,, ,,	1	65
Spirit-leveled heights, sheet No. 82	,, ,,	1	109
Kumaon and Garhwal forest map, sheet No. XLIV *(for Forest Department)* ...	,, ,,	1	69
Ditto ditto, No. LXII *(ditto)* ...	,, ,,	1	72
Ditto ditto, No. LX *(ditto)* ...	,, ,,	1	73
Ditto ditto, No. XII *(ditto)* ...	,, ,,	1	67
Reserved forests, Bamunpokri *(for Forest Department)* ...	,, ,,	1	95
Kumaon and Garhwal forest map, sheet No. LXI *(for Forest Department)* ...	March ,,	1	67
Ditto ditto, No. LXVII *(ditto)* ...	,, ,,	1	70
Cutch Survey, sheets Nos. 3, 4, 10, and 11	,, ,,	1	135
Ditto, sheet No. 16	,, ,,	1	141
Trans-frontier map No. 9, 2nd edition	,, ,,	1	136
Guzerat Survey, sheet No. 17	April ,,	1	140
Cutch Survey, ,, No. 13	,, ,,	1	139
Ditto, ,, No. 14	May ,,	1	130
Guzerat Survey, ,, No. 33	,, ,,	1	180
Ditto, ,, No. 33, section 1	,, ,,	1	85
Ditto, ,, No. 34	,, ,,	1	194
Russian Turkestan, ,, No. 9 *(for Foreign Office)* ...	,, ,,	2	32
Guzerat Survey, ,, No. 77	,, ,,	1	206
Ditto, ,, No. 50, section 1 *(Dang Forests)* ...	June ,,	1	95
Ditto, ,, No. 49, ,, 5 *(ditto)* ...	,, ,,	1	115
Ditto, ,, No. 49, ,, 8 *(ditto)* ...	,, ,,	1	95
Ditto, ,, No. 34, ,, 1	,, ,,	1	86
Kohat Survey, plane-table, sections Nos, 1, 2, 3, 4, 5, 6, and two unnumbered sections	,, ,,	8	1,069
Map of Mussooree and Landour *(for North-Western Provinces Gazetteer)*	July ,,	1	714
Alexandria Harbour, plan of	,, ,,	1	80
Northern Waziristan	,, ,,	1	202
Southern ditto	,, ,,	1	278
Turkistan map, sheet No. 1 (provisional prints)	,, ,,	1	30
Ditto, ,, No. 3 (ditto)	,, ,,	1	28
Ditto, ,, No. 4 (ditto)	August ,,	1	
Guzerat Survey, sheet No. 33, section 3	,, ,,	1	90
Mussooree Cemetery	September ,,	1	57
Total ...	.....	103	13,471

In addition to the foregoing, 460 blue prints and 726 silver prints (146 subjects) were prepared for the use of executive officers :—

Charts.

Subject.	When published.	Number of parts.	Number of copies printed.
Budhon Meridional Series, final	October 1881	1	407
Chart illustrating triangulation in Kattywar, degree No. IX ...	,, ,,	1	20
Kumaon and Garhwal forest triangulation, sheet No. III *(for Forest Department)*	January 1882	1	56
The Malabar Minor Series, season 1879-80	February ,,	1	69
Karara Meridional Series, final	March ,,	1	405
Reduction Chart of the Budhon Meridional Series, final ...	,, ,,	1	348
Eastern Frontier Series, season 1880-81, preliminary ...	April ,,	1	64
Hurilaong Meridional Series, final	May ,,	1	439
Calcutta Meridional Series, final	,, ,,	1	406
Chendwar Meridional Series, final	,, ,,	1	355
Eastern Sind Series, season 1879-81, preliminary	August ,,	1	67
Eastern Frontier Series, secondary triangulation to Bangkok, season 1879-80, preliminary	,, ,,	1	65
Western Coast of Burma, sheet No. 1 *(for Marine Survey)* ...	September ,,	1	50
Ditto ditto, No. 2 *(ditto)* ...	,, ,,	1	50
Northern Afghanistan	,, ,,	4	450
Sehwan Minor Series, season 1880-81, preliminary	,, ,,	1	69
Burmah Triangulation, Pegu, Rangoon, and Coast, showing also the traverse to the Krishna Shoals, seasons 1878-80, preliminary	,, ,,	1	88
Reduction Chart of the Jodhpur Meridional Series, final ...	,, ,,	1	78
Total ...	.....	21	3,486

Diagrams.

Subject.	When published.	Number of copies printed.
Polygons and other figures to illustrate figural reductions for volumes of the Great Trigonometrical Survey, bench-marks, &c. ...	October 1881	520
	January 1882	618
	February ,,	909
	March ,,	1,052
	June ,,	298
	July ,,	25
	August ,,	857
	September ,,	510
Total ...	.....	4,789
Professional and office forms	.....	24,987

The total number of negatives taken is 885, the number of chromo-carbon prints 1,089, and the number of transfers to zinc 189.

Contrasting the work performed since 1877-78, we have—

Year.	Maps.	Blue prints.	Silver prints.	Charts.	Diagrams.	Forms, &c.
1877-78	12,481	195	426	4,531	4,877	23,736
1878-79	20,229	1,394	353	2,642	2,603	20,070
1879-80	15,100	588	1,021	3,821	2,271	17,909
1880-81	15,659	414	52	1,886	3,367	19,508
1881-82	13,471	460	726	3,486	4,789	24,987

An abstract of the work executed during the past five years stands thus—

Subject.	Number of Prints.				
	1877-78.	1878-79.	1879-80.	1880-81.	1881-82.
Maps, charts, diagrams	21,889	25,474	21,192	20,912	21,746
Blue prints	195	1,394	588	414	460
Silver prints	426	353	1021	52	726
Forms, &c.	23,736	20,070	17,909	19,508	24,987

The money actually realized and credited to Government from sales of maps, &c., during the year is Rs. 743-10-10.

DRAWING BRANCH.

The following tables exhibit the work performed in this branch :—

Description of Work.	Number of Sheets or Diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Final Charts.				
Brahmaputra Series	.....	1	4	For reduction by photozincography.
East Calcutta Longitudinal Series	1	.....	4	
Eastern Frontier Series	.....	1	4	
Calcutta Meridional Series	1	.....	4	
Ganges River Triangulation, for incorporation in Gurwani Series	1	.....	4	
Preliminary Numerical Charts.				
Assam Valley Triangulation, seasons 1876-78 ...	2*	.....	4	For photozincography.
Eastern Sind Series, seasons 1879-81	1*	.....	4	
Sehwan Minor Series, season 1880-81	1	.....	4	
Gilgit Triangulation	1	.....	8	For office record.
Burma Coast Line Triangulation, secondary, seasons 1878-80	1	.....	4	For photozincography

* The letter-press appertaining to these charts is not yet complete.

Description of Work.	Number of Sheets or Diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Compilation.				
Charts of the Western Coast of Burma, with hills (for Marine Survey)	2	.....	4	For photozincography.
Turkistan map, sheets Nos. 1, 2, 3, and 4 (6th edition) ...	4	.....	32	
Spirit-leveled height charts, sheets Nos. 67, 81, 83, and 88	.....	4	2	
Map of Jaunsar Bawar, with hills	1	.....	1	
Atlas reductions of sheets 2 and 3, Dehra Dún and Siwalik Survey	1	1	Atlas scale	For incorporation in atlas sheet No. 48.
Map of Astor and Gilgit with surrounding country ...	1	.....	4	For photozincography.
The Aglar Valley, portion of country between Landour and Nagtiba ranges	1	.....	2	For reduction by photozincography and incorporation in atlas sheet No. 48.
Trans-frontier map No. 9 (2nd edition)	1	.....	8	
Trans-frontier map No. 9 (3rd edition)	.....	1	8	
Map of country on North-Western Frontier ...	1	.....	4	For correction of atlas sheet No. 14.
Sketch map illustrating the explorations of M— S— in and around Badakhshan, 1878-81	.....	1	8	For reduction by photozincography.
Map of the Panjah (Upper Oxus) States and Dardistan	1	.....	8	For office record.
Routes for new addition of pamphlet to accompany Himalayan Route map	.....	.....	.....	
Skeleton chart of principal chains of triangles west of meridian of 92° (for professional volume VII) ...	1	.....	96	For reduction by photozincography.
Maps of parts of Arabia and Persia for the Resident in the Persian Gulf	.....	2	32	For photozincography.
Skeleton chart of principal chains of triangles as completed up to May 1882; also the proposed secondary triangulation in Upper Burma and in the Malayan Peninsula (for Surveyor-General's Annual Report to Government)	1	.....	96	For reduction by photozincography.
Map No. 4, Southern India, illustrating spirit-leveling operations of G. T. Survey, season 1880-81 ...	1	.....	12	Ditto ditto.
Chart of the principal chains of triangles included in the N.-E. Quadrilateral (for professional vols. VII and VIII)	1	.....	32	For reduction by photozincography.
Charts of the N.-E. Longitudinal Series (for Captain Harman, R.E.)	8	.....	4	For use of field party.
Miscellaneous.				
Tabulated mean heights above sea-level of 5-minute compartments in 54 degrees of latitude and longitude	.....	.....	.....	
Calculated the areas of Chamba State, Dehra Dún district, and the dominions of the Maharaja of Kashmír (for various officers)	.....	.....	.....	
Examined and corrected the following :— atlas reductions, Guzerat Survey, sheets Nos. 5, 6, 7, 8, 14, 15, 16, 25, 26, 27, 28, 29, 31, 78, 79, and 80; Kattiwar Survey, sheets Nos. 39, 40, 41, 49, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60, and 61; Cutch Survey, sheets Nos. 3, 4, 5, 10, 11, 12, 13, 14, 15, 16, and 22 ...	... ..	.....	.....	
Examined and reported on, corrected and passed for the press, 16 original maps of topographical surveys, excluding the above sheets ...	.....	.....	.. ...	
Examined 294 proofs of maps and charts; coloured 8,749 maps	.. ..	... ..	.....	
Tabulated Dr. W. Griffith's heights in Afghanistan (for the Surveyor-General)	.....	.....	.....	
Plotted explorer M— S —'s route survey in and around Badakhshan	.....	.....	.....	For engraver.
Drew diagrams of zenith sector	.....	.....	.....	
Drew anemogram form (for recording velocity and direction of wind)	.....	.....	.....	For photozincography.
Drew actinometer observation curves	.....	.....	.....	
Prepared a tracing of level heights along Chenab river in Gujranwala district	.....	.....	.....	

Description of Work.	Number of Sheets or Diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Miscellaneous—concluded.				
Prepared two indexes showing level data in hand and data published (for office use)	.....	.....	.....	
Traced profile section of Bari-Doab Canal, 4th division (for level sheets)	.....	.....	.....	
Prepared tracing of Russo-Persian boundary east of the Caspian Sea (for Foreign Office)	.....	.....	.....	
Drew form for computation of interpolated points ...	.....	.....	.....	For photozincography.
Drew scale for pen equation (for longitude volume) ...	.....	.....	.....	
Extracted latitudes and longitudes of numerous places in several districts for Mr. Fisher's Gazetteer of the N.-W. Provinces	.....	.....	.....	
Corrected Atlas Sheets Nos. 67 N.E. and 13 N.E. ...	.....	.....	.....	For engravers.
Drew diagram of Cachar Branch Series (for professional volume VIII)	.....	.....	.....	For photozincography.
Prepared tracings of boundaries of several Hill States in the Punjab (for the Commissioner of Umballa) ...	.....	.....	.....	
Printed Plate III, Commutator Board (for longitude volume)	.....	.....	.....	For photozincography.
Drew diagram of ground thermometers	.....	.....	.....	
Compared 341 pages (royal size) of descriptions of bench-marks in Bareilly district (for Executive Engineer)	.....	.....	.....	
Miscellaneous current duties, including preparing for the press several maps of the topographical surveys and of the forest survey, transliterating Russian names, reducing maps by pantagraph, and affording assistance to officers and to the Photozincographic Office, &c., &c.	.....	.....	.....	

The preceding tables of the Drawing and Photozincographing branches present various points of general interest ; a few of these are selected for brief notice :—

The Camera as an aid to the draftsman.—Provided the Field Executive and the Photographic Officer are able to act in concert, there can be no question of the enormous help the latter may afford the former in compilations, changes of scale, and the ability to recognise at once what details from a large scale map may be adopted without crowding in the reduction. In fact, unless the operation required be so trivial that it may be put out of consideration altogether, the advantages of the camera over the pantagraph are so obvious as to need no recommendation. That these advantages continue to be appreciated appears from the number of silver prints taken, amounting to 726.

Additional prints of maps already published.—These approached to 4,000, showing the maintained demand for publications of former years.

Prints, urgent.—Such as Russo-Persian frontier, Alexandria harbour, Russian Turkestan, Hill States, &c. Photozincography still holds its own, especially in supplying such pressing wants which it can meet with celerity and neatness not as yet otherwise equalled, notwithstanding that 24 years have elapsed since the process was discovered.

Local.—As Dehra cemetery, Mussooree cemetery, the former surveyed by a draftsman from this office, and the latter by Major J. Wilmer during recess : these maps have already been found very useful, and similar delineations would, no doubt, be valued at other stations, where opportunity for making them, it is hoped, may occcur.

Spirit-leveled height charts.—Though more pressing work has interrupted the publication of these valuable records of work, done in and out of the Department, there are full four sheets in hand, besides that data for others have been collected to a certain extent in several districts in Bengal.

Various.—Kohat survey, Northern and Southern Waziristan, Mussooree and Landour for Gazetteer, a neat out-turn from old negatives, sketches of Lower Dawar Valley, Khaisor pass, and Waziristan defile, Astor, and Gilgit, &c., &c.

Forest Department.—The maps, 17 in number, and 1 chart, were all drawn, as usual, in the Forest Office, but published in the Survey Photozincographing press.

Charts and Maps.—Burma Western Coast for Marine Survey : Panja and Dardistan, Burma coast triangulation and traverse to Krishna Shoals, &c., &c.

Turkestan.—The compilation not having as yet been published, detailed notice would be premature. It may, however, be mentioned that the present will be the sixth edition of this map ; that it has been brought up to date, and compiled, like its predecessors, under directions from the Surveyor-General.

CORRESPONDENCE AND STORES.

The year's correspondence is represented by 2,244 letters and office memoranda. Of instruments, &c., received and despatched, there were—

Instruments, despatched	464
Ditto received	399
Stores, articles received	416
Ditto despatched	509

presenting a total of 246 parcels and packages received and of 93 packages issued. The principal occasions of issue and receipt occurred in connection with the measurement of the Mergui base line.

SOLAR PHOTOGRAPHY.

Mr. L. H. Clarke, Surveyor, 2nd grade, has continued to work as Solar Photographer, with Mr. C. F. Guthrie as his assistant. The working facts for the year are given in the subjoined table :—

1881-82.	No. of Days.				No. of Negatives.						Number of Working Days when Solar Phenomena were—	
	When negatives were taken.	Failures.			Solar Phenomena.							
		From bad weather.	From various causes.	Total.	Spots and faculæ.	Spots only.	Faculæ only.	None.	Runs.	Total.	Visible.	Absent.
October	31	.....	.....	31	90	.....	.....	.....	26	116	31	.....
November	29	1	.....	30	54	.....	.....	.....	24	78	29	.....
December	30	1	.....	31	97	.....	.....	.....	26	123	30	.....
January	26	5	.....	31	69	.....	.....	.....	19	88	26	.....
February	27	1	.....	28	70	.....	.....	.....	26	96	27	.....
March	31	.....	.....	31	86	.....	.....	.....	25	111	31	.....
April	30	.....	.....	30	92	.....	.....	.....	25	117	30	.....
May	31	.....	.....	31	88	.....	.....	.....	28	116	31	.....
June	27	3	.....	30	74	.....	.....	.....	17	91	27	.....
July	20	11	.....	31	47	.....	.....	.....	8	55	20	.....
August	19	12	.....	31	62	.....	3	.....	17	72	19	.....
September	27	3	.....	30	75	.....	.....	.....	22	97	27	.....
Total ...	328	37	.....	365	900	.....	3	.....	257	1,180	328	.....

This table shows that during the period of 365 days the sun was photographed on 328 days; that 903 negatives were taken, of which only three exhibited faculæ alone, while the others (900) showed both spots and faculæ.

It will also be seen that 257 runs were taken. These runs are quite useless for this particular instrument as it stands. A run is intended to exhibit the accuracy of instrumental adjusting, and the exhibit is true only if *no* telescopic shift in declination occurs in the instrument between taking the two images. But the declination clamp of this instrument is faulty in design and weak in construction; nor can it be remedied without a break of some days in the series of negatives, for which there really is no justification. Thus the pernicious shift occurs when least expected, and the runs then show instrumental errors which in reality do not exist. In fact the adjustments are always maintained in perfect order. This I never omit to state in my weekly extracts from the diary sent to the Solar Physics Committee. It follows from what has been said that the runs are even worse than useless, for they may mislead, unless the caution in the diary be attended to. I have no doubt that the runs, as the instrument stands, should be discontinued, and I have urged this more than once without eliciting any reply from Mr. Lockyer, so that the runs continue to be taken. The instrumental adjustments are examined daily.

The following percentages relate to daily visibility of the sun and presence of features, *i.e.* spots and faculæ :—

Year.	In 100 days the sun was invisible on—	In 100 working 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 ,,

Contrasting the *percentages* of number of days of invisibility above given with those furnished by the Astronomer Royal's annual reports, we have—

Year.	At Dehra, year ending 30th October.	At Greenwich, year ending May.
1880-81	15	60
1881-82	10	45

So that on an average, from above, for one day of invisibility at Dehra about four occur apparently at Greenwich. In view of the gaps thus caused in the Greenwich series, the Astronomer Royal, in his report dated 20th May 1882, remarks :—"As regards solar photography, the value of our results would be very greatly increased if the gaps in the Greenwich series were filled up by the help of the photographs taken in India and elsewhere under the auspices of the Solar Physics Committee, so that the areas and positions of sun spots and faculæ should be given for every day."

The photographs at Dehra are, and have always been, taken on every day of the year, *including Sundays*, when the sun is visible: at Greenwich no negatives apparently were taken on Sundays until the beginning of September 1881.

Solar activity, as indicated by the presence of spots and faculæ, has been enormous during the year under report. No attempt is made here to find the positions and magnitudes of these features, as it is intended that this work should be done in England, so that weekly batches of my negatives are sent home for the purpose by the mail; and as now that the Dehra negatives are to be placed (as I am recently informed) at the Astronomer Royal's disposal, early publication with his own results may be expected.

A rare exhibit of sun spots occurred in 1882—April 13 to 26—the Dehra negatives of which were fortunately obtained complete without a break. If, to distinguish between the two halves of the sun, we denote the visible half by *earth face* and call the other half *reverse-face*, I think it will be found that the majority of spots, not insignificant, burst out (or occur) on the latter face, so that their first appearance to us is on the sun's edge. Now whether earth-face or reverse-face spots are most potent in producing terrestrial effects can hardly be inferred from magnitudes alone, which may possibly continue to be visibly great for a time after the force which caused them has passed its maximum. Anyhow, a distinction between the two kinds of spots appears desirable. I therefore notice of the outburst or exhibit in question that, regarding them as three groups, numbered from east to west, No. 1 was a reverse-face group, and somewhat the largest; No. 2 was insignificant as a reverse-face group, but after considerable progress across (with) the earth-face it burst out and grew prodigiously, until it almost rivalled No. 1, besides that a relative displacement happened apparently between the two: the behaviour of No. 3 was somewhat similar to that of No. 2, but on a vastly smaller scale. Thus Nos. 1 and 2 present very remarkable groups of the two kinds of spots indicated, the former being a reverse-face and the latter essentially an earth-face group; and this rare combination suggests enquiry as to relation in time between these spots and (at least) the magnetic disturbances which are known to have occurred in their presence. In addition to the negatives taken, 879 silver prints were made from them. The negatives and prints have been regularly despatched weekly to the India Office.

The secondary magnifier for the old photo-heliograph, for enlarging the sun's image from 4 to 8 inches, was received during last monsoons, when the weather was too unsettled to admit of substituting the new for the old tube without great risk of break in continuity of series. This substitution was effected later on, and 8-inch negatives taken until the 18th December 1882, when, however, in accordance with a letter from General Strachey to the Surveyor-General, reversion to 4-inch negatives (with the old instrument) was effected. Negatives of the latter size are intended for the Astronomer Royal.

The new large photo-heliograph for 12-inch negatives came to hand safely in the end of last July, when it was set up for the purpose of ascertaining its dimensions exactly, in view of constructing a suitable building and dome for its reception. This necessary observatory is now being pushed on with the utmost vigour, and will, I hope, soon be finished. I much regret that its completion should have been delayed by circumstances beyond my control.

The sunshine recorder continues to act efficiently; too much so for evidence of opportunities when sun photographs may be taken, for the recorder may declare the sun to be present when for purposes of photography he is practically invisible.

Monthly Meteorological Results taken from the Register kept at the Head-Quarters Office, Trigonometrical Branch, Survey of India, Dehra Dún.

YEAR AND MONTH.	BAROMETER.						HYGROMETER.				THERMOMETER.								RAIN.		WIND.	CLOUD.	
	At 9-30 A.M.			At 3-30 P.M.			At 9-30 A.M.		At 3-30 P.M.		Dry Bulb.					Wet Bulb.							
	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.	Maximum in sun's rays.	Minimum on grass.	Maximum in air.	Minimum in air.	Monthly mean in air.	Maximum wet.	Minimum 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.
1881.																							
October	27·813	27·504	27·666	27·726	27·441	27·579	58·1	·592	58·8	·471	105·1	45·3	85·5	54·5	71·4	75·8	50·0	62·1	1	·07	Calm	.....	1
November	·875	·641	·771	·771	·578	·684	47·5	·564	46·4	·386	94·4	34·3	78·8	44·8	62·9	65·6	40·3	53·2	.....	.....	.....	.....	1
December	·924	·729	·832	·827	·655	·739	40·9	·559	42·1	·376	88·2	28·6	73·5	39·5	57·5	59·5	34·4	48·6	.....	.....	N.	2	2
1882.																							
January	·968	·689	·835	·859	·613	·746	45·8	·700	47·2	·518	89·0	31·1	74·3	38·7	57·1	69·6	37·0	50·6	4	3·10	W.N.W.	4	5
February	·868	·518	·738	·812	·403	·659	45·5	·696	43·4	·458	92·4	31·6	74·3	37·2	56·4	60·0	35·0	49·5	6	2·14	W.	4	5
March	·850	·407	·698	·762	·362	·607	48·4	·477	46·1	·312	109·3	37·4	80·4	44·3	68·3	69·4	41·7	56·1	3	·44	N.	2	5
April	·693	·486	·593	·605	·382	·496	43·5	·360	44·6	·246	112·6	43·2	96·7	50·7	75·0	73·5	46·7	59·6	3	·90	.....	2	4
May	·698	·381	·531	·600	·281	·427	54·7	·386	53·3	·309	119·0	54·3	101·1	60·7	80·2	70·2	49·9	64·8	3	2·67	W.	1	3
June	·546	·281	·383	·474	·190	·305	60·1	·625	69·7	·535	119·3	63·1	100·4	67·6	82·9	80·5	61·9	72·8	16	8·10	Calm	5	6
July	·497	·277	·395	·425	·217	·325	73·6	·821	74·6	·770	110·8	67·5	88·9	70·6	79·0	70·8	67·8	74·3	25	31·15	.....	8	8
August	·870	·182	·434	·529	·092	·380	73·3	·801	74·5	·768	109·0	64·8	88·7	68·5	79·2	80·1	66·6	73·8	21	17·22	.....	6	8
September	·671	·436	·550	·561	·345	·406	70·0	·726	71·4	·654	108·6	61·2	89·8	67·2	78·0	77·4	63·8	71·3	8	·53	W.	3	5

NOTE.—The height of the barometer cistern above mean sea-level at Kurrachee is 2,232·41 feet.

Mean Velocity in Miles of the Winds which blew at Dehra Dún during the twelve months of 1881-82 *for each Hour of the Day.*

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	·67	·54	2·77	2·61	2·08	3·19	2·93	1·08	1·47	·83	·74	1·77
1 ,, 2	·23	·18	2·00	2·58	2·25	2·97	3·47	2·00	1·43	1·13	1·00	1·90
2 ,, 3	·37	·36	2·10	2·52	2·18	2·08	2·70	2·10	1·30	1·23	·84	1·37
3 ,, 4	·17	·25	2·17	2·32	2·18	2·71	2·80	1·90	1·13	·97	·90	1·10
4 ,, 5	·13	·18	2·27	2·00	1·03	2·45	2·23	1·84	1·33	·93	·61	1·27
5 ,, 6	·10	·07	2·00	2·10	2·04	2·35	2·50	1·71	1·07	1·23	·65	1·10
6 ,, 7	·07	·07	2·27	2·13	1·75	2·03	1·77	1·35	·83	1·17	·87	1·07
7 ,, 8	·00	·11	1·60	1·71	1·89	1·52	1·43	1·45	1·10	1·03	1·04	·83
8 ,, 9	·03	·04	1·17	1·43	1·08	2·19	1·80	2·19	1·47	1·43	1·87	1·13
9 ,, 10	·00	·11	1·00	2·00	2·25	2·29	3·20	3·55	2·00	1·03	2·42	1·90
10 ,, 11	·20	·25	2·03	2·58	2·04	2·52	4·33	4·00	2·53	2·00	2·13	2·27
11 ,, 12	·43	·75	2·53	3·16	3·04	3·08	5·17	4·16	2·67	1·71	2·20	2·63
12 ,, 13	·83	·67	2·55	2·74	3·40	4·06	4·67	5·65	3·30	1·87	2·48	2·70
13 ,, 14	·77	·96	2·58	2·71	4·04	4·35	5·57	4·29	3·50	2·23	3·08	3·07
14 ,, 15	·03	·81	2·77	3·16	3·96	4·30	5·40	4·45	3·37	2·65	2·61	2·83
15 ,, 16	·50	·63	2·29	2·04	4·18	4·30	4·87	4·10	2·03	2·23	1·94	2·90
16 ,, 17	·30	·15	1·19	2·26	3·75	3·68	4·80	4·52	2·67	1·81	1·07	2·77
17 ,, 18	·03	·11	·90	1·42	2·29	2·61	3·20	4·10	1·97	1·57	1·19	1·28
18 ,, 19	·50	·20	1·90	1·55	1·14	1·61	1·90	3·08	1·37	·03	·74	·43
19 ,, 20	·87	·70	2·42	1·87	1·61	2·42	2·43	2·71	1·20	·70	·81	·83
20 ,, 21	·70	·78	3·13	2·06	2·20	3·23	3·20	2·87	1·73	·60	·87	1·27
21 ,, 22		1·22	3·10	2·06	2·29	2·90	3·07	2·55	1·77	·43	1·13	1·37
22 ,, 23	·57	·96	3·13	2·46	2·86	3·84	3·27	2·20	1·40	·50	1·00	1·63
23 ,, 24	·90	·67	2·84	2·10	2·57	2·90	3·20	1·71	1·47	·80	1·03	1·86
Sums ...	10·03	10·83	53·91	54·57	60·35	70·06	70·01	63·01	45·01	31·07	35·00	41·17
Average ...	·42	·45	2·25	2·27	2·51	2·92	2·93	2·87	1·88	1·33	1·46	1·72

W. H. D'C.—Reg. No. 9747J—401—22-8-83.

Circular No. 408.

Extract from the Proceedings of the Government of India, in the Revenue and Agricultural Department (Surveys),—dated Simla, 1st June 1883.

READ the General Report on the Operations of the Survey of India during the year 1881-82, submitted with the letter from the Officiating Surveyor General of India, No. 1084 of the 17th April 1883.

RESOLUTION.

FOLLOWING the order observed in reports of previous years, the first chapter of the Report deals with the triangulation work of the year. The chain of principal triangles, known as the Eastern Frontier series, which in previous years had been carried from Assam through Arakan and British Burma into Tenasserim, was completed: thus was brought to a close the principal triangulation of all India on the lines marked out in 1830 by Colonel Everest. Opportunity is taken of this fact by the Surveyor General to give an interesting history of the undertaking, from its inception almost single-handed by Major Lambton in the first year of the century. The maps accompanying this section well illustrate the principles on which this great work has been built up. As regards the secondary triangulation still to be done, the Surveyor General reports that a great deal is required on the coast lines to furnish fixed points for the marine surveys, and in localities in the interior at a distance from the nearest principal chains, where data may be required for topographical purposes. It is also wanted outside the limits of India proper on the North-Eastern Frontier to furnish a basis for the geography of Upper Burma, and southwards in the direction of Singapore.

2. The next chapter deals with topography. Thirteen topographical parties have carried on their regular work in continuation of that of last year, and chiefly in the same provinces. The parties were thus distributed:—three in Rajputana and Central India, four in the Bombay Presidency, and the remaining six in Assam, Mysore, Kohat, Beluchistan, Meerut, and on the Hooghly river. Following the above order, the work of each party may be briefly noticed. The party employed in Rajputana worked for the most part in the Jodhpore State and completed an area of 5,611 square miles. It has now been transferred to British Burma, and the part of country remaining to be surveyed has been made over to the Gwalior and Central India Survey party for completion. This latter party surveyed during the year the three Rajput States of Marwar (Jodhpore), Meywar (Oodeypore), and Sirohi, embracing an area of 2,440 square miles, of which 460 square miles are described as being "about as difficult and intricate as could well be found." The work of the Bhopal and Malwa party fell chiefly in the territories of Banswarra, Oodeypore, Pertabgarh, and Dangarpur, most of which is said to be very hilly, wild, and intricate country. In addition to the standard scale of topography, two cities—Banswarra and Jaora—were surveyed on the scale of 6 inches = 1 mile; the total area surveyed amounted to about 1,096 square miles. The greater part of the party has now been transferred to Mirzapur to complete the topography of that district which is required in connection with the cadastral survey operations now in progress there, and the completion of the survey of Malwa has been assigned to the Khandesh party.

3. The four Bombay parties were respectively employed in Guzerat, Khandesh, Cutch, and the Southern Collectorates of the Deccan. In Guzerat four descriptions of work were carried on:—

(i) The ordinary topographical survey of Native States, executed on the 2-inch scale and published on the 1-inch scale.

(ii) The preparation of a series of maps on the 2-inch scale, comprising British territory in detail, and foreign territory in skeleton; and for the former utilizing the maps of the Bombay revenue and settlement surveys as far as practicable.

(iii) The 4-inch scale of the Dang Forests.

(iv) The survey of the city, cantonment and environs of Surat on the 12-inch scale.

This party has done very good work during the year, and has now brought the total surveyed area of the district up to about 15,685 square miles, leaving about 14,850 square miles (or about half the district) yet to be completed. The Khandesh party surveyed an area of 1,551 square miles out of the 2,650 square miles which remained for completion at the close of the previous year, thus leaving only another season's work for the party. The area surveyed by the Deccan party includes a portion (130 square miles) of the Nizam's Dominions. This portion had to be surveyed, as there are no maps of the tract forthcoming in the records of the Hyderabad survey. The Cutch survey was conducted in a similar manner to that of last year.

4. Of the other six topographical parties, the Assam one was employed in surveying the lower spurs of the Tipperah Hills running northwards past the British boundary into the plains of Sylhet, as well as the group of low hills which lie between Fenchuganj and the Manu River. These tracts are now becoming very valuable, as they are being taken up and opened for tea cultivation. In Mysore the party completed an area of 4,226 square miles on the scale of 1 inch to 1 mile. The Kohat party surveyed some very intricate ground lying in the upper valleys of the Kohat and Teri rivers, and also the Surdag and Lawaghur Hills with the low lying plains at their foot on the west of the Bannu District; and the Beluchistan party did a fair amount of work, chiefly in the country lying between Quetta and Khelat.

The chief work of the North-Western Provinces party was to survey the Meerut and Bulandshahr Districts on the 2-inch scale. The riverain tract along the Ganges and the Jumna in Bulandshahr was, however, surveyed on the larger scale of 4 inches =1 mile. The survey of the Hooghly River, with a strip on each bank varying from a quarter of a mile to one mile and upwards, was commenced during the year. A reliable survey of the river has long been wanted, and it is now being carried on *pari passu* with a survey of the bed of the river now in progress under the orders of the Port Commissioners. The survey is to be conducted on two scales. From Kanchrapara, a station on the Eastern Bengal Railway, down to Atchipore it is to be on the scale of 16 inches to the mile, and from Atchipore to the sea on the 6-inch scale.

5. The Government of India notices with satisfaction that the triangulation has in each case been kept well in advance of the topographical work.

6. There were two *manzawar* or village survey parties employed during the year under review—one in the Punjab and the other in Bombay. The Punjab party was engaged on the 4-inch scale of—

(*a*) Pargana Leiah, in Dera Ismail Khan.

(*b*) Pargana Sinanwan (Thal portion) in Muzaffargarh.

(*c*) Kala Chitta Pahar, in Rawalpindi (for the use of the Forest Department).

The total area surveyed was 1,861 square miles.

The Bombay party was engaged in the Thana (Konkan) District. The larger scale of 4 inches = 1 mile was adopted instead of the 2-inch scale, in accordance with a letter from the Home Department, No. 830F., dated the 20th September 1881, on the ground that maps on the lesser scale are insufficient for the administration of the forests which cover large tracts in the Thana District. It was, however, agreed that the Forest Department of Bombay should be charged with the additional cost of the more expensive survey on the larger scale.

7. Cadastral or field surveys were conducted by six parties—two in the North-Western Provinces, three in British Burma, and one in Sylhet.

The Mirzapur party surveyed 750 square miles on the scale of 16 inches to the mile. With a view to effect a large reduction in the usual cost of preparing the record of rights, the experiment of allowing the surveyors to write

up the *khasra* (*i.e.*, the return in which the particulars about each field are entered) at the time of the survey of the fields, was undertaken by Colonel Anderson at the request of the Board of Revenue. The results of the experiment, so far as it has gone, is believed to be highly satisfactory. The second North-Western Provinces party completed the Ghazipur District, and continued work in Ballia during the season.

8. The three Burma parties were employed respectively in Hanthawaddy, Bassein, and Tharrawaddy. The outturn of work in this Province has been very satisfactory, the total area surveyed being 3,513 square miles. The Government of India regrets to observe the unfavourable opinion expressed as to the merits of Burman surveyors. Though their work is good in quality, they are said to be very inferior to the Hindustani surveyors in rapidity of execution, and to work in a half-hearted way with a sole eye to employment in some other Department.

9. In Assam a small party, specially organised, has been engaged on the cadastral survey of selected villages in three parts of the Sylhet District, to test the accuracy of the *mahalwar* maps of the district which were prepared by the civil authorities in 1862; sixteen photozincographed sheets of the work done by this party have been submitted to the Chief Commissioner of Assam, and the Government of India awaits the final report on the result of the testing.

10. The future employment of the cadastral parties which have been organised in the North-Western Provinces and in Burma, with great trouble and expense, has for some time past been under the consideration of the Government of India. A programme is now being drawn up in communication with Local Governments which, it is expected, will meet the requirements of the latter for the next ten years, and provide the Department with ample work for that period.

11. The survey of the Darjeeling District was undertaken in consequence of certain errors in the old maps having been brought to notice by the late Captain Harman's party when it was surveying new boundary lines and re-laying old ones. This has eventually involved the re-survey of the whole of the Hill Tracts west of the Teesta river. It is interesting to notice, in connection with this survey, the discovery made by Captain Harman, that the mountain which has hitherto been pointed out as Mount Everest from the neighbourhood of Darjeeling, is not that mountain; the true Mount Everest being immediately to the left (or south) of the peak which generally passes for it. The Government of India regrets to learn the recent death, when on furlough, of Captain Harman, an officer of much ability and energy.

12. The sections under the head of *Geography, Tidal and Levelling Operations* and *Geodetic* are, as usual, very interesting. The Burma-Manipur boundary was surveyed by Major Badgley, the demarcation of which was undertaken by the Political Agent and Boundary Commissioner, Colonel Johnstone. Major Badgley took advantage of his return journey to complete as much as possible of the survey of the Manipur territory. No actual survey was executed in Afghanistan, but a great deal of progress has been made with the final mapping of the surveys which were made during the late war. The Native Surveyor, Ahmed Ali Khan, deserves credit for the work he has performed in Dardistan and on the Kishanganga watershed; and the accounts of the Trans-Himalayan explorations are very interesting, and reflect great credit on the several officers who undertook them.

13. The Government of India notices with pleasure that the tidal observations, in addition to their practical value for the requirements of navigation, are now furnishing information which is found to be of much scientific value. These observations have recently thrown light on the question of the degree of the rigidity of the earth, and the following extract from paragraph 227 of the Report shews the esteem in which the Indian tidal observations are held by the scientific world:—

"At the recent meeting of the British Association for the advancement of Science at Southampton, Mr. G. H. Darwin brought forward a 'numerical estimate of the rigidity of the earth,' which gives evidence of a tidal yielding of the earth's mass, and further indicates

that the effective rigidity of the whole earth is about equal to that of steel. But it is only recently that there has been a sufficient accumulation of tidal observations, properly reduced by harmonic analysis, to test Sir William Thomson's theory (that the universal existence of oceanic tides of considerable height is a proof that the earth, as a whole, possesses a high degree of rigidity, and that the previously received geological hypothesis of a fluid interior is untenable); and Mr. Darwin points out that the great advances in knowledge that have now been made are principally due to the adoption of systematic tidal observations at a great number of stations by the Indian Government."

14. With regard to the spirit levelling operations, the revision of the Western Ghât section of the line of levels from Madras to Bombay was undertaken with a view to ascertaining whether any accidental error had been made in levelling up the steep ascent of the Ghâts, that would account for the discrepancy of 3 feet which had been met with at Madras on comparing the value of the mean sea determined from the local tidal observations with the value given of the spirit levelling from Bombay. The revision, however, gave practically identical results with the first operations.

15. The second part of the Report deals with the operations of the several Head-quarters Offices of the Department. The two Offices of the Surveyor General and the Deputy Surveyor General (Revenue Survey Office) at Calcutta are now accommodated in the new building recently constructed, which has been well designed and admirably built. It has also been found to be commodious and airy. The Government of India notices with satisfaction the progress that has been made towards completing a series of outline maps of India on scales of 1 inch to 64 miles, 80 miles and 96 miles. These maps are always in great demand to illustrate official reports. A new map of Bengal, Behar and Orissa, with hills, on the scale of 1 inch=16 miles was printed; and at the request of the Quarter Master General in India, a map of Lower Egypt was drawn and published for the use of the troops proceeding to Egypt. Maps of the Suez Canal, Cairo and Alexandria were also printed. All these were in great demand, and large numbers were bought by the public. The number of cadastral maps published during the year was 5,090. The experiments with the heliogravure process, which Major Waterhouse conducted in the Photographic Branch, seem to have been eminently successful. A full account of the process, which is practically a cheap substitute for copper engraving, is given at page 99 of the Report, and the print which appears as a frontispiece is a good example of the results attained.

16. The cost of cadastral surveys has been reduced even lower than what it was last year. In the North-Western Provinces it was Rs. 138-13-3 per square mile (Rs. 0-3-6 per acre) as compared with Rs. 159-4-11 per square mile (Re. 0-4-0 per acre) in 1880-81. In British Burma, too, the general rate for the year was lower than that of last year, *viz.*, Rs. 232-4-9 per square mile (Re. 0-5-0 per acre) against Rs. 250-8-7 per square mile (Re. 0-6-3 per acre). The topographical surveys worked at rates similar to those of last year. These results are very satisfactory, and tend to confirm the opinion of the Department that its field survey work will compare favourably in cost, as it unquestionably does in accuracy, with the surveys executed by patwaris and other unprofessional agencies. It now rests with the Survey Department to maintain, and, if possible, improve, the very creditable standard of economy attained in cadastral surveys during the year under report.

17. The ability with which General Walker administered the Department during 1881-82 is again acknowledged by the Government of India.

ORDER.—Ordered, that copies of the Resolution be forwarded to the Surveyor General of India, to the Local Governments and Administrations noted in the margin, and to the Foreign and Military Departments.

Madras.	Punjab.
Bombay.	Central Provinces.
Bengal.	British Burma.
North-Western Provinces and Oudh.	Assam.
	Coorg.

(True Extract.)

T. W. HOLDERNESS,

Offg. Secretary to the Government of India.

1883.

GOVERNMENT OF INDIA.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

Circular No. 408.

Dated Simla, the 1st June 1883.

SUBJECT.

Reviews the General Report on the operations of the Survey of India during the year 1881-82.

Govt. C. D. Press, Simla.—No. 177, R. & A. D.—4-6-83.—900.