GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India Department

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1890-91.

PREPARED UNDER THE DIRECTION OF

COLONEL H. R. THUILLIER, R.E.,

SURVEYOR-GENERAL OF INDIA.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1892.

Price Three Rupees.

Photo-etching.

Survey of India Offices, Calcutta, February 1892.

SIMVO - 22,300 Ft. (EASTERN SPUR OF KINCHINJUNGA - SIKKIM HIMALAYAS) FROM THE NORTH-WEST.

GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India Department

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1890-91.

PREPARED UNDER THE DIRECTION OF

COLONEL H. R. THUILLIER, R.E.,

SURVEYOR-GENERAL OF INDIA.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1892.

CALCUTTA:
GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,
8, HASTINGS STREET.

CONTENTS.

PART I.

SUMMARY.

PART II.

THE OPERATIONS OF THE SEVERAL FIELD PARTIES.

Geodetic.

Geographical Surveys.

Tabular Statements.

PART III.

THE OPERATIONS AT THE HEAD-QUARTERS OFFICES.

APPENDIX.

EXTRACTS FROM REPORTS BY EXECUTIVE OFFICERS.

ILLUSTRATIONS.

PHOTO-ETCHINGS, etc.

MAPS.

PESHAWUR
NANGAHAR
HYDRABAD

GENERAL REPORT

ON THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1890-91.

PART I.

SUMMARY.

1. The operations of the Department that are now reported on are for the survey year ending 30th September 1891.

2. The general administration of the Department and the superintendence of the Topographical Branch have continued in the hands of Colonel H. R. Thuillier, R.E., throughout the year. The direct supervision of the Revenue Branch has been carried on by Lieutenant-Colonel C. Strahan, R.E., and that of the Trigonometrical Branch by Colonel G. Strahan, R.E., except for three months, while he was absent on privilege leave, when Mr. W. H. Cole, M.A., officiated in the post.

3. As regards the Cartographic and other offices at the Head-Quarters, Colonel W. H. Wilkins, S.C., has remained in charge of the Drawing and Engraving Offices throughout the year, and the Correspondence and Mathematical Instrument Offices continued under the superintendence of Colonel M. W. Rogers, R.E. On the departure on furlough of Colonel J. Waterhouse, S.C., in May 1891, Mr. T. A. Pope was appointed to officiate in the charge of the Photographic and Lithographic Office, and retained the post during the remainder of the year.

4. Field operations have been carried on during the year under review by 23 parties and seven small detachments. Of these one party was employed on trigonometrical surveys, four parties and a detachment on topographical surveys, four parties on forest surveys, seven parties and one detachment on cadastral surveys, two parties on traverse surveys, three parties on scientific operations, and two parties and five small detachments on geographical surveys. The following tabular statement shows collectively the whole of these operations, and it is grouped according to the scope and nature of the work on which the parties were severally employed:—

Statement of Survey Operations and Parties.

Number of Party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Trigonometrical Survey.				
24	Burma	13	Lieutenant C. F. Close, R.E.	.....	D. S. G., Trig.
	Topographical Surveys.				
10	Bombay	14	Colonel H. S. Hutchinson, S.C. Lieutenant-Colonel J. Hill, R.E.	2″ = 1 mile for reduction to half scale; 1″ = mile and ½″ = 1 mile for reproduction.	Ditto, Rev.
13	Mergui	16	Mr. A. D'Souza	1″ = 1 mile for reproduction.	Ditto, ditto.

Statement of Survey Operations and Parties.

Number of party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
15	Baluchistan . . .	19	Lieutenant-Colonel T. H. Holdich, R.E. Captain R. J. Mackenzie, R.E.	2″ = 1 mile, ½″ = 1 mile, and ¼″ = 1 mile for reproduction.	D. S. G., Topo.
18	Himalayas . . .	21	Major St. G. C. Gore, R.E. .	4″ = 1 mile for reproduction and reduction to half scale; 2″ = 1 mile and 1″ = 1 mile for reproduction.	Ditto, Trig.
Det.	Indus riverain . .	22	Mr. J. S. Pemberton . .	4″ = 1 mile for reproduction.	Ditto, Rev.
	Forest Surveys.				
14	Central Provinces . .	24	Colonel J. R. Wilmer, S.C.	4″ = 1 mile for reproduction.	Ditto, Trig.
17	Bombay . . .	26	Colonel A. Pullan, S.C. . Mr. A. M. Lawson. Colonel H. S. Hutchinson, S.C.	16″ = 1 mile, 8″ = 1 mile, and 4″ = 1 mile for reproduction.	Ditto, Topo.
19	Madras . . .	27	Lieutenant-Colonel J. R. McCullagh, R.E.	4″ = 1 mile for reproduction.	Ditto, ditto.
20	Lower Burma . .	30	Colonel R. Beavan, S.C. .	4″ = 1 mile and 2″ = 1 mile for reproduction.	Ditto, ditto.
	Cadastral Surveys.				
2	Eastern Bengal . .	31	Mr. F. Grant . . .	16″ = 1 mile for reproduction; 2″ = 1 mile for reduction to half scale.	Ditto, Rev.
3	Upper Burma . .	35	Mr. G. B. Scott . . Mr. B. G. Gilbert-Cooper.	16″ = 1 mile for reproduction.	Ditto, ditto.
4	Western Dooars . .	37	Captain G. B. Hodgson, S.C.	16″ = 1 mile and 4″ = 1 mile for reduction to half scale.	Ditto, ditto.
5	North-West Provinces .	43	Lieutenant-Colonel J. E. Sandeman, S.C.	16″ = 1 mile and 4″ = 1 mile for reproduction.	Ditto, ditto.
6	Assam	48	Mr. E. C. Barrett . .	16″ = 1 mile for reproduction.	Ditto, ditto.
7	Lower Burma . .	50	Mr. C. Wood . . .	16″ = 1 mile and 4″ = 1 mile for reproduction.	Ditto, ditto.
8	Orissa	54	Mr. W. H. Patterson . .	16″ = 1 mile for reproduction.	Ditto, ditto.
Det.	Burdwan Khas Mahals .	57	Mr. T. Shaw . . .	Ditto ditto.	Ditto, ditto.
	Traverse Surveys.				
9	Central Provinces . .	60	Mr. G. H. Cooke . .	16″ = 1 mile (skeleton plots).	Ditto, ditto.
12	Lower Burma . .	61	Mr. E. J. Jackson . .	Ditto ditto.	Ditto, ditto.
	Geodetic.				
22 & 23	Madras Presidency .	63	Lieutenant G. P. Lenox-Conyngham, R.E.	.....	Ditto, Trig.
	Tidal and Levelling Operations.				
25	India	65	Lieutenant-Colonel J. Hill, R.E.	.....	Ditto, ditto.
	Geographical Surveys.				
11	Upper Burma . .	67	Mr. M. J. Ogle . . .	¼″ = 1 mile .	Ditto, Topo.
21	Upper Burma . .	68	Captain F. B. Longe, R.E. .	Ditto .	Ditto, ditto.
Det.	Miranzai border . .	71	Captain R. A. Wahab, R.E. Captain R. J. Mackenzie, R.E.	1″ = 1 mile and ½″ = 1 mile.	Ditto, ditto.
,,	Black Mountain country	72	Captain R. A. Wahab, R.E.	2″ = 1 mile and ½″ = 1 mile.	Ditto, ditto.
,,	Upper Irrawaddy . .	74	Major J. R. Hobday, S.C. .	Ditto .	Ditto, ditto.
,,	Eastern Frontier, Shan States.	76	Captain T. F. B. Renny-Tailyour, R.E.	Ditto	Ditto, ditto.
,,	Kyaington-Chiengmai Frontier.	77	Mr. J. M. Kennedy . .	Ditto .	Ditto, ditto.

The total area that has been surveyed in detail during the year amounts to 1,17,915 square miles. In addition to this, the traverse operations carried on for the purpose of furnishing a basis for field surveys under Settlement Departments comprise an area of 4,593 square miles. The following is a summary of the operations of the different field parties in the order in which they appear in the above statement. A detailed report of the work of each party for the year under review will be found in Part II.

TRIGONOMETRICAL SURVEYS.

5. The chief operations have been confined, as in the previous year, to the extension of the principal triangulation for Upper Burma, on the meridian of 96° 30′. One party only was employed on this work and succeeded in extending the series northwards for a distance of 44 miles, covering an area of 900 square miles. An easier description of country has now been entered upon, and the progress may be expected to be somewhat more rapid in future.

6. The observations at the four stations required to complete the series of secondary triangles, along the parallel of 30° N. latitude from the Great Indus series to the Khwaja Amran range beyond Quetta, were executed during the year in connection with the work of the Baluchistan survey. The season's work embraces an area of 960 square miles.

TOPOGRAPHICAL SURVEYS.

7. Four parties and one detachment have been employed on this class of operations during the year. Of these, the four parties have carried on, as before, topographical surveys on various scales in the Bombay Presidency, in Burma, in the tin-producing tracts of Mergui, in Baluchistan, and in the Himalayas. The detachment was employed on special work in the Punjab for the Local Government; its operations comprised a *mauzawar* survey on the 4-inch scale of that portion of the river Indus lying between district Dera Ghazi Khan and the Bahawalpur State, with a view to the laying down of a fixed line of boundary between the district and State.

8. In addition to the work of the regular topographical parties, several small areas have been topographically surveyed by other parties in connection with cadastral and forest operations. These small areas generally consist of intervening tracts not required for revenue purposes, and they are surveyed in order to complete the topography of the standard maps in which the revenue areas fall.

9. The areas topographically surveyed on various scales during the year amount to a total of 10,193 square miles compared with 13,652 in the previous year. The decrease is principally due to the smaller out-turn of regular topography by the Baluchistan party, consequent on the many calls on that party to provide surveyors to accompany the various military expeditions which took place on the North-West Frontier.

The total area is made up as follows:—

3,044	square miles	surveyed	on	the	½	-inch scale.
2,358	,,	,,	,,	1	,,	,,
3,747	,,	,,	,,	2	,,	,,
1,044	,,	,,	,,	4	,,	,,

FOREST SURVEYS.

10. Under this head the four parties employed during the previous year in the Central Provinces, the Bombay and Madras Presidencies, and in Lower Burma, have continued their previous operations. In addition to their work, forest surveys have been carried on in Bengal and in the North-West Provinces by detachments from the cadastral survey parties employed there.

11. In the Central Provinces, one party has continued the survey of the first and second class forest reserves in districts Hoshangabad and Betul, carrying on at the same time the classification of forest growths and soils therein. The operations again lay in a tract of country which is notoriously unhealthy,

and the field work had consequently to be restricted to a period of four months only; the out-turn slightly exceeds that of the previous year.

12. In Bombay, the operations were in continuation of those carried on during the previous year, *viz.*, surveys on the 8-inch scale of the forests in North Kanara, Dharwar, Poona, and South Thana districts and on the 4-inch scale in Poona and Ahmednagar districts. In addition, a small area was surveyed on the 16-inch scale in the Poona district. The out-turn of this party is again satisfactory, and exceeds that of last year by 27 square miles.

13. In Madras, forest survey operations were continued in the Madura and Tinnevelly districts, and the out-turn of work obtained is very satisfactory, the total area surveyed during the season amounting to more than that of the previous two seasons put together. The physical and climatic difficulties were as great as those previously met with, and the improvement is due to the experience gained by the newly trained agency which had to be organized when the work was first started. It is satisfactory, also, to note the decrease in the cost rate of the survey, which has fallen from ₹162 per square mile in the first year of these operations, 1888-89, to ₹112 in the year under report.

14. In Lower Burma, the survey of the reserved forests in districts Prome and Toungoo has been continued on the 4-inch scale and the intervening tracts on the 2-inch scale. The out-turn of topography of this party more than doubles that of the previous year, which however, for reasons given in last year's report, was unusually small. The difficulties of the country under survey are exceptionally great, and the result of the season's operations is satisfactory.

15. In connection with the cadastral surveys, an area of 174 square miles of forest reserves was surveyed in the Western Dooars, in which the forest growths and soils were also classified. In the North-West Provinces (district Garhwal) a survey was made of a small forest reserve near the Lansdowne cantonment.

16. The aggregate results of the forest surveys amount to 1,841 square miles as compared with 1,646 executed during the previous year by the same number of parties. The areas of these surveys on the different scales are as follows:—

1,426	square	miles	surveyed	on	the	4-inch scale.
393	"	"	"	8	"	"
22	"	"	"	16	"	"

CADASTRAL SURVEYS.

17. The same number of parties has again this year been engaged on cadastral work, *viz.*, three parties and one detachment in Bengal, two parties in Burma, one in the North-West Provinces, and one in Assam.

18. In Bengal, the three parties were employed in the Western Dooars, in Chittagong and in Orissa, whilst the detachment carried on some special work connected with the lands belonging to the estates of the Burdwan Raj. In the Western Dooars, there were the same difficulties as before to be faced, such as the dense jungle, and the apathy of the people; whilst the unpopularity of the work among the survey establishment, owing to the excessive unhealthiness of the climate and the nature of the country, had increased, rendering it still more difficult to get efficient *amins* to take service there. An area of 234 square miles was cadastrally surveyed. The cadastral survey of the Jalpaiguri district is practically completed, but a section of the party will be required for another year to complete the records. There still remains a large area of forest reserves and culturable lands, all covered with dense jungle, to be surveyed; the former on the scale of 4-inches, and the latter on 2-inches to a mile.

19. In Chittagong, the cadastral survey was continued and covered an area of 469 square miles, whilst that of the Serail *pargana* in Tipperah was completed together with the village records by the same party. The record-writing in Chittagong was made over to the Settlement Department, as it was found that, owing to the complexity of tenures, it was extremely difficult for the survey *amins* to understand, or to write up the *khasras*. The out-turn of this party was considerably reduced by the early setting in of the rainy season.

20. The Orissa party continued its operations in the districts of Pooree and Cuttack. Training schools, where considerable numbers of men were taught field-surveying, were established at certain centres in the districts. The detail surveys were made entirely by local men so trained, and under the supervision of Hindustani and Urya inspectors. In Cuttack the record-of-rights was invariably completed by the same man who surveyed the village. The area surveyed amounted to 687 square miles.

21. Besides the above three parties, a small detachment was employed in relaying the boundaries, as shown on the old settlement maps of 1854, of certain villages in the district of Bankoora, belonging to the estate of the Burdwan Raj, and on the cadastral survey of scattered lands in the district of Burdwan, which had been omitted from measurement during previous seasons.

22. In Lower Burma, an area of 408 square miles was surveyed on the 16-inch scale in Amherst district and 320 square miles in Thongwa, making an out-turn of 728 square miles of 16-inch survey; in addition to this, 164 square miles were surveyed on the 4-inch scale in the latter district. This brings to a close the survey of all the tracts assigned in Thongwa, which aggregate 2,910 square miles; the total cost of this work is ₹5,80,769, which gives a rate of ₹200 per square mile for all the survey operations. About 400 square miles have been traversed in advance for cadastral survey next year in district Amherst. The scheme for the employment of Burmans and Karens as field surveyors has made satisfactory progress. Of the 728 square miles surveyed this year, 54 Burmans contributed 404 square miles and 27 Hindustanis 324 square miles, besides 164 square miles of 4-inch survey. This gives the average out-turn of the Burman as about four-sevenths of that of the Hindustani, which is an improvement on that of last year.

23. The cadastral party in Upper Burma resumed operations in the Mandalay district, and also commenced and completed the survey of the royal lands in Meiktila, which had been specially asked for by the Burma Government. The out-turn was 584 square miles in Mandalay and 563 in Meiktila, or 1,147 square miles in all. In addition to this 714 square miles have been traversed in advance in Sagaing. A successful attempt was made to obtain locally a certain amount of labour for chaining purposes, and thus to save some of the heavy expenditure incurred in importing labour from India. It was accordingly decided that only two men should be imported with each *amin*, and that the other two men required should be obtained locally; after a time this was found to work well, and about 200 local men were employed at daily wages of 4 annas in Mandalay and of 6 annas in Meiktila. About 30 Burman *amins* were employed, and their average out-turn was found to be about five-sevenths of that of the Hindustanis; their work was found to be good in open country, but in the jungles much of it had to be rejected.

24. In the North-West Provinces, the party continued its survey operations in the Garhwal district, and completed those in the Rampur State. The work in Garhwal was carried on by a mixed establishment of Hindustanis from the plains, and of hillmen; but, as the cold climate and mountainous nature of the country did not suit the former class, many of those who had promised to return failed to do so, whilst the hillmen did not come forward in any numbers; the establishment was therefore very inadequate for the work to be performed. The total area of the tract over which the cadastral survey was carried is 299 square miles. In Rampur, 724 square miles were surveyed by a mixed establishment, of which about one-fourth were trained *amins* and the remainder local *patwaris*. The cost-rate per square mile of the Rampur survey is ₹95-10 for the complete operations of traverse, field survey, and record-of-rights.

25. Cadastral operations in Assam were carried on in districts Nowgong, Kamrup, and Darrang, as well as in Sylhet, by an establishment consisting partly of local and partly of imported *amins;* the Hindustani *amins* had writers to assist them in preparing the Bengali records. Some difficulty was experienced in inducing *amins* not belonging to Kamrup to enter that district, in consequence of the prevalence of the disease known as *kala ajar*, which is much dreaded; several men threw up their appointments rather than take up work in that district. The area surveyed amounted to 828 square miles, of which 47 square miles are in Sylhet. The field season was unusually unhealthy, especially in Sylhet, where the establishment suffered much from malarial fever.

26. The areas of cadastral survey completed this year in the different provinces are as follows:—

	Square miles.
Bengal	1,417
Burma	1,875
North-West Provinces	913
Assam	828
TOTAL	5,033

This shows an increase of 252 square miles over the out-turn accomplished by the same parties in 1889-90, and of 197 square miles over that of 1888-89.

TRAVERSE SURVEYS.

27. There were only two parties engaged on special traverse operations, for the purpose of providing an accurate basis for the field-to-field survey by village officials, or other local agency under the Settlement Department. One party was employed in the Central Provinces and the other in Lower Burma.

28. In the Central Provinces, an area of 3,229 square miles was traversed, nearly all of which was in the district of Mandla; part of the country operated in was rugged and unhealthy, which affected the progress of the work. A considerable area still remains to be traversed in the Mandla district, and the party will continue the traverse survey for another year. The details regarding area and cost of the traverse surveys that have been executed in the Central Provinces for settlement purposes during the past six years will be found at page 85. The average cost rate over the sixteen districts completed, covering an area of 51,473 square miles, is R26-11-2 per square mile.

29. In Lower Burma, the traverse survey was continued in the districts of Prome, Hanthawaddy, Tharrawaddy, and Henzada; the work was much scattered and the country was of a very difficult nature for such operations, and the cost thereof is consequently heavy. The area completed was 1,364 square miles, of which only about one-fifth was under cultivation. Although the traverse operations are not yet complete, it has been decided to transfer the survey party that was employed on them to Upper Burma for cadastral operations, and to carry on the skeleton traverse work under the superintendence of the local survey agency, with the aid of a trained officer from the Survey Department.

30. The areas which have been traversed during the year are as follows:—

	Square miles.
Central Provinces	3,229
Lower Burma	1,364
TOTAL	4,593

SPECIAL OPERATIONS.

31. In default of there being two officers available for carrying on the electro-telegraphic longitude operations, the work of observing latitudes was re-commenced on the Madras meridional series from the point where it had been left in the season 1888-89. Seven stations were observed at, the southernmost being on the parallel of 13° and the northernmost on that of 15° 56″.

32. The tidal operations have been continued as usual. Observations by the self-recording tide-gauge have been made at seventeen stations in India, Burma, Ceylon, and the Andaman Islands. Three tidal observatories have been closed and dismantled during the season, the tidal record at them having been completed, and two new ones at Minicoy and Trincomalee have been established.

33. Spirit-levelling operations have been carried on from Rájkot to Bhávnagar, from Sanosra to Port Albert Victor, and from Náydongri to Málkhet, over an aggregate distance of 425 miles.

GEOGRAPHICAL SURVEYS AND RECONNAISSANCES.

34. The very large area of comparatively unknown country, reported as having been geographically surveyed during last year, has been exceeded during

the year under review: the total out-turn for this class of operations amounting to 1,00,848 square miles as compared with 97,792 square miles executed last year. Of this total 41,844 square miles have been mapped in Burma and 59,004 in Baluchistan and Persia.

35. As was the case last year, two field parties, Nos. 11 and 21, have carried on the preliminary survey of Upper Burma on the $\frac{1}{4}$-inch scale, and have furnished surveyors to accompany various military and exploring expeditions The out-turn of the more regular survey work, which is being carried out by districts, amounts to 18,494 square miles.

36. Captain Longe and Lieutenant Gordon accompanied the military expeditions which operated to the north and west of Mogaung, and the latter officer subsequently joined the expedition to the Jade Mines. Arrangements had been made for two surveyors to accompany a column into the Baungshé country, lying to the south of the Chin hills and south-west of Gangaw, but the surveyors, on arriving at the base of operations, found that the expedition had been abandoned for that season. Their time, however, was not wholly wasted, as Mr. Kitchen and the native surveyor succeeded in making a rough reconnaissance of over 2,000 square miles of the Baungshé country from points on its eastern border. A native surveyor, Sher Shah, was attached to another expedition under Lieutenant Burton, which penetrated into the Kachin hills, east of Bhamo, and an area of 1,300 square miles was reconnoitred. The total area mapped by these parties in the above operations amounts to 23,294 square miles.

37. The expedition under the political charge of Lieutenant Eliott, which proceeded from Senbo, above the first defile of the Irrawaddy, to explore the upper branches of that river, was accompanied by Major Hobday. The column marched northwards along the right bank, as far as the confluence of the Malikha or western branch, and the 'Nmaikha or eastern branch, and thence along the right bank of the western branch as far as latitude 26° 15′. From a hill here, the course of the river could be clearly traced through the Kanti country, and as previous reconnaissances had determined its course from its source to the Kanti country, a fair knowledge has now been gained of the western branch throughout its length. From rough measurements taken at the confluence of the two branches, it was found that the 'Nmaikha or eastern branch was wider and deeper; that the water therein was of a colder temperature, from which it may be supposed that it receives a greater volume of snow-water; and that its volume was somewhat greater: so it may be inferred that the eastern branch is the main source of the Irrawaddy. The information obtained regarding the source of the 'Nmaikha was, however, scanty and unreliable. There is reason however to suppose that the eastern branch has not a much longer course than the western one, and that the Lu river of Tibet, instead of running into the Irrawaddy as shown in recent maps, is identical with the Salween river. Major Hobday succeeded in mapping an area of 4,300 square miles of previously unexplored country. The work done during this expedition, combined with that of Sher Shah's alluded to in the previous paragraph, and the explorations of former years, furnishes a very fairly reliable map of the eastern frontier of Burma between the 24th and 26th parallels of north latitude.

38. Further south, two columns also operated on the eastern frontier. One, under the political charge of Lieutenant Daly, started from Lashio, and marching through Theinni State traversed a large area of unknown country lying on the eastern border of the Northern Shan States. This was accompanied by Captain Renny-Tailyour, R.E., and one sub-surveyor, who secured an out-turn of 5,250 square miles of topography. The second expedition, known as the Kyaington-Chiengmai frontier mission, was accompanied by Mr. Kennedy and two sub-surveyors. This small party succeeded in mapping the large area of 9,000 square miles on the $\frac{1}{4}$-inch scale—a very creditable result.

39. The military expeditions on the North-West frontier were each accompanied by small survey detachments. Captain Wahab, R.E., succeeded in mapping 95 square miles on the 1-inch scale of the country on the Miranzai border during the first expedition there. On the close of operations he was detailed to join the Hazara Field Force and during the occupation of the country he was enabled to survey an area of 184 square miles on the 2-inch scale, and to sketch some 360 square miles on the $\frac{1}{2}$-inch scale. Captain Mackenzie, R.E., with one sub-surveyor, joined the Miranzai Field Force during the second phase of oper-

ations and extended the work previously done by Captain Wahab. An area of 160 square miles was surveyed on the 1-inch scale, and 20 square miles were sketched on the $\frac{1}{2}$-inch scale. The results of these surveys have been included in the out-turn given under the head of topographical surveys.

40. In addition to the regular survey of Baluchistan, the field party employed there has again secured a large out-turn of geographical work. During the latter part of 1890, Colonel Holdich, R.E., and Captain Mackenzie, R.E., accompanied the military expedition to the Zhob valley under Major-General Sir G. White, K.C.B., and mapped an area of over 5,000 square miles. In Mekran and on the Perso-Baluch frontier an area of 23,500 square miles was mapped on the $\frac{1}{4}$-inch scale by Mr. Tate and sub-surveyor Ahmad Ali.

41. Sub-surveyor Imam Sharif, K.B., was deputed from the Baluchistan party, on survey duty in Persia in association with the Intelligence Branch of the Quartermaster General's Department, and was employed there during the greater part of the year under report. He returned with the large out-turn of 30,500 square miles mapped on the $\frac{1}{8}$-inch scale.

42. The aggregate areas geographically surveyed, and for the most part now mapped for the first time, are as follows:—

30,500 square miles on the $\frac{1}{8}$-inch scale
70,348 " " " $\frac{1}{4}$ " "

HEAD-QUARTERS OFFICE.

43. The details of work done in the various offices at head-quarters are given in Part III of this Report.

44. The number of new maps and new editions of departmental subjects published during the year amounted to 4,779, of which 4,449 were cadastral maps. The total number of maps issued was 2,08,484 and their value ₹1,45,245. The cash sales of maps amounted to ₹12,917. The demand for maps has steadily increased year by year, and the issues are now four times greater than they were ten years ago, the number issued in 1880-81 having been 50,869.

45. In the Drawing Branch, the preparation of maps of Burma on various scales has been the principal work. The second edition of the general map, on the 32-mile scale, has been completed, but the publication thereof has been delayed for want of alterations in internal boundaries, which the Local Government has been asked to supply. A new map of Upper Burma, on the 16-mile scale, which is a great desideratum, has been commenced and has made good progress. The third edition of the 32-mile map of India, with extensions to the east and west, so as to include the limits of Burma and Baluchistan, is still in progress. Considerable additions have been made from the surveys in progress on both frontiers; and to avoid the delay that would take place in engraving the new materials on the copper plates, it is intended to make the necessary additions, including all other existing geographical information of those frontiers, on stone, transfers from the copper having been made for this purpose.

46. Considerable difficulty has again been experienced in dealing with the regular departmental mapping owing to the great increase of extraneous work demanded by various outside departments, which are of such a pressing and continuous nature as to put a heavy strain on this section of the office. The work has increased enormously in the last few years owing to the above cause, as well as to the vast amount of trans-frontier work and the mapping of Upper Burma that has had to be dealt with. The efficiency of the office to meet the demands made on it cannot be maintained without an increase to the staff of draftsmen.

47. In the Engraving Office, good progress has been made with the various provincial maps on the 16-mile scale. The new railway map of India, on the 96-mile scale, is practically completed, but the many alterations required by the Railway Department have delayed its publication. A map of India, on the scale of 128 miles to the inch, has been commenced, and another map, on the 256-mile scale, has been progressed with.

48. In the Calcutta City Survey Office, the drawing of the fair sheets, 235 in number, on the original scale of survey, 1 inch = 50 feet, which are being prepared for reproduction by photo-zincography, is completed, with the exception

of certain boundaries, the survey of which is incomplete. Delay in laying down these boundaries has been caused by difficulty in getting the proprietors of holdings to attend and point out the boundaries. It has been necessary to institute prosecutions for non-attendance, which have had some, effect, but considerable delay is still experienced, and it is estimated that 1,550 holdings now remain for final demarcation. The map of Calcutta for general purposes will be published on the 16-inch scale, and the sheets, 15 in number, are being re-drawn for reduction with the object of producing the map by heliogravure.

49. The work done in the Photographic and Lithographic Office again shows a considerable increase. Out of a total of 7,067 original subjects received for reproduction during the year, 4,376 were cadastral maps, 1,145 were ordinary departmental maps, &c., and 1,546 were miscellaneous subjects for other departments. There was an increase of 284 extra-departmental subjects over the previous year, and this class of work is now much in excess of the regular departmental work, excluding cadastral maps. The total number of copies of maps and various other subjects printed off was 745,993, besides 1,074,280 impressions from type and 3,796 photographic prints, and their value was about R2,08,654, or R8,280 more than last year.

50. The new steam machinery was working throughout the year without any hitch or difficulty, and proved of vast use in dealing with the increased demands, which could not have been met without its aid. Most of the hand-printing presses as well as the machines were fully occupied.

51. The 24-mile map of Afghanistan, and the two railway maps with hills on the 48 and 64-mile scales, noted in last year's report as ready for press, were printed off and published. The completion of the 32-mile map of India (third edition) has been delayed in consequence of the heavy additions of hills in Burma, and with the further addition of hills in Sind, Baluchistan, and Kashmir; the map will probably not be completed till well on in the current year. The 6-inch map of Calcutta in two sheets was published, but further additions are now being made to it for a new edition.

52. Among other departmental maps photo-zincographed and published, may be noticed new issues of the maps of the Madras Presidency, the North-Western Provinces and Oudh, and the Central Provinces, on the 32-mile scale; also of the Presidency and Chittagong Divisions on the 8-mile scale. Nine district maps on the 4-mile scale were lithographed by transfer from the engraved copper-plates, and 239 standard sheets of the Topographical and Revenue surveys were published, exclusive of reprints.

53. The extra-departmental work has again been very heavy, and includes railway and telegraph maps on the 96-mile scale brought up to date; a military map of India on the 32-mile scale; a forest map of the Punjab on the same scale; several large scale maps of the new oil-fields in Burma; and block-plans of the City of Mandalay. Besides the usual weather charts and meteorological diagrams, a new series of charts for the monthly weather reports has been commenced, and will be a steady demand on the office.

54. The out-turn of the heliogravure section also shows a large increase in photo-etched plates, photo-blocks and electrotypes, nearly the whole of which was required for other departments. Seventy plates were reproduced by photo-etching, including 17 plates for the illustration of Mr. Cotes' reports on economic entomology, published by the trustees of the Indian Museum (14 of these plates are being reprinted for Dr. Watt's "Dictionary of Economic Products"), also 34 photo-blocks for the same publication. Twenty-one plates of the technical art series have been printed and issued during the year. Three plates of the outline of the new 24-mile map of Afghanistan were photo-etched; the remaining plate will be done as soon as certain necessary corrections have been carried out in the original. Outside demands which require the utilization of the heliogravure process are steadily increasing. The introduction of photo-block work in half-tones is an important feature of the work of the year, and bids fair to be of immense use in providing a cheap and practical method of half-tone printing suitable for book illustration. Colonel Waterhouse has obtained some ruled glass screens from America, and with these it is hoped that very greatly improved results may be obtained.

55. Colonel Waterhouse was on furlough in Europe for six months, and spent part of his time in making enquiries in England and abroad regarding methods of quick copper-plate printing and new processes of reproduction. He

has made further advances in the process of producing positives direct in the camera as reported last year.

56. The demands on the Mathematical Instrument Office for survey and other scientific instruments were in excess of those of last year, the total number of instruments issued amounting to 64,203, valued at R2,88,337, as compared with 60,128, valued at R2,70,458, issued during the previous year. The heavy demand of the Meteorological Department for the supply of 5-inch rain gauges of an improved pattern to nearly every recording station in India considerably taxed the resources of the office; large indents also for cheap instruments were received from the Local Governments of the Central and North-West Provinces. During the year 63,196 serviceable instruments, valued at R2,59,909, and 3,668 repairable instruments, valued at R60,734, were received into store.

57. In the Trigonometrical Branch Office, Dehra Dun, the Computing section has been engaged in passing through the press volume XIV of the Account of the Great Trigonometrical Survey, containing the final reduction of the principal triangulation of the south-west quadrilateral. Considerable progress has also been made with the synoptical volumes of the several chains of principal triangulation. As has been the custom hitherto, photographs of the sun have been taken on every day on which the sun was visible throughout the year, and the negatives forwarded to the Solar Physics Committee at South Kensington for incorporation in the yearly volumes of the Greenwich observations.

58. In the Drawing Office, Simla, the principal work of the year under report has been the preparation of trans-frontier maps on the scale of 1 inch = 8 miles. A new edition of the Turkestan map, on the 32-mile scale, is in preparation, and several miscellaneous maps, illustrating the military expeditions of the year on the north-west frontier, have been drawn; a new general map of Baluchistan, on the 16-mile scale, has been commenced and is nearly completed.

INSPECTION TOURS OF THE ADMINISTRATIVE OFFICERS.

59. On the 8th April 1891, the Surveyor-General left Calcutta for Madras and returned on the 30th idem, during which time he inspected at Bangalore the office of No. 19 party, which is employed on the forest surveys in that Presidency, and at Madras conferred with the Forest Member of the Board of Revenue and the Conservator of Forests, and discussed the arrangements to be made for the future working of the party, with the view of increasing its annual out-turn and diminishing the cost-rates. On 5th May, the Surveyor-General proceeded to Simla under the orders of the Government of India, to be in personal communication with them, and the opportunity was taken of visiting and inspecting the survey offices that are located there. He returned to Calcutta on 22nd July, and on 3rd September he proceeded to inspect the various field parties recessing in the Madras and Bombay Presidencies. He visited at Bangalore the offices of Nos. 11, 13, and 21 parties, and at Poona those of Nos. 10, 17, and 25 parties, and returned to Calcutta on 28th September. On 3rd October, the Surveyor-General proceeded to Dehra and Mussooree to inspect the offices of the Trigonometrical Branch and of the Forest Survey Branch, and returned to Calcutta on the 23rd idem.

60. The Deputy Surveyor-General, Trigonometrical Branch, proceeded on tour on 11th August 1891, and inspected No. 18 party at Simla and No. 25 party at Poona, and returned to his head-quarters on 27th idem. The recess offices of the other survey parties under his immediate superintendence were located at his head-quarters, and were duly inspected from time to time, *viz.*, Nos. 14, 22, 23, and 24 parties.

61. On the 13th February, the Deputy Surveyor-General, Revenue Branch, accompanied the Lieutenant-Governor of Bengal on an inspection tour to Chittagong, visiting the camp of the settlement officer on the 15th and inspecting the office of the survey party (No. 2, Cadastral) on the 16th; he returned to Calcutta on the 18th idem. On the 31st March he inspected the office of No. 4 party (Western Dooars) at Jalpaiguri, and on the 1st April attended a conference, at which the Lieutenant-Governor of Bengal, the Commissioner of the Division, and the survey and settlement officers were present; the future programme and procedure of the survey party were discussed, and orders were given for increasing the survey office establishment to allow of the more rapid submission of records to the Settlement Department.

On the 16th April he left for Burma, returning to Calcutta on the 16th May. During his tour he inspected No. 7 (Cadastral), No. 20 (Forest), No. 11 (Topographical), No. 3 (Cadastral), No. 21 (Topographical). and No. 12 (Traverse) parties, visiting their head-quarters and camp offices. He also attended a conference at Rangoon, at which the Chief Commissioner and the Financial Commissioner were present, when the future survey operations in Burma were discussed and arranged. He also enquired into the complaints made by the Superintendent of Supplementary Surveys, that delay was caused to that department by the non-submission of traverse plots by the survey party; in consultation with the Director of Land Records and the Superintendent, arrangements were made for their more speedy submission in future.

On the 29th June he met the Director of Land Records, Lower Provinces, at Burdwan, and consulted with that officer and the manager of the Burdwan Raj Estate as to the advisability of allowing the survey detachment to continue working on the estates of the Raj for another season. From the 8th to the 18th July he visited Cuttack, inspecting the survey office of No. 8 party there, and, meeting the Director of Land Records, arranged with him a future programme of survey and prepared estimates in consultation with him and the settlement officer. He also attended a conference, at which the Commissioner, the Director of Land Records, and other officers concerned were present, when arrangements for the revision survey of the irrigated lands were made and other survey matters in Orissa were discussed. From the 3rd to the 10th September, he was again on tour and inspected No. 9 party (Traverse) at Jubbulpore, where he also met the Commissioner of Settlement and Agriculture. From the 15th to the 27th September, he visited Shillong and inspected No. 6 party (Cadastral).

ESTABLISHMENT.

62. The strength of the senior division of the department was settled last year in conformity with the programme of operations that had been arranged, and recruitments have been made during the year under report to bring the establishment up to its full strength. Ten officers have been appointed, three of whom belonged to the Bombay Revenue Survey department, and were transferred under the orders of the Government of India.

63. During the year, five officers of the senior division have retired from the department, all of whom have been associated with it for many years.

Colonel J. Sconce, S.C., Deputy Surveyor-General in charge of the Revenue Branch, was superannuated on attaining the age of 55 years on 2nd April 1891, after a service of 32 years in the Survey Department, during the whole of which time he was employed in the Revenue Branch, and both as an executive and administrative officer has rendered valuable services, especially in connection with cadastral surveys. Colonel Sconce was Deputy Surveyor-General, and superintended the Revenue Surveys for twelve years; the ability and industry he evinced in the discharge of the duties of his office have been highly appreciated by the different Surveyor-Generals he has served under, and it is hoped that his long and meritorious services may meet with recognition from the Government of India.

Colonel D. Macdonald, S.C., Deputy Superintendent, 1st grade, was superannuated on 10th December 1890, after completing a service of 30 years in the department. With the exception of a period of three years when he was Assistant-Surveyor General at the Head-quarters office, he was employed entirely on revenue surveys, and has rendered much useful work as an executive officer.

Colonel W. Barron, S.C., Deputy Superintendent, 1st grade, retired from the service on 19th February 1891 owing to ill-health, which incapacitated him for duty. He joined the department in June 1862, and was employed continuously in the Revenue Branch. His principal services have been in connection with cadastral surveys; the development of the economical system under which the operations of survey and settlement are combined, and in which the survey and revenue officials work together, is largely due to Colonel Barron's labours. He compiled the first hand-book of instructions for conducting such operations in the North-Western Provinces, for which he received the thanks of the Government of India.

Colonel A. Pullan, S.C., Officiating Deputy Suprerintendent, 1st grade, was superannuated on 31st March 1891 after a service of 28 years in the department. He was employed throughout on topographical surveys, for which his skill as an artist rendered him specially fitted, and he has done good work as an executive officer. His death was reported within a month of his leaving the department from an illness contracted while on active service in India.

Colonel S. H. Cowan, S.C., Deputy Superintendent, 2nd grade, retired from the service on 13th October 1891 after an useful career of nearly 25 years in the Survey Department. He was employed almost throughout his service on revenue surveys, and was an able and experienced officer in cadastral operations.

64. The recruitment of the junior division, which had been contracted for some years under the orders of the Government of India, was authorized up to the existing sanctioned scale during the year under report, and the vacancies have been accordingly filled up. Fourteen officers have been appointed to this division, and three have left it during the year—two by promotion to the senior division and one by retirement.

PART II.

THE OPERATIONS OF THE SEVERAL FIELD PARTIES.

TRIGONOMETRICAL SURVEYS.

PRINCIPAL TRIANGULATION.

BURMA.

No. 24 Party.

65. This party under Lieutenant Close continued the principal triangulation in Burma northward, from the side Omáza-Thantaung, up to which it had been carried in the previous season. The direction of the series from this side, for about fifty miles, has been diverted slightly eastwards from the original meridian of 96°30′ in order to avoid the dense jungle in the plains on the western flank of that meridian, and to enable the stations on both flanks to be fixed on the Karen hills, where the ground is favourable for triangulation. Thus the season's work was mainly in the north-west Karen hills, where the principal difficulty met with was in communicating between the flanks of the series.

Personnel.

Lieutenant C. F. Close, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. T. H. Rendell, Surveyor, 3rd grade.
Mr. J. Hickie „ 4th „
Mr. B. R. Hughes, Assistant Surveyor, 2nd grade.

66. The assistants arrived at Toungoo on the 25th of October, when the preliminary field work was commenced. Messrs. Hickie and Rendell were detailed to select and build forward stations for observation on the east and west flank respectively, whilst Mr. Hughes was entrusted with the building of the stations for the intersected points. The principal observations were commenced by Lieutenant Close on the 18th of November, and continued till the 23rd of February, after which, owing to haze having set in, no further observations to principal stations were possible. Astronomical observations were then taken for azimuth, which occupied Lieutenant Close till the 22nd of March, and the work on the approximate series in advance was continued till the end of April, when the field operations were closed.

67. The result of the season's out-turn is as follows: Horizontal and vertical angles have been taken at nine principal stations, and star observations for determination of azimuth of verification were taken at two stations. The series was extended over a direct distance of 45 miles, embracing an area of 900 square miles. Thirteen principal stations were selected and built in advance of the completed work, extending as far as Mandalay, a distance of 175 miles. This will enable the employment of two observers simultaneously next season, and the final observations will be materially increased. This is a matter of great importance in a country where the conditions of the atmosphere allow of observations being taken during a very limited period.

68. The triangulation has been arranged in two figures, the first a tetragon with a central station, the second a quadrilateral. The northern figure of last year's work was also re-adjusted with the additional angle at Toungoo observed this season.

69. The observations were made with Troughton and Simm's new pattern 12-inch theodolite No. 1, the same instrument that was used the season before. The method of observing was altered from that of the previous season, as intersections were made with the eye-piece micrometer wire, and two sweeps were taken on each face, right and left, on each zero, and the angles were measured on nine pairs of zeros, instead of taking three sweeps on six pairs of zeros. The performance of the instrument may be considered remarkably good, the mean triangular error being 0″·36, between a maximum of 1″·07 and a minimum of 0″·01—the triangular error in the previous season being 0″·82.

70. Lieutenant Close reports as follows:—

"The couutry through which the triangulation was carried, *i.e.*, the north-western Karen hills, Sulé and Mobyé, is mountainous, densely-wooded, and thinly-populated. With the exception of the road from Leiktho to Yadu, the roads are mere tracks, and it was found that pack bullocks were the best means of transport. Communication was not easy with people who spoke neither Burmese, Shan, nor Karen. North of Sulétaung in the south-west portion of the Shan Plateau, better country was entered—an undulating tract with few trees and isolated hills. The difficult country is now done with, and next year progress should be fairly rapid."

71. The party left the field for recess quarters at Mussoorie on dates varying between the 20th of April and the 4th of May, Lieutenant Close leaving Pyinmana on the latter date. During the recess, the season's observations were computed, and were utilized in calculating the graduation error of the horizontal circle of the theodolite. The results go to prove that the graduation is very accurate, as the maximum mean error of any two divisions 180° apart appears to be about 2″·56, which is equivalent to a linear displacement of one thirteen-thousandth of an inch. Another result of the calculations is to show that an angle measured on six zeros, compared with one measured on nine zeros, may be expected to be liable to an additional error of about 0″·2.

72. A statement, giving the details of the out-turn executed during the year, will be found at page i of the appendix.*

TOPOGRAPHICAL SURVEYS.

GUJARAT, RAJPUTANA, AND SOUTHERN MARATHA COUNTRY, BOMBAY PRESIDENCY.

No. 10 Party.

73. This party has continued topographical operations, during the year under report, in Gujarat and in the Southern Maratha country, Bombay Presidency, as well as in a small portion of Rajputana. The superintendence of the party remained in the hands of Colonel Hutchinson during the field season and up to the early part of June 1891, when he relinquished charge on transfer to No. 17 Party, Bombay Forests, and was relieved by Lieutenant-Colonel J. Hill, R.E., under whom the recess operations of the party have been carried on.

Personnel.

Colonel H. S. Hutchinson, S.C., Deputy Superintendent, 2nd grade, in charge up to 7th June 1891.
Lieutenant-Colonel J. Hill, R.E., Deputy Superintendent, 2nd grade, in charge from 8th June 1891.
Mr. W. Todd, Surveyor, 1st grade.
„ W. Stotesbury, „ 3rd „
„ C. E. Tapsell, „ 4th „
„ W. M. Kelly, Assistant Surveyor, 1st grade.
„ R. R. Dickinson, Assistant Surveyor, 1st grade.
„ W. F. E. Adams, Assistant Surveyor, 3rd grade.
34 sub-surveyors and others.

74. As in the previous year, the party was divided into two sections, one being employed in the Southern Maratha country, and the other in Gujarat. The survey work in Rajputana was undertaken by a small party detached from the section which had been allotted to Gujarat. This detachment commenced field operations on the 15th October, and after the completion of the Rajputana work in the middle of February, it moved southwards and joined the other portion of the Gujarat section which had taken the field between the 15th and 20th November. The Southern Maratha section also commenced field work on the 15th November, and the whole party returned to Poona by the end of May.

75. The total out-turn of the season's work is as follows:—

Triangulation, 1,440 square miles, fixing 186 points (including stations).
Detail survey, 2-inch scale, 2,742 square miles.
Ditto 1-inch „ 896 „
Ditto ½-inch „ 925 „
Traversing, 1,226 linear miles, covering an area of 1,727 square miles.

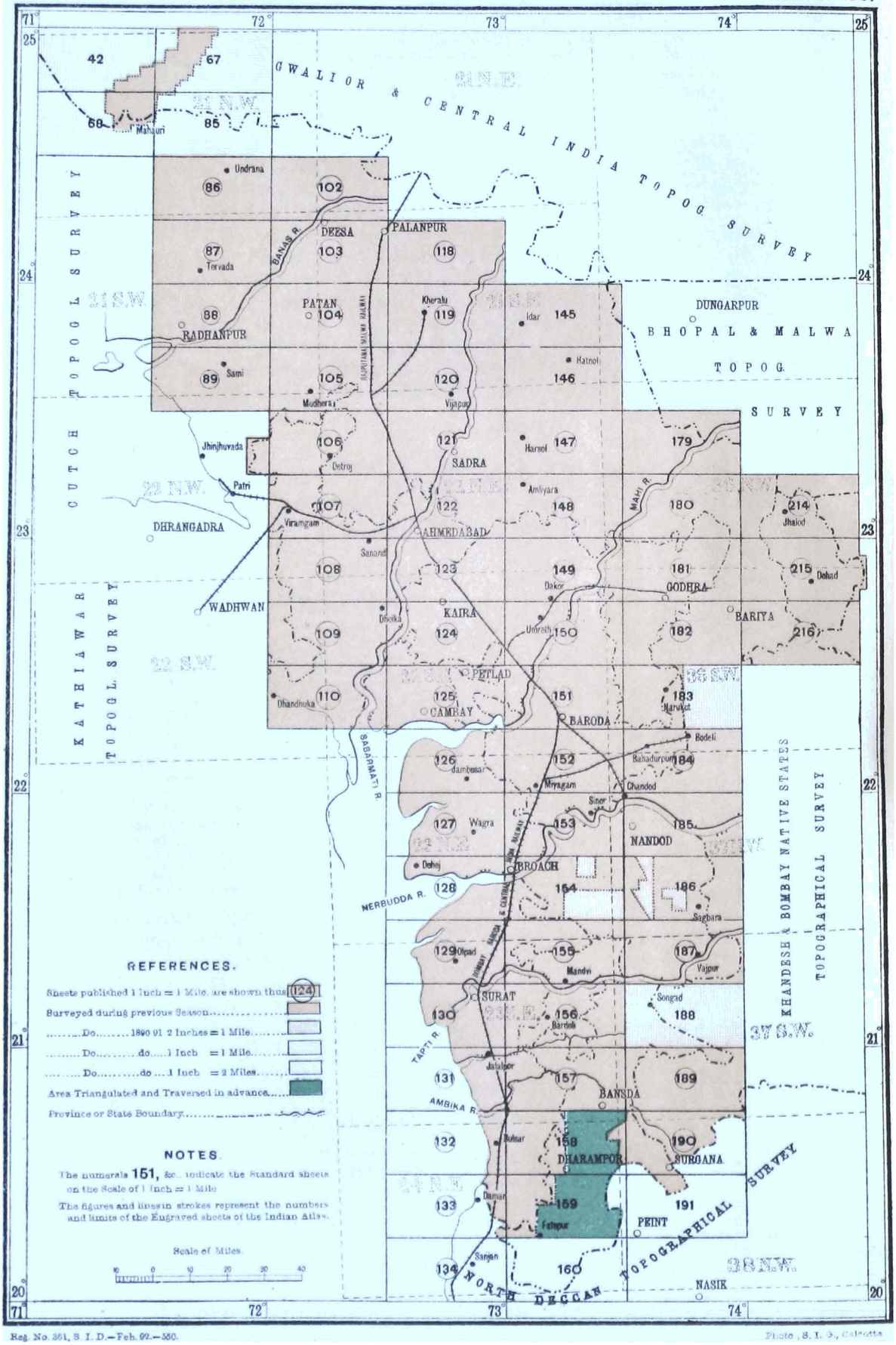
The operations of the different sections will be described separately.

* Lieutenant Close speaks highly of the zeal and ability displayed by Mr. J. Hickie in carrying out the most difficult part of the approximate work.

BOMBAY SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN GUJARAT.

No. 10 PARTY.



Reg. No. 351, S. I. D.—Feb. 92.—350.

Photo., S. I. S., Calcutta.

North Gujarat and Rajputana Survey.

76. This work was allotted to Mr. W. M. Kelly, and as the climate of this part of the country becomes excessively hot towards the end of March, he was despatched into the field with five of the best sub-surveyors a month before the rest of the party, so as to enable him to get the work done during the most favourable time. At starting, he experienced some delay due to the failure of the Hakim of Sanchor to furnish the promised camel carriage. This, however, was overcome by the kind assistance of the Commissariat officer at Deesa, and by the energetic co-operation of the Hakim, subsequently secured through the influence of the Resident, Western Rajputana States, and the work was successfuly completed. The whole of the country surveyed was very open and clear of vegetation, the main features varying between sand hills, sandy plains, and the salt wastes of the Rann of Cutch and other small isolated ranns, the sandy plains being however surprisingly fertile and populous.

77. The area surveyed included 896 square miles in sheets Nos. 57 (Rajputana survey) and 85 (Bombay survey) on the 1-inch scale, and 925 square miles in sheets 42 (Rajputana survey) and 68 (Bombay survey) on the $\frac{1}{2}$-inch scale, the remainder of these sheets having been surveyed on the 1-inch scale in connection with the Luni river survey during season 1878-79. The survey contains as much detail as the scales admit of, and was tested throughout by Mr. Kelly; 93 linear miles of test lines having been run in the 1-inch work, and 59 linear miles in the $\frac{1}{2}$-inch work. Sheets Nos. 57 and 85 have been finally mapped for reproduction on the 1-inch scale; their reduction by pentagraph for incorporation with sheets Nos. 42 and 68 on the $\frac{1}{3}$ inch scale has also been made, and the whole of those sheets traced for reproduction on that scale.

Gujarat Survey.

78 The work in the southern portion of this district was made over to Messrs. W. Todd and Stotesbury with six sub-surveyors, it being understood that on the completion of the Rajputana work the detachment employed in that direction would be moved southwards into the Gujarat district, and both establishments would work under Mr. Todd up to the close of the season.

79. In sheet 183, the eastern half of which was first taken up (the western half having been surveyed in season 1883-84), the surface of the country is in the former portion thickly covered with jungle and foliage; the ground being intricate and much of it hilly, and in the more cultivated areas covered with large trees which obstruct the view. The climate at the time of starting the work was unhealthy, and one or two of the sub-surveyors and nearly all the *khalásis* were laid up with malarial fever. Later on the health of the detachment improved, but the progress of the work was still slow, as the most efficient sub-surveyors had been sent to the Rajputana work, and this sheet was not completed till the beginning of March. Colonel Hutchinson tested all the sections of this sheet and has expressed himself as much pleased with their accuracy. Of the area surveyed in this sheet Mr. Stotesbury himself did 57·5 square miles, and he has written an interesting description of the hill fort of Páwagad which will be found in the appendix.

80. Sheets Nos. 154 and 186, which could not be completed last field season, were next taken up. The country is densely covered with jungle and it could not have been surveyed earlier in the season, as the forest is at that time filled with an undergrowth of tall reed grass standing 10 and 13 feet high, obscuring the view in every direction. At the time survey operations were commenced there, however, most of the undergrowth had been burnt, and a carpet of ashes covered the ground; the heat was intense, and as the water-supply was bad, the work proved very trying. Besides surveying 47 square miles himself, Mr. Stotesbury tested the work done by the sub-surveyors during the season in these sheets, together with what they did in the same sheets during the previous year, both by *in situ* examination, and by 120 linear miles of test lines, and found it very satisfactory.

81. In sheet No. 188, the survey of which was undertaken by Mr. Kelly with his detachment from Rajputana in the latter end of February, forms a marked contrast to that to the north of it, being fairly free from jungle; but the climate is unhealthy, and there was a good deal of fever in the detachment in the beginning of March. The northern half of the sheet consists of generally undulating ground

intersected with ravines, studded with isolated hills, and fairly easy to survey. In the southern half of the sheet, there is a plateau rising about 1,500 feet above the general level of the country, which averages 600 feet above sea-level. Besides surveying a section of 68 square miles in this sheet, Mr. Kelly checked the work of the sub-surveyors by running 89 linear miles of traversing and found it satisfactory. The work was completed by the middle of May with the assistance of a couple of sub-surveyors besides those he brought down with him from Rajputana. In all 1,083 square miles were topographically surveyed on the 2-inch scale by this section.

Sheets Nos. 154, 186, and 188 have been finally mapped on the 2-inch scale, and the drawing of sheet 183 is well advanced.

Southern Maratha Survey.

82. Mr. Tapsell, with Mr. Adams and 15 sub-surveyors, continued the topographical survey, on the 2-inch scale, of the Southern Maratha country, and Mr. Dickinson was told off for the triangulation. The topographical detail work of sheets Nos. 273, 274, 304, and what remained of sheet No. 330, was completed; and the traverse work was extended over sheets Nos. 272, 273, and 274, comprising an area of 1,727 square miles.

83. This country is mainly flat, open and easy of survey. One intricate and interesting range of hills crosses sheet No. 274 from south to north and contains the well known falls of Gokak. The area of topographical work executed by this detachment during the season is 1,659 square miles. It was tested by a close examination *in situ*, as well as by 199·5 linear miles of test lines, and was found excellent in quality and up to the standard of previous years' work.

84. Before taking up the triangulation, Mr. Dickinson undertook the mapping of the South Maratha Railway on to all the old sheets of Deccan survey that had been surveyed and published previous to the construction of the line, commencing the work from Poona and finishing at Miraj. He then extended the triangulation over sheets Nos. 242, 272, and 273, accomplishing an out-turn of 1,440 square miles. The mathematical results of this work are good, both as regards angular and linear errors. The final mapping of sheets Nos. 274, 304, and 330 has been completed.

85. The recess office of the party was inspected by the Surveyor-General in September 1891. The records were found in good order and the recess duties progressing satisfactorily. The drawing of the fair standard maps is deserving of high commendation; they are executed in a highly artistic and effective style, while the field sheets give evidence of the survey having been carried out with care and accuracy. The general efficiency of the establishment was all that could be desired.*

MERGUI DISTRICT, LOWER BURMA.

No. 13 Party.

86. It had been intended to discontinue the operations in the Mergui district after the field season of 1889-90. The Burma Government, however, applied for the retention of the party for another year, and this having been sanctioned, arrangements were made to take the field again in November 1890, with a view to carrying on the survey of the tin-bearing tracts in the Mergui district.

Personnel.

Mr. A. D'Souza, Officiating Deputy Superintendent, 3rd grade, in charge.
„ A. J. Gibson, Surveyor, 1st grade.
„ G. Vander Beek, Assistant Surveyor, 1st grade.
„ P. White, Assistant Surveyor, 1st grade.
„ R. F. Warwick „ „ „
„ J. A. Higgs „ „ „
„ M. Gastaud „ „ „
7 sub-surveyors and others.

* Regarding the European Assistants, Colonel Hill reports as follows:—

"Mr. Todd supervised all the work done in Gujarat, and his arrangements throughout the season were good, and the work completed, satisfactory."

"Mr. Stotesbury is a first-rate assistant, intelligent active, hardy and willing, whilst he is an excellent topographical surveyor and draftsman. His individual work and influence amongst the surveyors are highly appreciated."

"Mr. Tapsell has maintained throughout the season an excellent supervision of his work, and has secured a capital out-turn; he is a most valuable assistant."

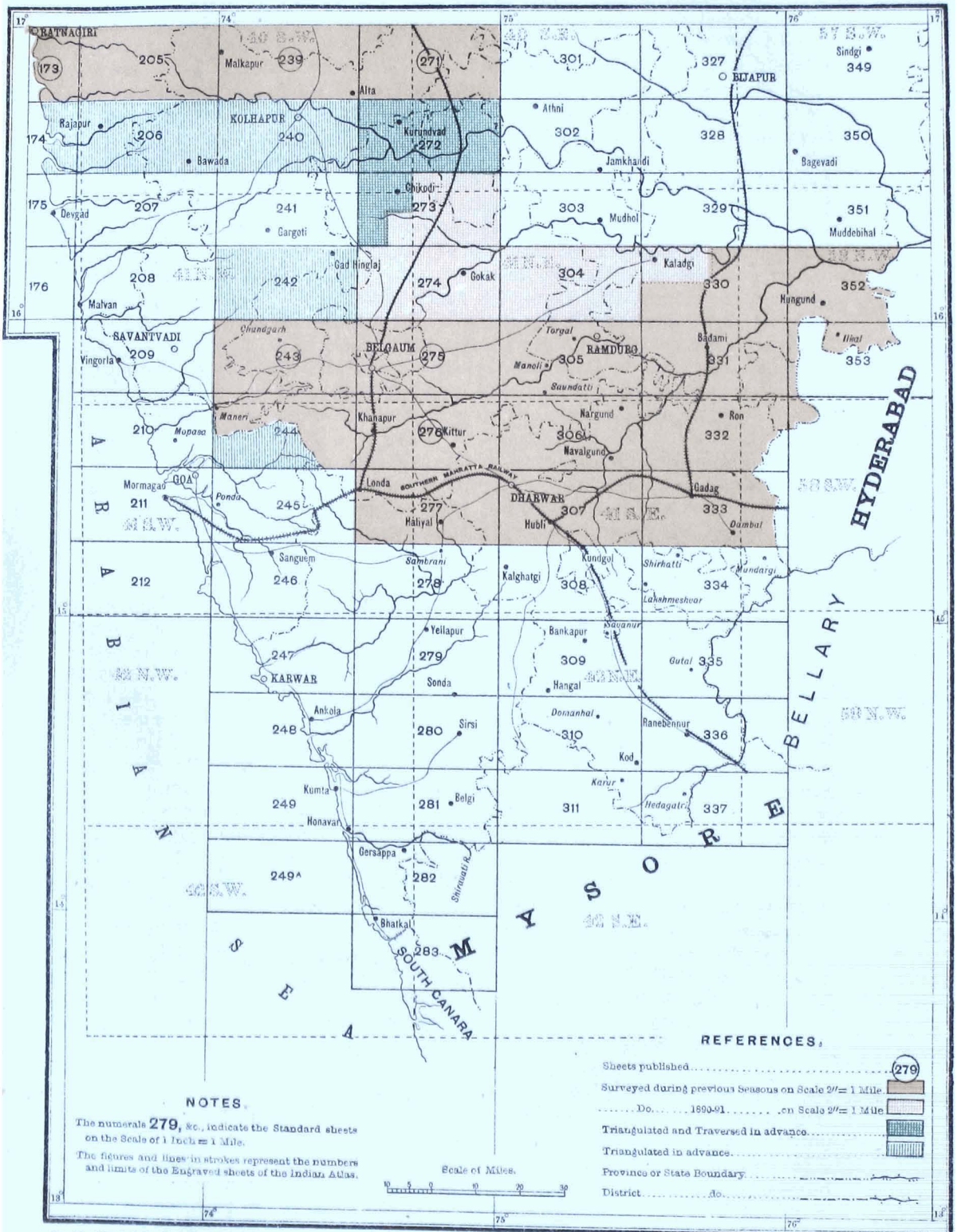
"Mr. Kelly deserves the greatest praise for the energy, zeal, and perseverance with which he completed the Rajputana survey, which is of excellent quality."

"Mr. Dickinson continued to be a very good assistant, and has worked up to his previous reputation."

BOMBAY SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN SOUTHERN MARATHA COUNTRY.

No. 10 PARTY.



Reg No. 361, S. I. O.—Feb. 92.—569.

Photo., S. I. O., Calcutta.

87. The party left recess quarters at Moulmein on the 4th of November 1890, and remained in the field until the 28th May 1891, when it returned to Mergui, and thence to Bangalore, the new recess quarters.

88. It had been arranged that the coolies and *khalásis* who had been recruited at Hazaribagh should leave Calcutta by the steamer of the 28th October, so as to reach Mergui a week after the arrival of the party from Bangalore, but, owing to the dilatoriness of the men, they failed to catch the steamer and were thus delayed in Calcutta; a further delay in Rangoon would have taken place (the service between that port and Mergui being a fortnightly one), had it been not for the loan of the steamer *Mergui* which was obtained through the Financial Commissioner. The men on their arrival at Mergui were despatched by boats to Bokpyin, where they awaited the survey party. This place being centrally situated with regard to the country to be surveyed, and being also a calling station for the coasting steamer plying between Mergui and Maliwun, was made the basis of operations. The time spent at Mergui, whilst waiting for the coolies, was not entirely lost, for guides and interpreters had to be engaged, the obtaining and transporting of sufficient supplies had to be organised, and huts had to be erected at suitable places for the storage of the supplies. Mr. D'Souza held a conference at Mergui with the Deputy Commissioner and the District Superintendent of Police, when it was arranged that the head *chetanjies* of sub-divisions of Bokpyin and Lynia should be placed under his orders with respect to furnishing the detached parties with extra coolies, provisions, and other requirements, when possible, in the populated portions of the country; in other places the survey had to be entirely dependent on its own resources. Instructions were also issued to the head constables of each *thana* and outpost to render every assistance; Indian police constables who were conversant with the Siamese language were also provided.

89. The keeping up of a proper supply of provisions to the several detached camps in a country where local supplies were very scanty or altogether wanting, and where communications, except by boat, did not exist, was a source of great difficulty and anxiety. The provisions were obtained through the Agent of the British India Steam Navigation Company at Mergui and were distributed to various depôts. The main depôt was established at outer Bokpyin, and four branch depôts at Hangpro, Hangachin, Klongkitong and inner Bokpyin; two or three boats were attached to each depôt for keeping up communications and for the carriage of supplies. The use of elephants for transporting provisions overland not having proved a success last year, coolies were employed between the depôts and the detached survey camps. As the work progressed inland, however, the usual difficulty attending the use of coolie transport over long marches was felt, *viz.*, the inability of the men to carry much more than the food required for themselves on the march; this difficulty was moreover increased by the nature of the country, the coolies often losing their way in the dense forest, and thus taking longer over their march than the actual distance necessitated. In January, complaints about the inability of the coolies to keep the camps supplied became so frequent that it was evident that the depôts must be moved to more suitable positions; four new sites were accordingly selected at Lynia, Hangpro, Tophan, and Pla-an, where huts were built and tracks cleared through the jungle to open up communications with the camps: communication between the main and branch depôts was also much facilitated by the use of a steam launch, the purchase of which has been sanctioned by the Government of India; it also enabled the officer in charge to visit the various sections of the work with ease and rapidity. The launch is a very good boat and has proved a great success, and now that it has been decided to again send a survey detachment to complete the two districts, the purchase will prove to be a very economical arrangement.

90. Field operations were commenced on the 20th November 1890 and closed on the 28th May 1891. The district to be surveyed on the 1-inch scale lay between latitudes 10° 45′ and 11° 30′ and longitudes 98° 30′ and 99° 0′, covering an area of about 1,000 square miles, comprised in sheets Nos. 214, 215 and 216, portions of which had been completed last year. To each assistant was allotted an area of about 75 square miles; he was despatched fully equipped and with a month's supply of provisions to the depôt nearest his work, whence he had to march inland. The experience gained in the previous year greatly assisted the surveyors in taking up their work; those whose work was in the vicinity of the

coast had little trouble in reaching their ground, as tracks had in many places been already cleared by the triangulators, but it was otherwise with those whose work was situated inland, and many of them had considerable difficulties to encounter before they could commence field operations.

91. The out-turn of work completed was 930 square miles of topography. No triangulation was carried on, as a sufficient number of points had been fixed the year before. A few hills were cleared with a view to connecting part of last year's work with the stations of the South-East Frontier series, but the necessity of constantly superintending the detail surveyors, and of being on the spot to look after the transport of supplies, precluded the possibility of the observations being made by Mr. D'Souza, and there was no one else available to do it.

92. The country in which operations were carried on very much resembled that surveyed and described last year, being a succession of rugged hills and valleys covered with impenetrable forest, and broken up by numerous creeks and inlets fringed with thick mangrove swamps. The density of the jungle and the size and height of the trees proved great impediments to the progress of the work, and necessitated the clearing of every hill top before survey operations could be commenced. To avoid this labour the surveyors frequently adopted the plan of constructing platforms in the trees several feet from the ground, but from these elevated positions it was generally impossible to follow the run of the streams and nullahs, owing to the density of the jungle, and these had, as a rule, to be traversed. With the exception of those mentioned in last season's report, the country is devoid of roads or even footpaths. Those cut by the surveyors are now being made use of by rattan-cutters and garjan oil extractors, and it would appear that a few good roads cut through the jungles would go far towards opening up the country to settlers coming over from Siam.

93. Mr. D'Souza reports as follows on the nature of the country surveyed :—

"The Chung-Pi range of hills, the highest in the portion surveyed, rises to a height of 2,750 feet above sea-level, and runs due north and south for a distance of about 15 miles, ending abruptly on the coast in a prominent headland, visible for miles out at sea. To the east of this range lies another, the highest point of which, Klongtophat, rises to a height of 2,260 feet above sea-level. This range runs in a southerly direction till it meets the Khow-than-dung range, and from these break off minor spurs, all of about the same height and densely covered with jungle. From the pass where the Khow-than-dung and Klongtophat meet, two principal rivers take their sources, the Klongkra and the Lynia. The former flows in a southerly direction, and meeting with the Plyingan, finally falls into the Pakchan river. The latter flows for 70 miles in a northerly direction and empties itself into Whale bay. This river was found navigable by the launch up to Lynia, by boats to Tophan, and from thence to Pla-an only by canoes or small dugouts. About midway between the mouth of the Lynia river and the town of that name is a whirlpool, called by the Natives 'Wajidway,' dangerous for boats to cross, except at certain periods of the tide. Lynia and Bokpyin are the two chief towns in this sub-division of the Mergui district; the former, with a large population, scattered over a long distance on the banks of the river, the inhabitants being chiefly Siamese, with a few Burmese and Chinamen. There are two villages of the name of Bokpyin, the outer and inner. The former is situated on the coast, and consists of a fishing village of some 50 huts, the inhabitants of which are principally Malays, whose chief occupations are fishing and the manufacture of salt-fish and *Napi*; inner Bokpyin is situated some four miles inland."

94. No fresh discoveries of tin were made during the survey operations, but a number of old workings were found in the jungle and noted on the map. These are merely surface washings, which must have been worked years ago. Indications of tin, however, were found almost everywhere, but in such small quantities as to be hardly worth working.

95. Sickness prevailed to a great extent throughout the period of field operations, the native establishment especially suffering greatly from fever, dysentery, and ulcers. The average proportion on the sick list throughout the season amounted to 10 per cent., and there were 29 deaths.

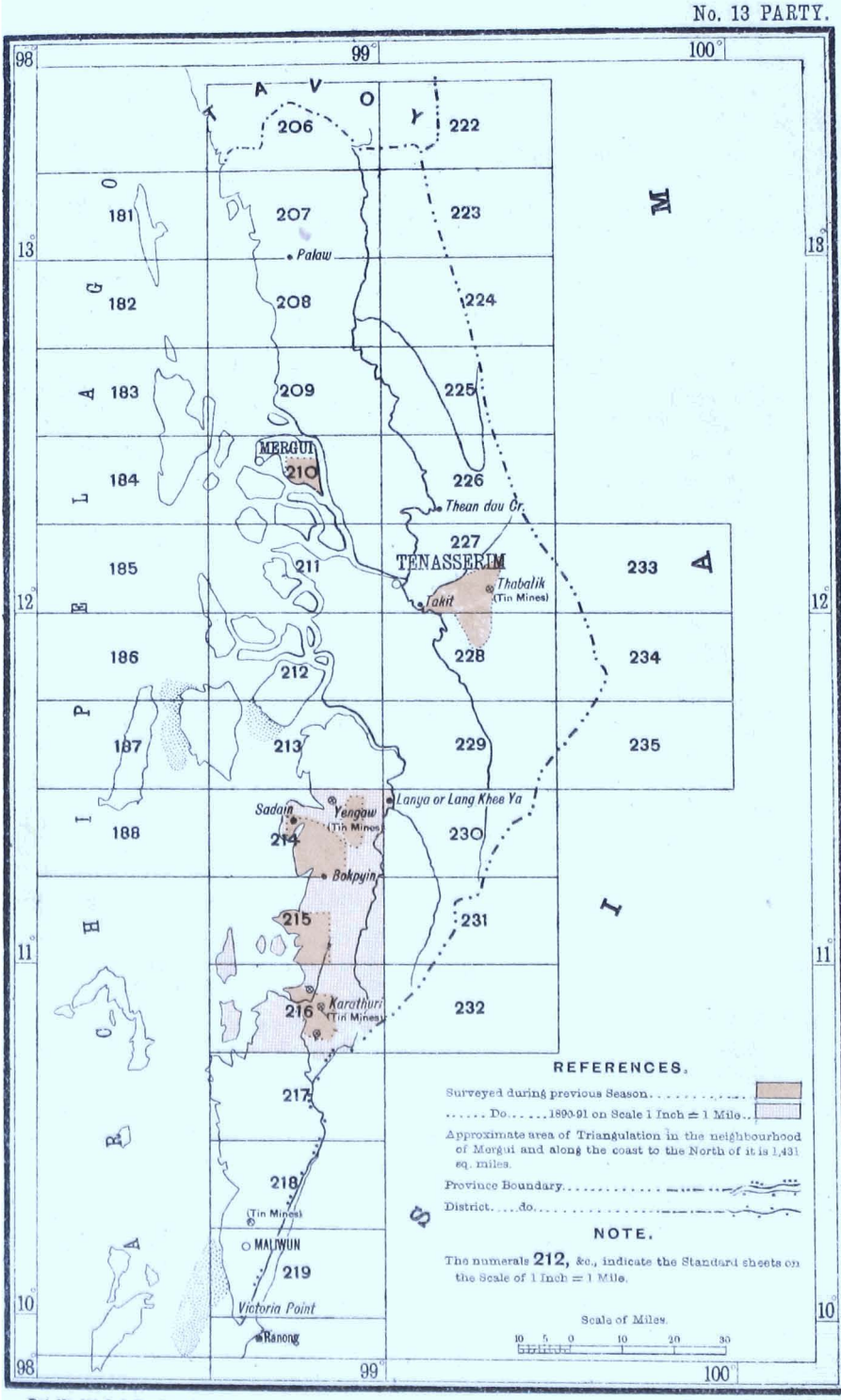
96. During the recess the computations of last season's work have been completed, three fair maps were drawn for publication and one preliminary chart of triangulation. In addition to the regular mapping, tracings of the entire two seasons' field work have been prepared for the Geological Survey Department.

97. At the close of the recess season the party was broken up and absorbed among other parties, with the exception of a small detachment under Mr. Gibson, which is left to continue the survey of the tin-producing areas on the

BURMA SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN DISTRICT MERGUI.

No. 13 PARTY.



Reg. No. 325, S. I. D.—Oct 91.—550.

Photo., S. I. O., Calcutta.

Tenasserim river and in the Maliwun district, and also to traverse the Pakchan and Tenasserim rivers.

98. The recess office of the party was inspected during September at Bangalore by the Surveyor-General, who found the state of the records and the style of the mapping all that could be desired.*

BALUCHISTAN.

No. 15 Party.

99. During the year under report, detachments from this party have been largely employed on geographical reconnaissances in connection with the various expeditions on and across the North-Western Frontier. The extension of the regular topographical work of the Baluchistan survey, undertaken by the party, consisted of—

Personnel.

Lieutenant-Colonel T. H. Holdich, R.E., Deputy Superintendent, 2nd grade, in charge up to 1st April 1891.

Captain R. J. H Mackenzie, R.E., Deputy Superintendent, 4th grade, in charge from 2nd to 16th April and from 22nd June 1891.

Mr. T. E. M. Claudius, Surveyor, 3rd grade, in charge from 17th April to 21st June 1891.

Mr. E. A. Wainwright, Surveyor, 4th grade.

„ E. Graham, Assistant Surveyor, 1st grade.

„ G. P. Tate, „ „ „ „

Yusuf Sharif, Khan Bahadur, Assistant Surveyor, 3rd grade.

Hira Singh, Rai Bahadur, Assistant Surveyor, 3rd grade.

Sub-Surveyors.

Imam Sharif K. B., Ahmad Ali, Abdul Gaffar, Hussein Baksh, Sheik Mohidin, Asghar Ali, Jaffar Ali, Nizamuddin, Mohamed Nagi, Madat Khan.

(1) The completion of the Dera Ghazi Khan and Quetta triangulation. This was entrusted to Mr. Wainwright, who completed the series as far as the Khojak range, and also effected a junction with the Kalat series; the season's work covering an area of 960 square miles.

(2) The extension of the triangulation commenced in 1888-89, along the parallel of 26° N. latitude. This work was entrusted to Mr. Graham, who, on account of the many difficulties he encountered, and from political causes, was unable to carry out his programme in its entirety. He however secured an out-turn of 7,900 square miles of triangulation, and an extract from his report will be found in the appendix.

(3) The completion of the 2-inch to the mile survey around Quetta, of which 29 square miles remained. This was carried out by sub-surveyor Jaffar Ali.

100. A survey detachment from this party composed of the following:—

Lieutenant-Colonel Holdich, R.E., in charge,
Captain Mackenzie, R.E.,
Sheik Mohidin and Asghar Ali, sub-surveyors,

accompanied the Zhob Valley Field Force under the command of Major-General Sir George White, K.C.B. Colonel Holdich accompanied the column under Sir Robert Sandeman, Agent to the Governor General, Baluchistan, and Captain Mackenzie with the two sub-surveyors, joined Sir George White's column. This party remained in the field from early in October 1890 until December 12th, 1890. It accomplished the reconnaissance of some 4,000 square miles on the $\frac{1}{4}$-inch scale. and 1,359 square miles on the $\frac{1}{2}$-inch scale, whilst the triangulation was extended north of the Kundar valley: the above being all over country previously unexplored. A special report on the country operated in by the Zhob Field Force, by Lieutenant-Colonel Holdich, R.E., has been separately printed.

101. Meanwhile, Imam Sharif, K. B., had been deputed to Persia on special duty, and the services of Hira Singh, R. B., had been placed at the disposal of

* Of the Assistants Mr. D'Souza says:—
"Mr. A. J. Gibson succeeded in completing, under very great trials and hardships, the survey of 105 square miles of a very difficult piece of country. I have therefore much pleasure in commending him for his hearty co-operation, zeal, and energy."
"Mr. G. A. Higgs has worked zealously and well, and the successful completion of the season's programme is in a measure due to the excellent services rendered by him."
Messrs. Warwick and P. White are also favourably reported on. The sub-surveyors are all well mentioned.

the Quarter Master General in India for exploration work. Imam Sharif has practically been employed on this special work for the whole year, and has returned with the large total of 30,500 square miles of reconnaissance on the scale of 8 miles to the inch. Hira Singh rejoined the party on the 17th of January, having been unable, from political causes, to carry out the work required.

102. Early in April, Captain Mackenzie, R.E., with sub-surveyor Hussein Baksh, proceeded to join the second Miranzai expeditionary force: details of the work accomplished with that force will be found under the head of geographical surveys. A re-survey of portions of the Zhob valley, and some additions in the neighbourhood of Yusuf Kach, were completed by sub-surveyor Jaffar Ali, after Captain Mackenzie had joined the Miranzai expedition. In all, about 1,000 square miles on the $\frac{1}{4}$-inch scale, and 380 square miles on the $\frac{1}{2}$-inch scale, were completed by the sub-surveyor.

103. Early in December Mr. Tate accompanied Sir Robert Sandeman on a tour through Southern Baluchistan, and completed about 108 miles of route survey between Las Bela and Panjgur, with 1,500 square miles of reconnaissance on either side of the road, on the $\frac{1}{4}$-inch scale. On the 1st of April his services were placed at the disposal of the Political Department for employment in the Kalat State.

104. At Sir R. Sandeman's request sub-surveyor Ahmad Ali was deputed to meet him at Panjgur for survey purposes. The sub-surveyor left Quetta on the 27th of December 1890, and on the 27th of June 1891, returned with a geographical survey based on triangulation, of 22,000 square miles, on the $\frac{1}{4}$-inch scale, of country on the Perso-Baluch frontier, of which we possessed very meagre information. He displayed considerable tact, energy and perseverance in successfully accomplishing the work he was entrusted with; an extract from his report will be found in the appendix.

105. A survey, on the scale of 2 inches to the mile, of the country lying between Kach and Mangi, on the Sindh-Pishin Railway, was undertaken and completed by Mr. Claudius, assisted by Yusuf Sharif, K. B., and Hira Singh, R. B. This special work was required for a new alignment of the railway in that section. The necessary triangulation was commenced by Mr. Claudius on the 18th of May; the detail survey, comprising an area of 47½ square miles, was completed on 14th of June, and the fair map despatched for reproduction on the 7th of August.

106. By the completion of the main series of triangles which has been carried westward from the Great Indus Series of the Great Trigonometrical survey a secure base has been fixed on the Khojak range for an extension of the triangulation westwards when required. The number of points also fixed to the northward in the Zhob valley work, will allow of an extension being made in that direction.

107. The total out-turn of work for the season is as follows:—

	Square miles.
Triangulation	8,920
Topographical Survey, 2-inch scale	76½
" " ½-inch "	1,739
Geographical " ¼-inch "	28,504
" " ⅛-inch "	30,500

108. During the recess the greater part of the arrears of mapping which had accumulated owing to large demands for field work have been cleared off, as 22 fair standard sheets and four preliminary maps have been submitted during the year for reproduction, whilst two sheets also have been compiled for the new map of Baluchistan: the computations have been all completed.

The health of the party, especially towards the end of the recess, has been anything but satisfactory; fever and other ailments having been very prevalent, as was the case this year throughout the Quetta district.*

* The officer in charge reports highly of the services of the Assistants.

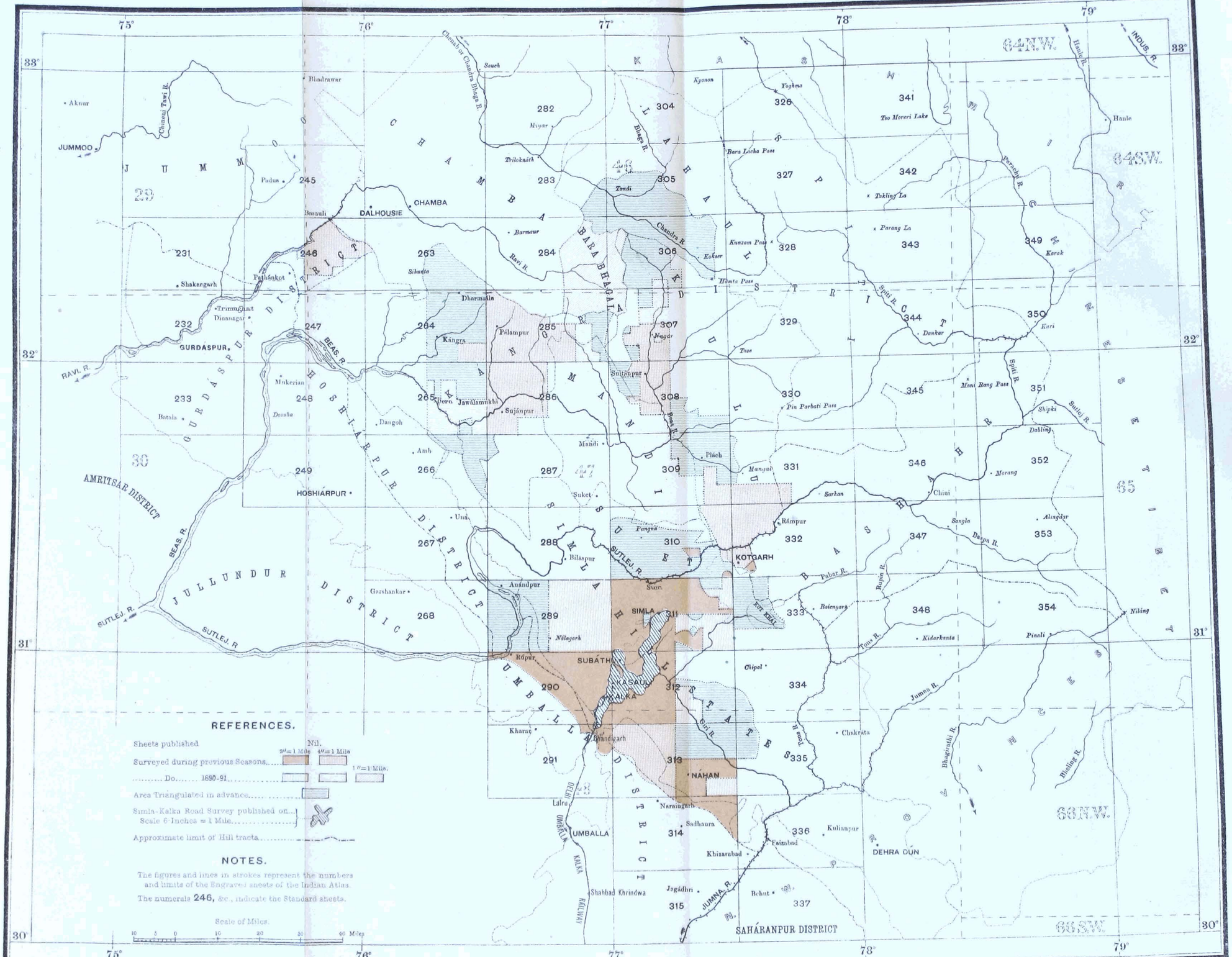
Mr. Claudius has had a very large share in the management of the party, and has kept up his previous reputation for zeal and ability.

Messrs. Wainright and Graham, with Yusuf Sharif, K. B., and Hira Singh, R. B., are also favourably mentioned, as well as sub-surveyor Jaffar Ali. Sub-surveyors Imam Sharif, K. B., Ahmad Ali, Abdul Gaffar, Hussein Baksh, Sheik Mohidin, and Asghar Ali, were all favourably reported on by the various officers under whom they served, whilst detached from the party on special duties.

PUNJAB SURVEY.

INDEX TO THE SURVEY OPERATIONS IN THE HIMALAYAS.

No. 18 PARTY.



Eng. No. 180, S. I. O.—Oct. 91.—500.

Photo., S. I. O., Calcutta.

HIMALAYAS, PUNJAB.

No. 18 Party.

109. On Colonel Tanner retiring from the service, after having superintended the operations of this party for several years past, Major St. G. Gore, R.E., assumed charge on the 30th of October 1890, Captain Bythell, R.E., being posted to it as an Assistant on the 1st November.

Personnel.

Major St. G. C. Gore, R.E., Deputy Superintendent, 3rd grade, in charge.
Captain W. J Bythell, R.E., Officiating Deputy Superintendent, 4th grade.
Mr. C. D. Potter, Surveyor, 4th grade.
„ W. Robert, Assistant Surveyor, 1st grade.
„ W. A. Fielding, ditto, ditto.
„ P. F. Prunty, ditto, ditto.
„ R. W. Senior, ditto, ditto.

Sub-surveyors.

Shah Nasiruddin, Atma Singh, Wahid Ali Khan, Ramsaran, and 29 others.

110. The nature and scope of the operations of this party were mentioned in the General Report for last year. The only modification which need be noted is the cessation of the traverse operations to fix *mauza* and *tikka* trijunctions, the whole of the work of this nature which had been called for, having been completed and the plots submitted to the local authorities.

111. The party took the field early in November and remained at work until the end of June, with the exception of one detachment, which was engaged on the survey of Bara Bangahal, and which did not reach Simla, after completion of the work, until the end of July. The season was a particularly unfavourable one for surveying in the hills. The snowfall, with accompanying bad weather, was abnormally heavy throughout the winter and, being succeeded by a dull and cloudy summer, the snow remained on the higher ground until the rains to as low a level as 11,000 feet—an almost unprecedented occurrence. The result was that a certain amount of the detail of the higher ground in Kulu had to be left unfinished until a more favourable opportunity.

112. The British tracts were surveyed, as heretofore, on the scale of 4 inches = 1 mile, with the exception of Bara Bangahal, the survey of which was added to the programme of the season's operations at the special request of the local authorities. This inhospitable tract (a short account of the survey of which will be found in the appendix) is so rugged and mountainous, and has such a small cultivated area, that it was determined to survey it on the smaller scale of 1 inch = 1 mile. The survey of the Native States was continued on the 2-inch scale.

113. The area topographically surveyed during the season under report, in the different localities, is as follows :—

Localities.	Scale.	Area in square miles.
District Kángra	4-inches = 1 mile	272
Ditto	1-inch = 1 „	254
Simla Hill States	2-inches = 1 „	458
	TOTAL .	984

114. The very considerable area of 1,446 square miles has been triangulated in advance for detail survey, 476 square miles being for 4-inch, and 970 square miles for 2-inch topography. With the exception of a small increase in the cost of the 4-inch detail survey, owing to a short field season in Kulu, there is a very considerable decrease in the cost rate in all classes of survey.

115. For the Forest Department in Kángra, 20 complete forest blocks and parts of four others have been surveyed. These, with the exception of one which is under the Deputy Commissioner of Kángra, have been permanently demarcated with distinguishing pillars at the salients. In Kulu the number of demarcated blocks surveyed during the year, either wholly or in part, amounts to 22, while in the Simla Hill States 40 forest blocks in Hindur State, 21 in Baghal, 5 in Kahlur, 2 in Kuthar and 1 in Kunihar, 69 in all, have been surveyed. This brings the total number of forest blocks surveyed by this party up to date to 298 in British territory, and 244 in Native States.

116 Four native soldiers have been under instruction in surveying during the year. Two of these were selected as usual from among those who had passed the Roorkee course. The other two, however, were, at the request of the Quarter Master General, sent direct from the Assam Military Police, without any previous training, to be taught surveying and reconnaissance, with a view to their being utilised for survey work in expeditions on the eastern frontier. The experiment has not been very successful as the men were entirely ignorant of surveying, and their two years' course will be much too short to fit them to take up independent reconnaissance work.

117. As mentioned in last year's report, the work of fixing prominent snowy peaks in Bhutan, with a view to elucidate the geography of that little known region, was prosecuted by Sub surveyor Wahid Ali from the trigonometrical stations in the neighbourhood of Shillong. The weather was excessively unfavourable, and he was only able to observe from five stations He, however, succeeded in fixing a fair number of peaks, the farthest of which lay at a distance of more than 220 miles from the point of observation.

118. The programme of work for the coming field season, which has been approved by the Local Government, is as follows:—

The triangulation will be carried on in Kángra, Kulu, Mandi, and the Simla Hill States. The detail survey will be continued on the 4-inch and 2-inch scales in Kángra proper, Chota Bangahal, and Simla Hill States; also the re-survey of as many of the forests in the Simla Hill States on the scale of 4 inches to 1 mile as can be taken up. There will be no detail survey in Kulu next season, as it is intended to close field operations in April, so as to enable the party to take the field in the following season in September and October.

119. The recess office of this party at Simla was inspected by the Deputy Surveyor-General in August, who has suggested some changes in its management to avoid in future the accumulation of arrears which has somewhat hampered its progress in the past, under its late Deputy Superintendent, Colonel Tanner. The arrears seem to be due chiefly to the too liberal employment of young native sub-surveyors, who have been entertained in larger numbers than the existing European staff could deal with. These sub-surveyors, being inexperienced and new to the work, required a great deal of supervision in the field, and proved for the most part quite useless in recess, consequently the greater number of them were allowed to go away on departmental leave and the recess work fell into arrears. Another cause was the scattered nature of the work and the great variety of the operations included in the programme of this party, for, in addition to the forest and ordinary topographical work on three different scales, it has been occasionally called upon to send a detachment for fixing survey peaks in Bhutan and Nepal, and sketching some of the ground in those districts adjacent to our frontier. In consultation with the present Deputy Superintendent arrangements have been made which, it is hoped, will not only prevent such arrears occurring again, but will gradually clear off those at present existing.*

INDUS RIVERAIN, PUNJAB.

DETACHMENT.

120. This detachment was formed from No. 1 party, which was abolished at the close of season 1889-90, for the purpose of undertaking a special survey which had been asked for by the Punjab Government, of a portion of the river Indus, where it forms the boundary between Dera Ghazi Khan district and the Bahawalpur State. The object of the survey was to afford the means of laying down a fixed line of boundary between the district and the State, with a view to avoiding the frequent disputes, which, under prevailing regulations, were constantly arising and causing considerable administrative inconvenience.

Personnel.

Mr. J. S. Pemberton, Surveyor, 1st grade, in charge.

11 sub-surveyors and others.

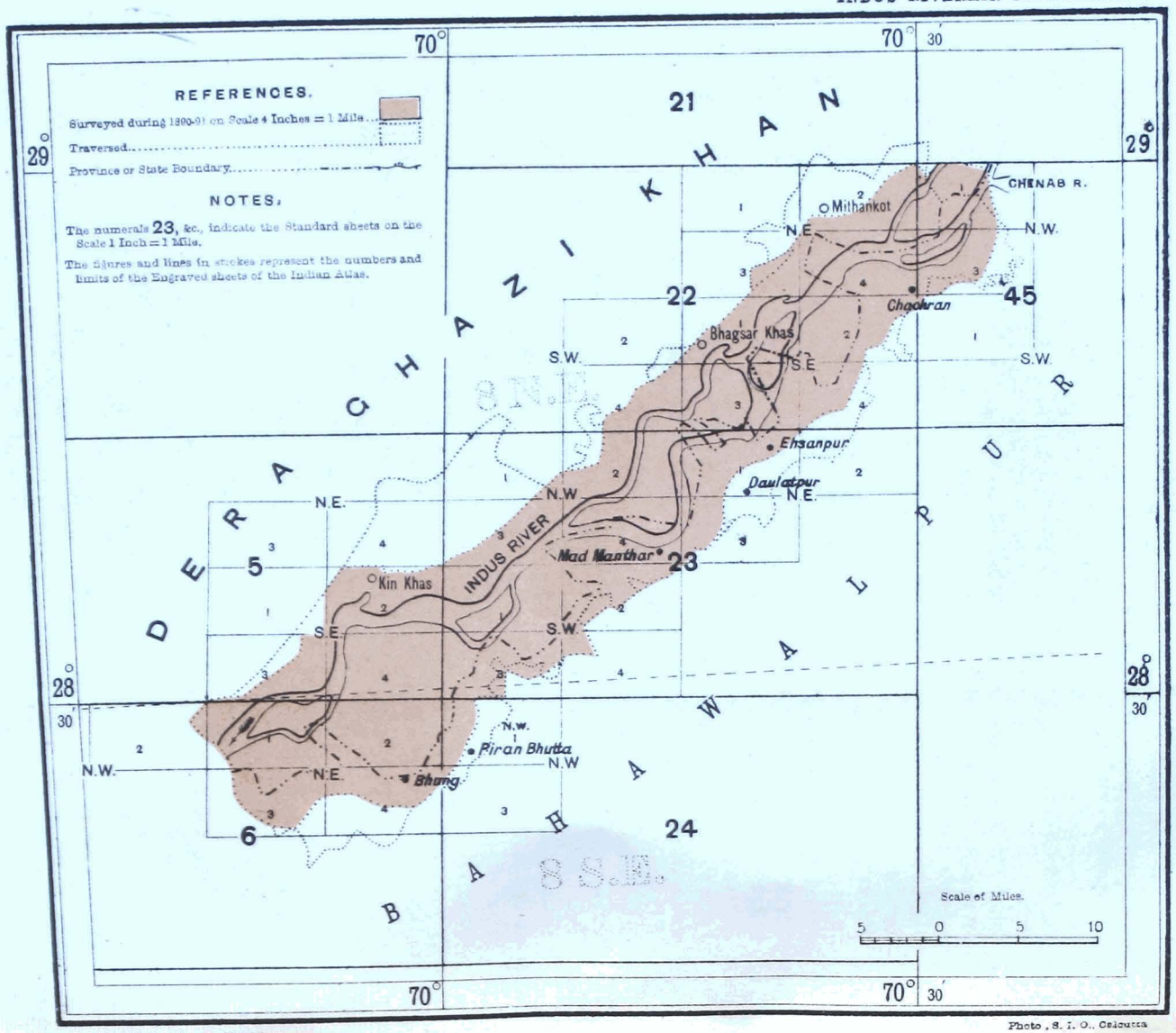
121. Field work commenced on the 19th of November 1890 and was continued to the 11th of April 1891, when the detachment returned to recess quarters

* Major Gore reports favourably on the work of all his European Assistants. Sub-surveyors Ram Saran and Dan Singh are also especially mentioned for good work.

PUNJAB SURVEY.

INDEX TO THE INDUS RIVERAIN SURVEY IN THE PUNJAB.

INDUS RIVERAIN DETACHMENT.



Reg. No. [illegible]

Photo, S. I. O., Calcutta

at Simla. The programme of operations, which was fully carried out, was as follows:—

(1) The traverse survey of both banks of the river with a line of adjacent *mauzas* limited to a distance of 1½ miles from either bank.

(2) A traverse survey of the actual boundary between District and State (which, except for short distances, was quite distinct from the river) with a line of *mauzas* limited to 1½ miles on either side of this boundary.

(3) A detail survey on the scale of 4 inches to the mile of the river and the adjacent country, confined to the limits of the *mauzawar* survey described above.

122. The traverse work was connected with a continuous line of *mauza* trijunction platforms, above the sphere of river action, which were taken up by traverse and shown on the old Revenue Survey maps of 1872 and 1874; the object being, first, to afford an easy means of incorporating the present with the old survey; and, secondly, to facilitate the laying down of any boundary (but especially any portion of the State boundary) which might hereafter be washed away. Whenever practicable boundary pillars were adopted as traverse stations.

123. The total area comprised within the limits of the *mauza* trijunctions referred to above, amounted to 693 square miles; but of this only 552 square miles were surveyed in detail. As on starting field operations the demarcation was in several places found to be either very defective or altogether wanting, the survey of boundary marks was not taken up by the traverse surveyors. This was subsequently carried out when the plane-table or detail survey came to be made, by which time the settlement *patwaris* had all the marks put up. The demarcation was good, but the pillars erected were intended to answer temporary purposes only, the heavy floods during the rains rendering any attempt at permanent marks useless.

124. To ensure the accuracy of the boundary between British territory and the Bahawalpur State, orders were issued that no part of it should be surveyed unless *zamindars* or other responsible officials on both sides were present, and that in case of disputes the boundary marks, as pointed out by both sides, should be surveyed and shown on the maps: these orders were carried out throughout the whole line. In the case of *mauza* boundaries the presence of the *zamindars* concerned was insisted on.

125. The accuracy of the detail survey was tested by 52 linear miles of *partal* and by the examination *in situ* by Mr. Pemberton, of a certain percentage of field sections, principally those of the younger and less experienced plane-tablers.

126. The only difficulty experienced throughout this survey was the jungle-clearing, but by the very able assistance rendered by the villagers, especially in the tract owned by the Nawab of Rojhan, this was overcome much sooner than might have been expected. The services of Imam Bux Mazari, Nawab of Rojhan, are especially commended, he having very materially forwarded the work by his energetic and zealous assistance in getting the jungle cleared through his estate

127. The following tabular statement shows the work performed during the field season:—

District and State.	Linear miles of traverses.	Number of traverse stations.	Number of villages.	Number of field sections (skeleton plots).	Detail survey 4-inch scale, square miles.	Remarks.
Dera Ghazi Khan District . .	Main . 138 Minor . 444	1,834	50	43	377	(*a*) This represents the area of the *mauzawar* traverse and the area mapped. The area covered by the four main circuits is 693 square miles.
Bahawalpur State .	Main . 125 Minor . 186	992	24	27	175	
Totals	893	2,826	74	70	552(*a*)	

128. The whole area (552 square miles) has been fair mapped on 30 sheets for reproduction on the scale of 4 inches = 1 mile. In addition to the above this detachment has, during the recess season, set up and proved the traverse work done in the town of Rewari by two sub-surveyors lent to the Deputy Commissioner of Gurgaon, and has plotted the same on 16 sheets on the scale of 100 feet to the inch. The plotting of 13 villages, on the scale of 24 inches = 1 mile, has also been prepared on 47 sheets for the Settlement Officer of Gujrat.

129. The recess office of the party was inspected by the Surveyor-General at Simla in October 1891. The work in all its branches was found to be highly satisfactory, reflecting credit on Mr. Pemberton's supervision and management.*

FOREST SURVEYS.

CENTRAL PROVINCES.

No. 14 PARTY.

130. This party has remained under the charge of Colonel Wilmer throughout the year, and has been again employed in surveying on the scale of 4 inches to the mile, the first and second class forest reserves in the Hoshangabad and Betul districts; the *malguzári* lands, except where very small detached portions were met with, being left unsurveyed. The party took the field in the last week of December, and carried on field operations till the first week in May, carrying out the following work:—

Personnel.

Colonel J. R. Wilmer, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. A. Christie, Surveyor, 3rd grade.
„ N. C. Gwynne, Surveyor, 3rd grade.
„ J. Keating, Assistant Surveyor, 1st grade.
„ D. Campbell, Assistant Surveyor, 1st grade.

Sub-surveyors.

Azim Khan, Mohammad Zakaria, Hydar Ali, Gurdutt Singh, Kadir Sharif, and 44 others.

(*a*) Triangulation in the Bori forest reserve and in the second class forests in sheets Nos. 23, 24, 34, and 35. All this work is in advance of the area surveyed in detail, except a portion in sheet No. 24, the computations of which were done in the field and the topography completed.

(*b*) Theodolite traversing for taking up forest boundaries and fire lines, and for supplementing the triangulated frame work for the detail survey in sheets Nos. 23, 24, 25, 26, 34, and 35; also boundary traversing of forest blocks Nos. VI, XI, and XII in sheets Nos. 10 and 11.

(*c*) Detail survey, on the scale of 4-inches to a mile, in the Saonligarh and Bhowergarh forest reserves, and in the second class forest in sheets Nos. 24 and 25, also in the part of Khámapur forest in sheet No. 26, which was left unsurveyed last year

(*d*) Boundary survey of detached forest blocks Nos. I, II, III, IV, V, VI, VIII, IX, and XI in sheets Nos. 10 and 11. This was done with the plane-table, and all principal details were shown that fell within a distance of 5 chains on either side of the boundary, as required by the Forest Department. It was subsequently decided that the survey of these blocks should be undertaken when the party operates in Nimar district.

(*e*) The classification of forest growth and soil of the area surveyed in detail in the year under report.

131. The out-turn of the season's work amounts to the following:—

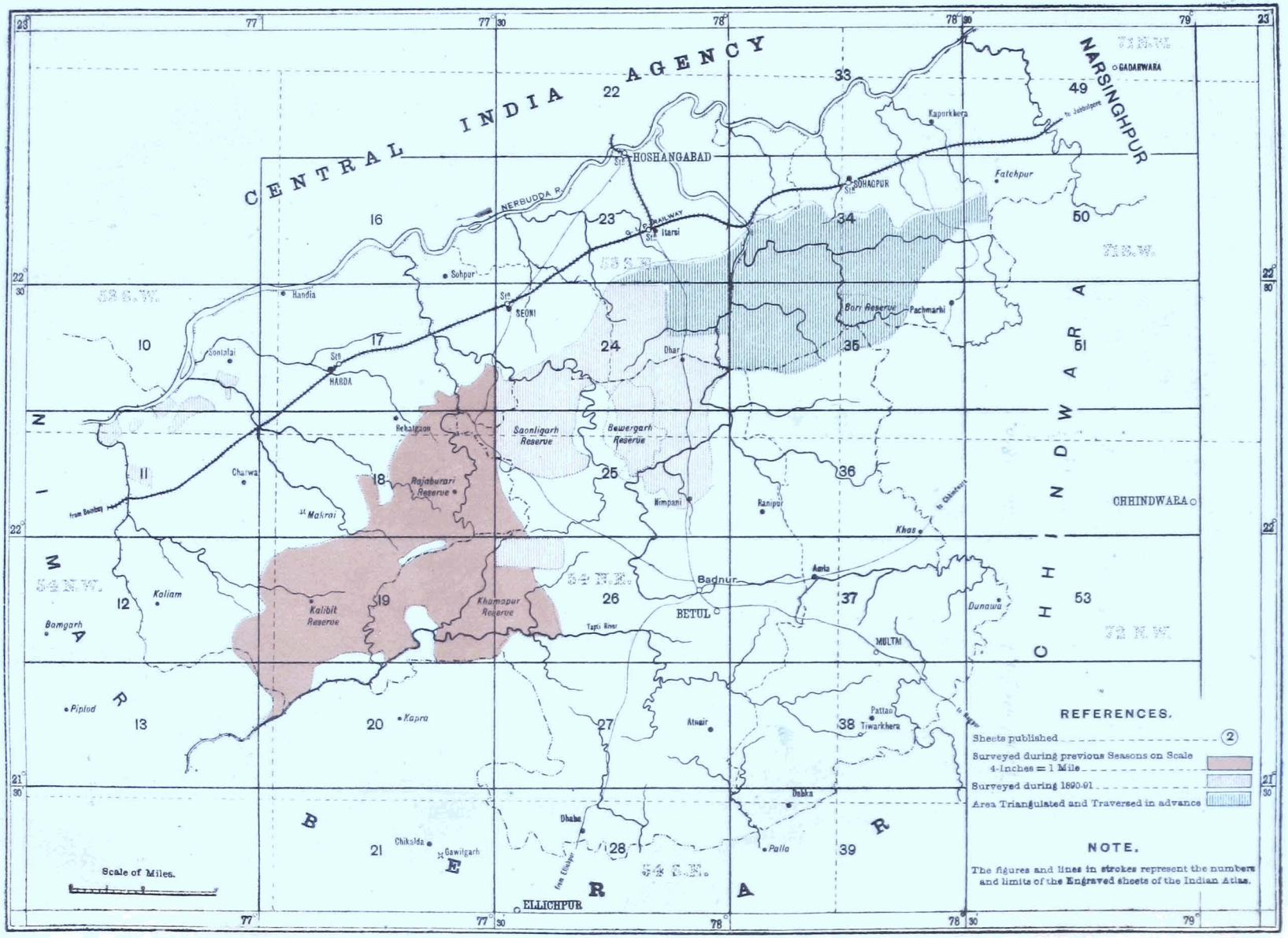
1. Triangulation of 499 square miles, fixing 665 points (including stations) and 689 heights.
2. Detail survey, on the 4-inch scale, of 461 square miles.
3. Traversing of 600 linear miles.

* With reference to his men Mr. Pemberton reports that all the sub-surveyors, without an exception, have worked most cheerfully and well throughout the season; and none, therefore, need be specially mentioned.

CENTRAL PROVINCES SURVEY.

INDEX TO THE FOREST SURVEYS IN DISTS. HOSHANGABAD & BETUL.

No. 14 PARTY.



Reg. No. 80, S. I. D.—Mar. 92.—55

Photo., S. I. O., Calcutta.

4. The classification of forest growth and soils of the whole area surveyed in detail.

132. The country surveyed in detail was similar to that met with last year in regard to the nature of the ground. It was for the most part very hilly and covered with jungle and high grass which greatly hindered the progress of the work. There were no passes or roads of importance, and the only rivers met with were the Tapti and Moran. The field depôt of the party was changed from Harda to Hoshangabad, as the distance to the scene of operations from the former place became too great for effectual communication and supervision.

133. The health of the party was not quite so good as last year, which was probably due to the peculiarity of the climate and the unhealthiness of the ground. At one time there were six sub-surveyors with their squads incapacitated from sickness, and their work was stopped for about a fortnight. The chief diseases were fever and dysentery, and towards the end of the season there were some severe cases of sunstroke also: there were six deaths in the establishment. The four years' experience which this party has now had in these forests unquestionably establishes the fact that it is impossible to work in them without having some 10 per cent., at least, of the establishment always sick with fever and dysentery, and that the precautions which are taken to prevent illness, *viz.*, the issue of blankets, quinine, and tea, to the establishment and making the men drink filtered water, are indispensably necessary to keep down illness within reasonable limits. Experience has also shown that field operations cannot be commenced much before the first week in January, and, owing to failure of water, must be discontinued by the first week in May: the large rivers certainly have water in them, but it is a remarkable fact that drinking their water or encamping near their banks is a prolific source of fever.

134. The Deputy Conservator of Forests, Mr. W. P. Thomas, has afforded very valuable assistance and advice to Colonel Wilmer when surveying the forest tracts in the Hoshangabad district. Mr. Thomas identified himself with the party, and Colonel Wilmer's thanks are due to him for the personal interest he has taken in the progress of the work, in frequently visiting the several detached camps, and giving the surveyors timely advice and assistance, and encouraging all with whom he has come in contact.

135. The fair mapping of the season's operations has been completed and comprises 25 standard-sized sections on the 4-inch scale in sheets Nos. 24, 25, and 26, which have been drawn for reproduction. The tracings, to illustrate the classification of forests and soils of all the sheets of Hoshangabad and Betul districts specified above, have also been prepared and sent in original to the Forest officers concerned. In addition, office copies of triangulation charts of sheets Nos. 23, 34, and 35 have been completed, and there are no arrears either in the triangulation or traverse computations.

136. Four soldier surveyors joined the party in the beginning of last field season for instruction, three of whom were trained in plane-table survey, and one was instructed in traversing with theodolite and chain: in recess they were practised in map drawing. They will be taught the use of the sextant, boiling point thermometer and artificial horizon before the party again takes the field, and will also be given lessons in route surveying. They will be attached for another year and a half to complete their training in the several branches of surveying.

137. The programme of work for the ensuing field season is as follows:—

(*a*) The triangulation of about 500 square miles in sheets Nos. 8, 9, 14, and 15, in district Nimar;

(*b*) The detail survey of about 500 square miles in Bori forest reserve, and of the second class forest in sheets Nos. 23, 24, 34, and 35;

(*c*) Thedolite traversing over the ground specified in (*a*); and

(*d*) The classification of forest growth and soil of the area to be surveyed in detail.

138. The recess office of the party was inspected by the Deputy Surveyor-General, Trigonometrical Branch, on the 8th September 1891, who has written as follows:—

"I place on record with much satisfaction my appreciation of the very efficient state in which I find your party to be in all particulars. The general discipline, and system of

division of labour, as well as the standard attained in the drawing of your maps, merit the highest commendations."*

BOMBAY PRESIDENCY.

No. 17 Party.

139. Colonel Pullan on return from privilege leave in December resumed charge of this party and held it up to the 13th of March 1891, when he retired from the service. Mr. Lawson officiated in charge throughout the other periods of the field season, and handed over to Colonel Hutchinson on the 9th of June 1891.

Personnel.

Colonel A. Pullan, S.C., Officiating Deputy Superintendent, 1st grade, in charge from 11th December 1890 to 13th of March 1891.
Colonel H. S. Hutchinson, S.C., Deputy Superintendent, 3rd grade, in charge from 9th June 1891.
Mr. A. M. Lawson, Surveyor, 2nd grade, in charge from 1st October to 10th December 1890 and from 14th March to 8th June 1891.
Mr. S. F. Norman, Assistant Surveyor, 1st grade.
Mr. C. A. Norman, Assistant Surveyor, 1st grade.

Sub-Surveyors.

G. R. Bhopatkar, Gopal Vishnu, Gobind Gopal, R. V. Joshi, N. V. Bhopatkar, and 27 others.

140. The party took the field on the 8th of November 1890, closed field work in the commencement of June 1891, and opened office for recess duties at Poona on the 9th idem.

141. The field operations were carried on, as during the previous year, in the Northern and Southern circles of the Presidency, and the party was divided into two sections—Mr. A. M. Lawson supervising the work in the Southern circle and Mr. S. F. Norman that in the Northern circle. Camp No. 1 under Mr. Lawson was employed in completing the survey on the 8-inch scale of the forest reserves in Kalghatgi *taluka*, Dharwar district, and in continuing the survey of Mundgod, Yellapur and a portion of Sirsi *talukas* in North Kanara.

Camp No. 2 under Mr. S. F. Norman was employed in the Northern circle on 4-inch and 8-inch surveys of the forests in the Khed *taluka*, Poona district, Bhiwandi *taluka*, South Thana district, and Sirur, Bhimthadi and Haveli *talukas*, Ahmednagar district.

142. Camp No. 1 accomplished the survey of 300 square miles on the 8-inch scale in the *talukas* mentioned above. In connection with this work an area of 340 square miles of triangulation was executed and 660 linear miles of traverse were run, fixing 5,643 stations. The heights of these stations were obtained approximately, in order to assist in the correct delineation of the ground, and the mathematical results of the whole work proved satisfactory.

Camp No. 2 completed 124 square miles of topography on the 4-inch scale, 93 square miles on the 8-inch, and 22 square miles on the 16-inch scale of *babul* reserves in Bhimthadi, Sirur, and Haveli *talukas*. In connection with these areas, 170 square miles of triangulation were completed, fixing 179 points, and 236 linear miles of traverse were run, fixing 1,223 points, the heights of which were approximately determined.

143. The aggregate out-turn of work for the field season amounts to—

Triangulation	150 square miles.
Traversing	896 linear miles.
Topography	124 square miles on the 4-inch scale. 393 square miles on the 8-inch scale. 22 square miles on the 16-inch scale.

Of the total area triangulated during the season, 85 square miles are in advance of the detail survey in the Southern circle, and 97 square miles in the Northern circle.

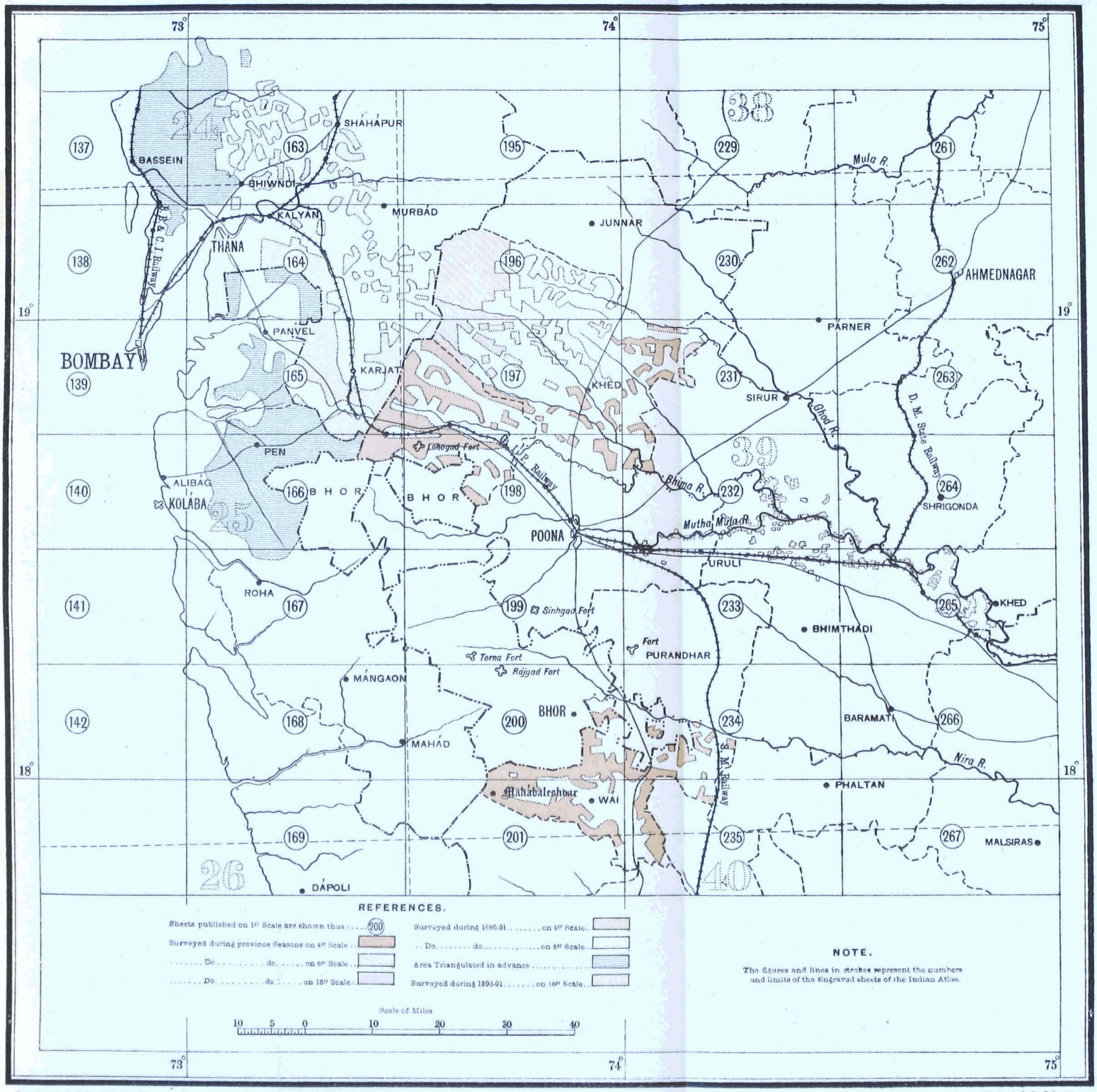
144. The accuracy of the detail survey in both circles was tested either by chain traverses, or (where the nature of the ground did not allow of this method) by examinations *in situ* of each plane table section: that in the Northern circle was tested by 113 linear miles of *partal* lines, and the 16-inch *babul* forest reserve survey was checked by Mr. Lawson, by 37 linear miles of check traverse.

* Colonel Wilmer reports very favourably of Messrs. Christie, Gwynne, Keating, and Campbell, all of whom have worked with zeal and spirit. The following sub-surveyors are also brought to notice, and also the head writer Syed Zille Hasnain:—Sub-surveyors Azim Khan, Hydar Ali, Gurdutt Singh, Kadir Sharif, Karimdad Khan, Ram Singh, Mahadeo Daji, Sutto Charan Ghosal, Surjan Singh, Abdul Haq, Abbas Ali, Sita Ram, Mohammad Zakaria, Sahaidin, and computer Mohindro Nath Bose.

BOMBAY SURVEY.

INDEX TO THE FOREST SURVEYS IN PORTION OF THE NORTHERN CIRCLE.

No. 17 PARTY.



REFERENCES.

Sheets published on 1″ Scale are shown thus ..... (200)

Surveyed during previous Seasons on 4″ Scale.

..... Do. ..... do. ..... on 8″ Scale.

..... Do. ..... do. ..... on 16″ Scale.

Surveyed during 1890-91 ..... on 4″ Scale.

.. Do. ..... do. ..... on 8″ Scale.

Area Triangulated in advance .....

Surveyed during 1890-91 ..... on 16″ Scale.

Scale of Miles

10 5 0 10 20 30 40

NOTE.

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

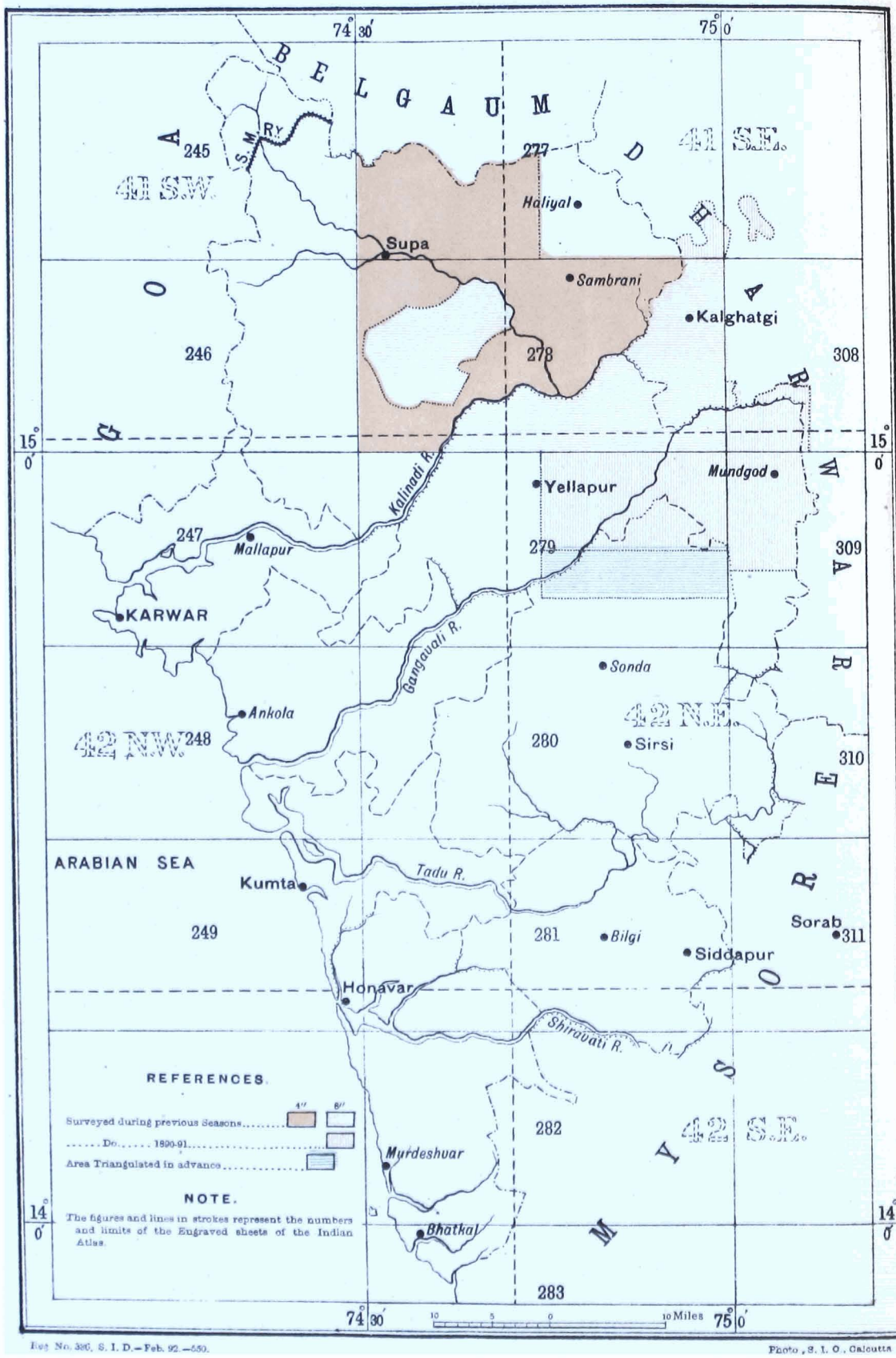
Reg. No. 401, S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta

BOMBAY SURVEY.

INDEX TO THE FOREST SURVEYS IN THE SOUTHERN CIRCLE (N. KANARA).

No. 17 PARTY.



Reg No. 386, S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta

145. The cost rate per square mile of the 8-inch survey, including cost of triangulation and traversing, amounts to R112 in the Southern, and R167 in the Northern circle; the former rate is very low, which is due to the ground being favourable and easy for survey, while the latter is not high for 8-inch work, the enhancement being due to the scattered nature of the work, and intricacies of the ground met with in the Northern circle. The 4-inch work cost R112 and the 16-inch R193 per square mile.

146. During the recess the fair mapping of the detail survey executed during the field season was completed, and in addition certain arrears of mapping of previous seasons' work in districts Nassik, Poona, and Thana. The computations of the triangulation and traversing were also brought up to date.

147. The health of the establishment employed in the Northern circle remained fair throughout the season. In the section working in the Kanara jungles fever and dysentery were very prevalent, as can only be expected, and during the earlier part of the field season, survey operations almost came to a standstill owing to the number of men in the native establishment incapacitated by sickness.

148. The following is the programme to be carried out during the coming field season as approved by the local authorities :—

In the Northern circle, the 16-inch survey of the *babul* reserves in the Bhima valley will be continued: the 8-inch survey will be carried on in Salsette and Bhiwandi *talukas*, Thana district; in Haveli *taluka* of the Poona district and Jaoli Boleshwar, and in parts of the Akola and Sangamner *talukas*, Ahmednagar district. In the Southern circle, the 8-inch detail forest survey is to be carried on in the Pen and Panvel *talukas*, Kolaba district, and the 4-inch survey is to be continued in the Sirsi *taluka* of the Kanara district.

149. The recess office of the party at Poona was inspected during September 1891 by the Surveyor-General. The field sections were scrutinized and gave evidence that the survey had been executed with care and accuracy. Of these, sixteen sections were suitable for reproduction by photography, which saved the labour of re-drawing fair maps thereof. All the professional records were found to be systematically kept and well up to date, and the general arrangements for the division of work excellent. The standard maps were well drawn, and no arrears of any description existed. The Officiating Survey and Settlement Commissioner and the Conservator of Forests, Northern circle, were consulted regarding the general utility of the work for its special requirements, and they expressed themselves completely satisfied with the maps that were being rendered for forest purposes.*

MADRAS PRESIDENCY.

No. 19 Party.

150. The season for field operations in this party differs from that of other survey parties, owing to the local peculiarities of the climate, and commences about two months earlier than the ordinary date. The recess office was closed in the last week of August 1890, and the different sections immediately started for the various localities in which field operations were to be carried on, *viz.*, No. I section, under Mr. R. Todd, to the Coimbatore district, to commence the preliminary operations of triangulation and traversing to which the work of this section was confined; No. II section, under Mr. Hamer, to continue the topography of the reserved forests in the Madura district, together with any additional triangulation

Personnel.

Lieutenant-Colonel J. R. McCullagh, R.E., Deputy Superintendent, 2nd grade, in charge.
Mr. C. F. Hamer, Surveyor, 3rd grade.
„ H. Todd, „ „ „
„ R. Todd, Assistant Surveyor, 1st grade.
„ T. J. J. Mills, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

T. Raghava Ayengar, V. Tiruvenkatsami, Lachman, D. Jadow, Balaji Dhondiba, Govindraju Mudaliar, Anantarao Dhondiba, Govind-Mukund, and 12 others.

* Colonel Hutchinson reports favourably on the services of the three European Assistants, Messrs Lawson, S. F. Norman, and C. A. Norman, especially of the first named who held charge of the party during a large part of the field season and by whose energy and perseverance the successful results of the field operations has been mainly secured. The following sub-surveyors receive special mention :—G. R. Bhopatkar, Gopal Vishnu, Gobind Gopal, R. V. Joshi, N. V. Bhopatkar, Ramrao Sadao, and N. R. Patwardhan.

and traversing that might be needed; No. III section, under Mr. H. Todd, to continue the detail survey of the reserved forests in the Tinnevelly district.

151. The field operations were commenced early in September 1890, and continued until the beginning of March 1891, when the party returned to recess quarters in Bangalore.

152. In Coimbatore, the triangulation was carried southwards over a considerable portion of the Anaimalai hills, and also over the western part of the district; it embraces an area of 700 square miles, obtained by observations at 95 stations, from which 333 points were fixed. In Madura, the existing triangulation was extended over an area of 250 square miles by observations at 23 stations, whereby 98 points were fixed and their heights obtained. In Tinnevelly, it was only necessary to supplement the triangulation which had previously been done for a survey on the 1-inch scale, and additional points were fixed to give a suitable basis for the 4-inch survey.

153. The traversing carried out during the season amounts to 266 linear miles of boundary survey. The small amount of this class of work, compared with the area topographically surveyed, is due to the circumstance that the exterior boundaries of the reserved forests had, in some instances, been completely, and in others partially, surveyed by the Madras Survey Department, and the data were obtained therefrom and utilised; the labour and expense of fresh boundary traverses was thereby saved, while at the same time the subsurveyors who would have been engaged on this duty became available for the detail survey.

154. The area of topography executed amounts to 465 square miles on the 4-inch scale, which is a very considerable increase on that previously obtained, this out-turn being more than that of the two previous years put together. This result is very satisfactory, for the country operated in is as difficult as that met with before, and the work was considerably retarded by the abnormal rainfall in February and the amount of sickness which prevailed among the native establishment, the casualties from various causes amounting to 55 during the season.

155. The European assistants exercised a constant supervision over the men in their respective sections, and were held directly responsible for the accuracy of the work turned out: in addition to this, the Deputy Superintendent visited the different sections from time to time and examined the work of the various members of the party, as far as the distances to be travelled over, and the difficulties of moving from place to place permitted. The work, wherever examined, was found to be generally accurate and carefully done.

156. The country surveyed this season differs but little from that described in previous years. In Tinnevelly, the same high and precipitous mountains were met with, in some places densely covered with impenetrable forest growth. Similar difficulties were experienced in the Anaimalai hills and in Madura, though the general level of the country therein was not at so great an altitude above the sea, yet the hills were sufficiently high and intricate to entail considerable labour in moving about amongst them. With but few exceptions, and to a very limited extent, the reserved forests were situated in the most out-of-the-way and inaccessible tracts of country, which rendered the arrangements for supplies, labour, and carriage peculiarly difficult.

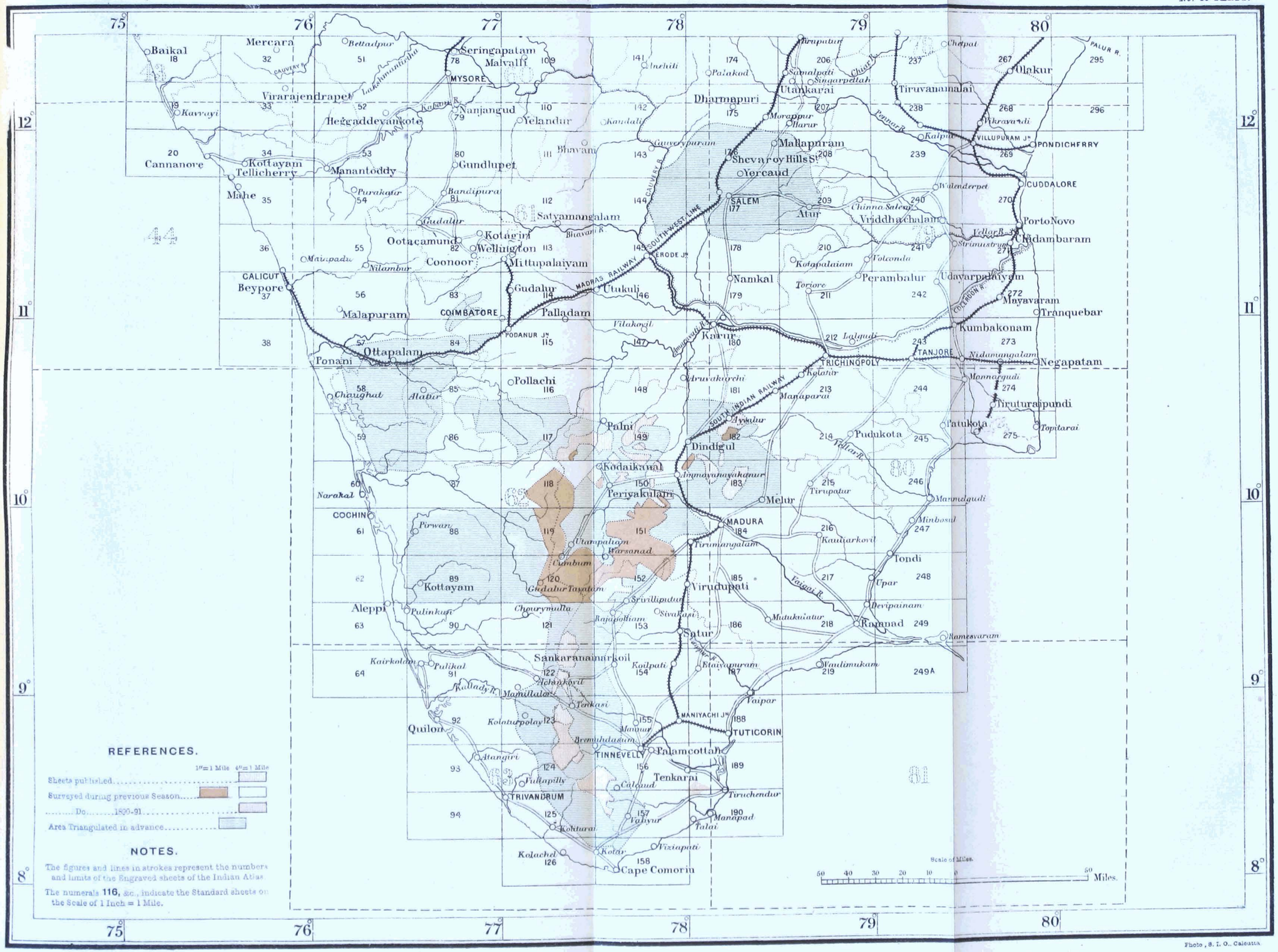
157. Over a considerable extent of the forests in Tinnevelly met with this year, the forest growth was found to be so dense as to be practically impenetrable, and an accurate survey showing all the details of the ground thereof could only have been effected by going to an enormous expense, a course which was not considered justifiable. After reference to the local forest authorities it was decided to get as good a reconnaissance of the tract as possible without incurring much time or expense over it. By cutting tracks and clearing some of the hill tops, a fair general view of this difficult country was obtained, and the main features thereof have been thus fairly delineated; but as the accuracy of the details therein cannot compare with that of the other tracts surveyed, a note has been inserted on the map stating that the survey of this portion is approximate only.

158. During the recess the various computations have been brought up to date, the fair mapping has been completed of eight reserved forests, and part of a ninth, in Madura, and of three large reserves (with the exception of a few square miles) in Tinnevelly—the whole being included in thirty sheets. In

MADRAS SURVEY.

INDEX TO THE SURVEY OPERATIONS IN MADRAS.

No. 19 PARTY.



REFERENCES.

1″=1 Mile 4″=1 Mile

Sheets published.....

Surveyed during previous Season.....

.....Do.....1890-91.....

Area Triangulated in advance.....

NOTES.

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

The numerals **116**, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

Reg. No. 868, S. I. D.—Oct. 91.—350.

Photo., S. I. O., Calcutta.

addition to the ordinary mapping, and as demanded in previous years, a good deal of time and labour was also expended in the preparation of tracings of the field sheets, for the immediate use of the officers of the Forest Department.

159. The annual out-turn of work in this party has been much below, and the cost rate consequently much in excess of, the original estimates made before the survey of the forests was commenced. This has been chiefly due to causes beyond the control of the Survey Department, *viz.*, the physical difficulties of the country, its unhealthiness, the high rates of pay prevalent, and the difficulty in obtaining suitable recruits to increase the staff of native surveyors so as to obtain a proper proportion of the working to the supervising agency, on which the cost of survey work mainly depends. Such difficulties were not foreseen when the original estimate of cost was made, and from the experience that has now been gained it is evident that the cost was under-estimated. There has, however, been a steady and very decided decrease in the cost of the work since it was first commenced, as the following statement will show:—

		R
In 1888-89,	cost rate per square mile .	162
„ 1889-90,	ditto ditto . .	149
„ 1890-91,	ditto ditto . .	112

These rates are for the final survey, including the cost of triangulation and traversing, and when the party obtains its full complement of native surveyors, it is hoped that the rate will be still further reduced; but owing to the difficulties to be encountered, it is doubtful if a lower rate than R100 per square mile will be possible.

160. In April 1891, the Surveyor-General proceeded to Madras to inspect Colonel McCullagh's party, and to confer with the local authorities regarding its cost and future working. A conference was held on 25th April with the Forest member of the Board of Revenue and the Conservator of Forests, when the causes for the excess cost over the original estimate were fully explained, and the necessity shown for increasing the grant of annual expenditure which had been fixed at R60,000, and which was found insufficient to maintain a properly equipped party with the desirable proportion between the number of Native surveyors and the European staff. This was accepted, and the Board agreed to urge the Madras Government to sanction a grant of R75,000, which has been subsequently allowed. It was also explained that one of the causes effecting the high cost of the survey was due to the survey sections having to re-visit the same localities several times owing to the separate and contiguous blocks of forests requiring to be surveyed not being all settled, and finally notified as reserved forests before the surveyors come on the ground. The Forest Member and Conservator promised to take special measures to expedite the settlement of all the forest blocks in the districts in which survey is being undertaken, so that the survey of adjacent blocks may be dealt with at one time, a measure which is obviously necessary for economical working.

161. The recess office of the party was inspected at Bangalore, and the Surveyor-General was well satisfied with all that he saw and with the arrangements that Colonel McCullagh had made to cope with the exceptional difficulties he had to contend with. To his energy and good management of the means at his disposal the improved results of the labours of the party are attributable. The professional records were found to be systematically arranged, and the field maps showed evidence that the survey had been executed with much care, and with as great regard to accuracy as the nature of the country permitted, without undue expenditure of time and money, and as far as the objects of the survey required.

162. The programme for the ensuing season, which has been approved by the local authorities, comprises the completion of the detail survey of the forests in the Tinnevelly district, where only a small area remains; the continuation of topographical operations in the Madura district, and the commencement of the same in the Coimbatore district, in which the triangulation will also be further extended.*

* Colonel McCullagh reports very favourably of the services rendered by the European assistants, all of whom have done well, and he specially selects Messrs. Hamer and H. Todd, on whom the greater responsibility rested. The sub-surveyors generally are reported to have done very well; special mention being made of the work of Lachman Jadow, and Govind Mukund, while that of Raghava Ayengar, V. Teruvenkatsami Balaji Dhondiba, and Ramasami Naidu is commended.

LOWER BURMA.

No. 20 Party.

163. Colonel Beavan held charge of this party throughout the year, with the exception of the period from 20th of September to 15th of November 1890, during which he was absent on privilege leave, when Mr. Barker officiated in charge.

Personnel.

Colonel R. Beavan, S. C., Officiating Deputy Superintendent, 2nd grade in charge.
Mr. W. A. Wilson, Surveyor, 2nd grade, from 18th November 1890.
„ J. A. Barker, Surveyor, 4th grade.
„ A. F. Ewing, Assistant Surveyor, 1st grade.
„ H. A. Charrier, Assistant Surveyor, 2nd grade.

Sub-Surveyors.

Venkat Swamy, Abdulla Khan, Sharf ud-Din, Girdhari Lall, Amjad Ali, Moung Kyow Nyein, Moung Hpo Nyein, and 16 others.

164. The party has been engaged in carrying on the survey of the forests in districts Prome and Toungoo, on the scale of 4 inches to the mile: and of the intervening tracts on the scale of 2 inches to the mile, the reserved forests being surveyed on the larger scale to meet the requirements of the Forest Department.

165. The first detachment under Mr. Ewing left Rangoon on the 25th of November, and proceeded *viâ* Prome to Pakkaung, to undertake the 2-inch survey required to complete sheet No. 226: the remainder of the party was detained for some time at Rangoon, owing to an outbreak of cholera among the *khalásis* during the voyage from Calcutta. It eventually left Rangoon on the 23rd of December, and proceeded *viâ* Toungoo to start work in the Kabaung forest, on the 4-inch scale. The delay, fortunately, did not very materially affect the out-turn, as it is not safe to enter the forests in Toungoo earlier than the end of December, owing to their unhealthiness.

166. The head-quarters camp was established at Toungoo as in the previous season, and the hospital was stationed at Thabetkwe, 15 miles to the west, where all ordinary cases were treated, the more serious ones being sent in to the Toungoo hospital.

167. The 2-inch work in the Prome district was completed by the 20th of March, after which Mr. Ewing with his detachment proceeded across the Yoma range, and joined the rest of the party in the Kabaung valley. The upper portion of this valley having proved, during the previous field season, to be extremely unhealthy, the survey of it was postponed until the latter part of the season and with good results, as the amount of sickness was not nearly so great as had been the case the year before. Still there were a good many cases of fever and dysentery, which must necessarily be the case in so malarious a tract of country. The party lost by death, during the field season, one sub-surveyor, two *chuprasis*, and seven *khalásis*, not including five men, who died of cholera on boardship.

168. Field work was continued until the 20th of May 1891, after which the party returned to Rangoon for the recess. The result of the season's work shows an out-turn of 167 square miles of topography on the 4-inch scale, and 204 square miles on the 2-inch scale. In addition, there are about 250 square miles of traverse work, the total length of chained traverse lines being 340 miles, all through dense jungle. Some triangulation was also carried out with a view to fixing points on which to connect the traverses, and prevent any accumulation of error.

169. Regarding the country Colonel Beavan reports:—

"It would be difficult to find anywhere else a tract of country which offers so few facilities for an accurate survey. The hill ranges rise to a height of 1,400 to 1,500 feet, but there are no very prominent peaks, and they are all covered from base to summit with a dense forest growth. The detail surveyor has to rely entirely upon traverse and chain measurement, and to cut his way through the bamboo jungle, while the traverse surveyor has to contend against the drawbacks of very short lines and broken ground, most unsuitable for accurate chaining. The country surveyed on the 2-inch scale near Pakkaung is of a less formidable character; it is not so hilly, and the forest is more open, being broken up by occasional patches of cultivation."

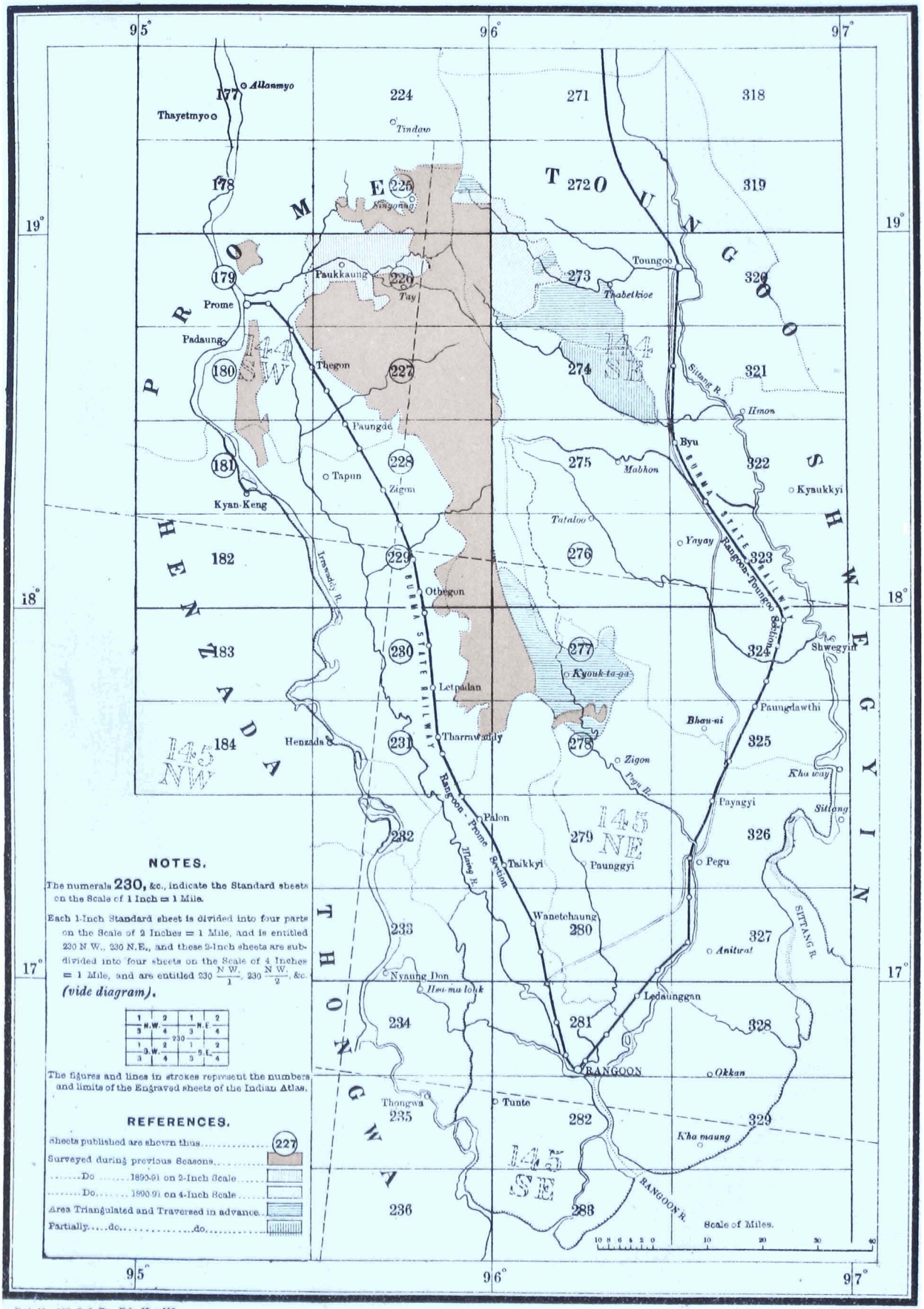
170. The triangulation and traverse work, after computation, proved satisfactory. The detail survey was carefully tested by means of *partal* lines, of which 115 linear miles were run through the different field sections: the work generally was found to be very accurate.

171. During the recess, the computations have all been brought up to date. Some of the old work had to be revised and the corrections re-distributed, in

BURMA SURVEY.

INDEX TO THE FOREST SURVEY IN LOWER BURMA.

No. 20 PARTY.



NOTES.

The numerals **230**, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

Each 1-Inch Standard sheet is divided into four parts on the Scale of 2 Inches = 1 Mile, and is entitled 230 N.W., 230 N.E., and these 2-Inch sheets are sub-divided into four sheets on the Scale of 4 Inches = 1 Mile, and are entitled 230 $\frac{\text{N.W.}}{1}$, 230 $\frac{\text{N.W.}}{2}$, &c. *(vide diagram).*

1 / 3 N.W.	2 / 4	1 / 3 N.E.	2 / 4
1 / 3 S.W.	2 / 4	1 / 3 S.E.	2 / 4

230

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

REFERENCES.

Sheets published are shown thus..... (227)

Surveyed during previous Seasons.....

.....Do .....1890-91 on 2-Inch Scale.....

.....Do.....1890-91 on 4-Inch Scale.....

Area Triangulated and Traversed in advance.....

Partially.....do.....do.....

Reg No 367, S. I. D.—Feb. 92.—550

Photo., S. I. O., Calcutta.

order to make the traverse co-ordinates conform to data derived from triangulation, but the alterations are not sufficient to distort the topography to any sensible extent. Six standard sheets, on the 4-inch scale, have been drawn for reproduction, and four sections of sheet No. 226 have been drawn on the 2-inch scale for reduction to one inch. The compilation of General Report volumes has been proceeded with systematically. The junior sub-surveyors and apprentices have been steadily practised in map-drawing and topography.

172. The programme for the ensuing field season provides for the detail survey of the remaining portion of the Kabaung reserve, the whole of the Bhongdong reserve, the Pyu reserve, and the portions intervening between these reserved forests. This will complete (as far as forest surveys are concerned) standard sheets Nos. 273 and 274. The advance traverse and triangulation will be extended northwards in the east and west Swa reserves, as far north as 19° 15′ or beyond this line, if time allows.

173. On the 27th April, the Deputy Surveyor-General, Revenue Branch, inspected the field office and one of the traverse camps of the party; more than this it was impossible to do, as the rest of the party were engaged on the field work at considerable distances from Toungoo in a very inaccessible country. The traverse camp was in charge of Mr. W. A. Wilson, who was supervising it under great difficulties in consequence of the fever from which he constantly suffered. The Deputy Surveyor-General was thoroughly satisfied with all that he saw, and considers, so far as he could judge from a distant view of the country where the field operations were being carried on, that Colonel Beavan's remarks as to the difficulty of effecting an accurate survey are fully justified.*

CADASTRAL SURVEYS.

CHITTAGONG AND TIPPERAH DISTRICTS, BENGAL PRESIDENCY.

No. 2 Party.

174. This party, of the strength shown in the margin, continued its operations in the district of Chittagong, and finished the survey of *pargana* Serail in Tipperah. The record-writing of that portion of the island of Dakhin Shahbazpur, which it had been found impossible to complete last season, was handed over to the settlement department; tracings having been made of the original sheets, they were sent to the settlement officer.

Personnel.

Mr. F. Grant, Officiating Deputy Superintendent, 4th grade, in charge up to 10th July 1891.

Chittagong Section.

Mr. W. J. O'Sullivan, Surveyor, 3rd grade, in temporary charge of party, from 11th July 1891.
„ J. McHatton, Surveyor, 4th grade.
„ C. G. Lee, Assistant Surveyor, 2nd grade.
Babu Sarat Chandra Sen, Assistant Surveyor, 3rd grade.
42 sub-surveyors, computers, etc.
97 field surveyors, and others.

Serail Section.

Mr. P. C. H. Smart, Assistant Surveyor, 1st grade.
3 sub-surveyors.
27 field surveyors and others.

175. The regular field operations did not commence until the 10th December, the delay being caused by the necessity of completing as many villages as possible for the settlement officers before moving into the field, and from the difficulty experienced in preparing the records. In Chittagong, however, from the early part of November, revisions of the previous season's record-writing, as well as the new record-writing of what had been surveyed, were carried on.

Survey of the Chittagong District.

176. During the previous season local *amins* had been employed on writing the *khasras*, but the supervising staff were Hindustanis, who, through a want of sufficient knowledge of the language, were unable to exercise a proper check on the work. In consequence of this, numerous mistakes crept into the records, and it was decided at a conference with the Director of Land Records that the writing of the *khasras* should be handed over to the settlement department, and on the 1st January this portion of the work was accordingly transferred to the

* Colonel Beavan reports favourably on the work performed by all the European assistants, giving special mention to Mr. Ewing. The Native assistants, with three exceptions, are well reported on.

settlement officer. The *amin*, being thus freed from the labour of making out these intricate returns, would have all the more time to carry out the survey proper. It was also decided to strengthen the establishment of *amins*, so as to enable the party to complete by the end of March 1892 the 650 square miles of cultivation and the 500 square miles of hill tracts which it was then supposed formed all that was left for survey. Since then it has been reported that there will be considerably more ground to be included in the survey, in which case it is doubtful whether the party may not have to remain another season in the district: during the season under report the native staff was increased by nearly 50 per cent.

177. The country presented many difficulties to the traverse surveyors, more especially to the new and inexperienced hands, of whom there were a considerable number. The dense undergrowth intertwined with creepers, the big swamps covered with elephant grass, the intermixture of the cultivation with the hills and the distances the men had to go to and from their camps, all combined to make the survey slow and laborious. In the hilly tracts there were many tea gardens dotted about and the demarcation and mapping of these was difficult. But the worst task of all was the laying down of the boundary of the hill tracts as well as that along the watershed between *thanas* Hathazari and Fatikchari on the one side and Mirkiserai and Kumira on the other. These boundaries are situated far from any villages and run over steep hills, through valleys thickly covered with jungle, and across broad swamps.

178. The actual amount of traverse surveying completed is shown in the following table:—

District.	Number of village circuits.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Chittagong	450	747	22,427	806

At all the trijunctions of villages and their adjacent stations, stone prisms or blocks of ballast were embedded; the other intermediate traverse stations were marked with baked clay cylinders. Three trigonometrical stations were connected with the work to check the chaining, whilst 342 azimuths were observed to check the angular work. It was hoped that the traverse survey of the district would have been completed this year; but, owing to the difficulties already described and to the early setting in of the rains, an area of about 200 square miles was still untraversed, when the sub-surveyors were forced to return to recess quarters.

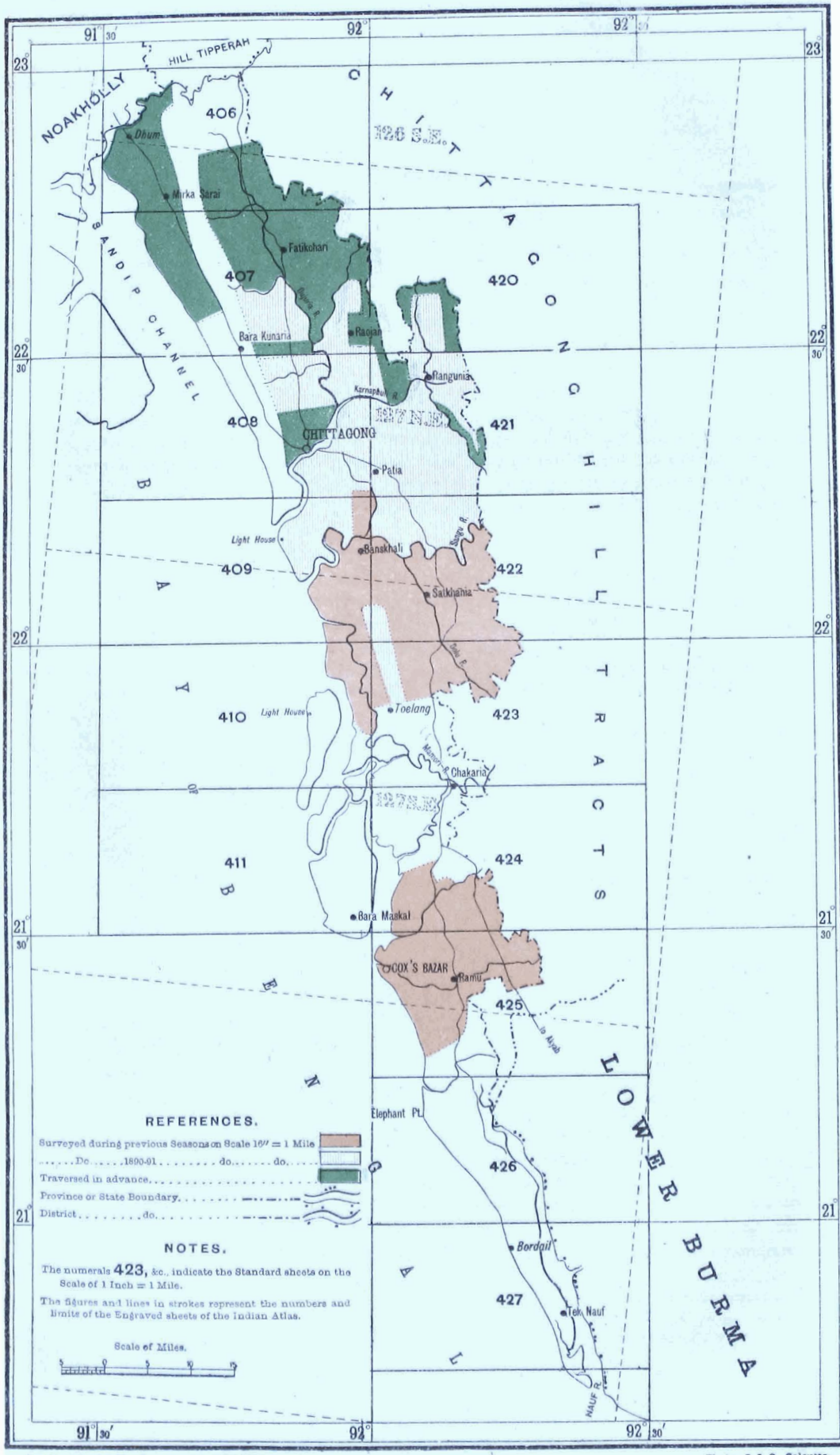
179. The detail survey commenced about the 15th December 1890 with only 80 *amins* at first; this number was increased during the first six weeks to 93, and subsequently in February 1891 to 140. In May, the numbers were greatly reduced, as the unusually early and very heavy rains flooded the country and put an end to field work. In *thana* Patia, where work was commenced, the fields were fairly large, averaging about ·25 of an acre, and consequently good progress was made; but as the work advanced towards the hills to the east, the fields became very small indeed, so much so that the average size of the fields throughout the entire work proved to be only ·13 of an acre. The extraordinary amount of minute detail in the village sites necessitated the special employment of some of the best *amins* on this survey, no ordinary *amin* being able to deal with such intricate work. These sites varied from small towns of half a mile square to small hamlets of 5 or 6 homesteads. Each homestead has its own little plot of vegetable garden or betel-nut plantation, and frequently a tank marked off with a trench and bamboo fence, while to secure privacy the whole is surrounded by a thick hedge of cane or bamboo. A mass of such residences all close together, embedded in trees as they are, appears like a wood instead of a town or village site, not even the roof of a single building being visible from outside.

180. The cost rate per acre on traverse and cadastral survey is 6 annas 6 pies, which is somewhat high, owing mainly to the causes specified in the previous paragraph, together with the fact that wages in Chittagong are very high, amounting to ₹8 per mensem for each chainman.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. CHITTAGONG.

No. 2 PARTY.



Reg. No. 337, S. I. D.—Sep. 91.—550. Rev. 1,000.

Photo., S. I. O., Calcutta.

181. The average daily progress of an *amin* under these circumstances was only about 14 acres of cultivation or 5 acres of village sites. In addition to the 16-inch field-to-field survey, a tract of country of 82 square miles in *thana* Ramoo was surveyed on the 2-inch scale; another of 65 square miles between *thana* Banskati and Satkania; and a third tract of 55 square miles was topographically surveyed in skeleton on the 16-inch scale. The total out-turn of detail survey was as follows:—

District.	Number of villages.	Number of fields.	Area in square miles.		
			Cadastral, 16-inch scale.	Topographical Skeleton, 16-inch scale.	Topographical 2-inch scale.
Chittagong	505	16,50,875	349	120	82

182. With regard to the attitude of the inhabitants towards the surveyors, Mr. Grant reports that they did not interest themselves much about the survey of the fields, but left it to the *chaukidars* to point out the boundaries to the *amin*; they were however very civil to the *amin*, and attended him closely when writing the records. Many errors and omissions of village and other undefined boundaries, which should never have occurred had they attended on the survey *amin*, were readily pointed out; in these cases the field surveyor was the sufferer, as he had to return and revise the boundaries, which, as he worked by contract, was a loss to him.

183. On the night of the 21st April the first heavy shower of rain fell, and, contrary to custom, the wet weather continued until the 20th May, when the fields were flooded and out-of-door work became impossible. It then became evident that it was useless expense to keep on the costly field establishment, and by the 4th June the detail surveyors were discharged. The traverse camp returned to recess quarters on the 12th June, leaving a few parties to complete the work actually in hand. This early setting in of the rains considerably reduced the season's out-turn.

184. During the recess the following maps and records have been supplied to the settlement officer:—

District.	Prepared for record-writing.		Drawing completed.			Tracings completed.		Areas of fields completed.	
	Villages.	Area in square miles.	Villages.	Sheets.	*Khasra* numbers.	Villages.	*Khasra* numbers.	Villages.	*Khasra* numbers.
Chittagong .	418	619	268	516	6,16,528	288	6,76,230	228	4,73,495

185. During the field season it was found very difficult to keep pace with the demands of the settlement officer for tracings and areas, as it was not possible to entertain a large staff of draftsmen and estimaters to take up and finish each batch of sheets as it was received from the settlement office, as this would have involved most of the men remaining idle afterwards till another batch of sheets was received. As the men were working by contract, it would not have paid them to do this, and they would have deserted had they been forced to do so. In recess, when a sufficient quantity of work had accumulated, the establishment was increased, and during the coming field season it is believed that, acting on the experience of the last season, more effectual measures will be taken to prevent delays. It is satisfactory to be able to add that, within seven weeks after the above statement of work submitted to the settlement officer was made out, the whole of the records due to that officer had been sent in and the cadastral party took the field unencumbered with any arrears. To the energy of Mr. O'Sullivan, who held charge temporarily from 11th July, this is due.

186. The head-quarters office of the party was inspected by the Deputy Surveyor-General on the 15th and 16th of February 1891 at Chittagong. The record-writing was at this time being done by the settlement department, the survey party being only responsible for the cadastral work; the Deputy Surveyor-General also accompanied His Honor the Lieutenant-Governor when inspecting the record-writing in the field under Mr. Slack, the Settlement Officer. All the records, the computations, etc., etc., in the office were carefully inspected and approved of.

Survey of the Serail Pargana, Tipperah District.

187. A detachment under the immediate supervision of Mr. P. C. H. Smart was sent to Serail to complete the survey and the record-writing which remained incomplete from last season. Twenty *amins* were employed on the field survey and on the *khanapuri*, of whom some were sent to Chittagong after a month, and in six weeks from the commencement of field work the number was reduced to ten. As these men finished their work, they were also drafted away to Chittagong, until by the end of March they had all joined the main party.

188. The field was the unit of survey; but the holding was the unit of the record-writing, and where more fields than one belonging to the same *rayat*, and in all respects similar, were found clubbed together, they were treated as one, and one number was given to them. The *amins*, both for survey and record-writing, were Hindustanis, it having been found that Bengalis were unable to make sufficiently rapid progress; moreover, with the exception of two men, none of those who had worked in Serail last year applied for employment this season; local men were engaged to assist the Hindustanis in writing in Bengali. Each *amin* surveyed on an average 45 acres a day, earning an average of ₹32 a month; in record-writing, their average out-turn was 99 fields, or about 74 acres a day, by which they earned ₹45 a month. The inking-in of field sheets and the tracings were done by Hindustanis. Areas were extracted by Hindustanis and Bengalis; these areas, which were as usual taken out in the first place in acres and decimals, had to be converted into two different local standards of measure, one for *khalsa* and another for tenure-held lands; the separation of these different measurements, for the purpose of totalling, was perplexing and tedious.

189. The detachment took the field on the 13th December and retired to recess quarters on the 27th April. The actual out-turn of work completed is shown in the following table:—

District.	Cadastral Survey.			Record-writing.		
	Number of villages.	Number of fields.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Tipperah . .	16 in part	16,089	23·11	44	80,335	77·18

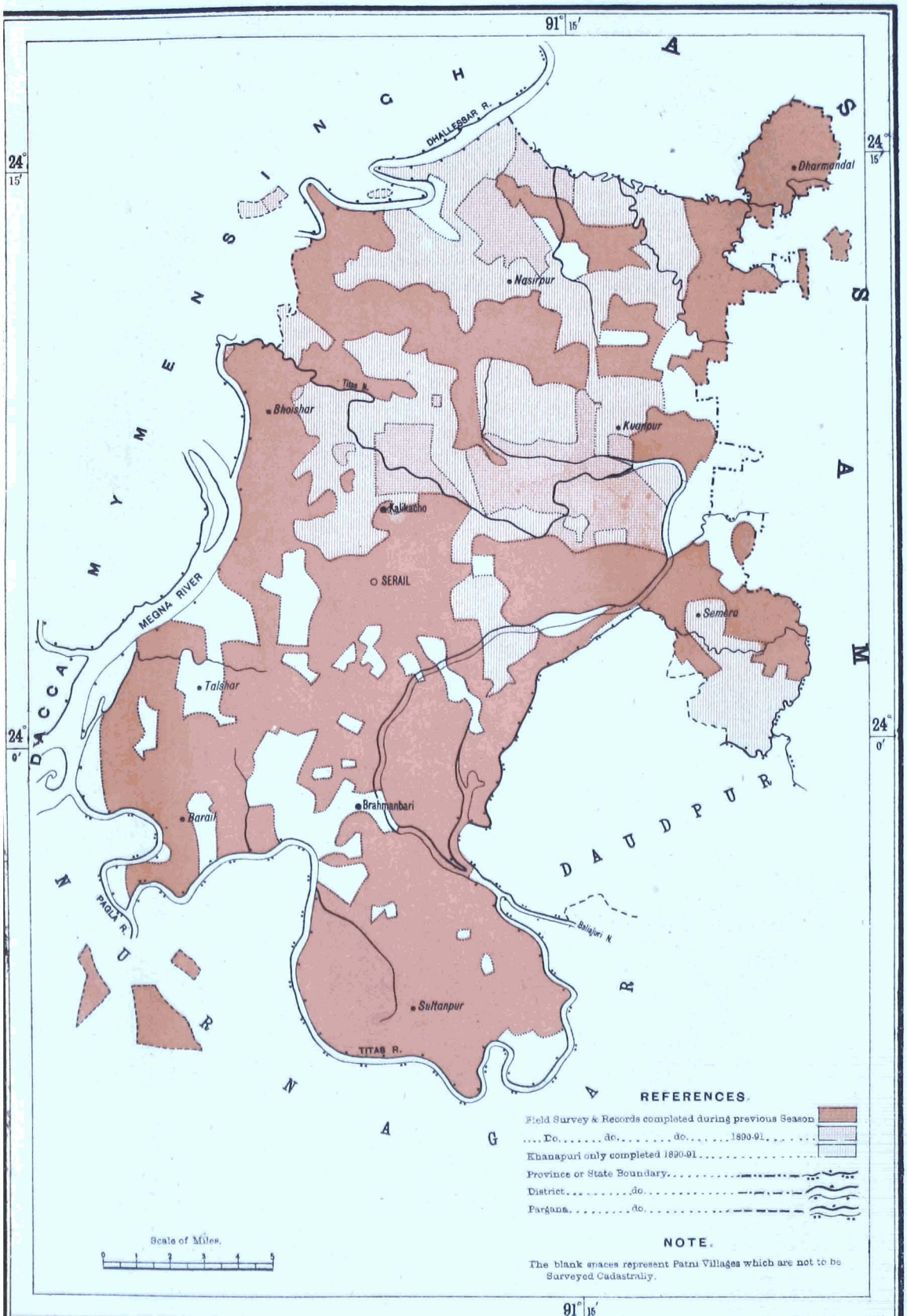
The average size of the field was ·60 of an acre. The field surveyors who were sent to complete those villages, which had been partly surveyed last year, reported having found the permanent traverse stations well preserved. Twenty-three linear miles of *partal* to check the field survey were run by the European assistants and *munsarims*, and the work was pronounced to be first class. To test the accuracy of the record-writing, 23,096 numbers were checked; the principal errors were due to the absence of the tenure-holders at the time of the record-writing. All doubtful points were put down as disputed without any attempt on the part of the survey officials to decide them.

190. The inhabitants of the *parganas* have from the beginning been much opposed to the survey, and, notwithstanding all efforts, they could never be induced to attend in a body to point out their fields; one or two only would go out, and with great difficulty be persuaded to accompany the *amins*; the delays on this account were again this season of constant occurrence. Subsequently, after numerous summonses to attend at the survey office had been issued and warnings

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY OF PARGANA SERAIL, DIST. TIPPERAH.

No. 2 PARTY.



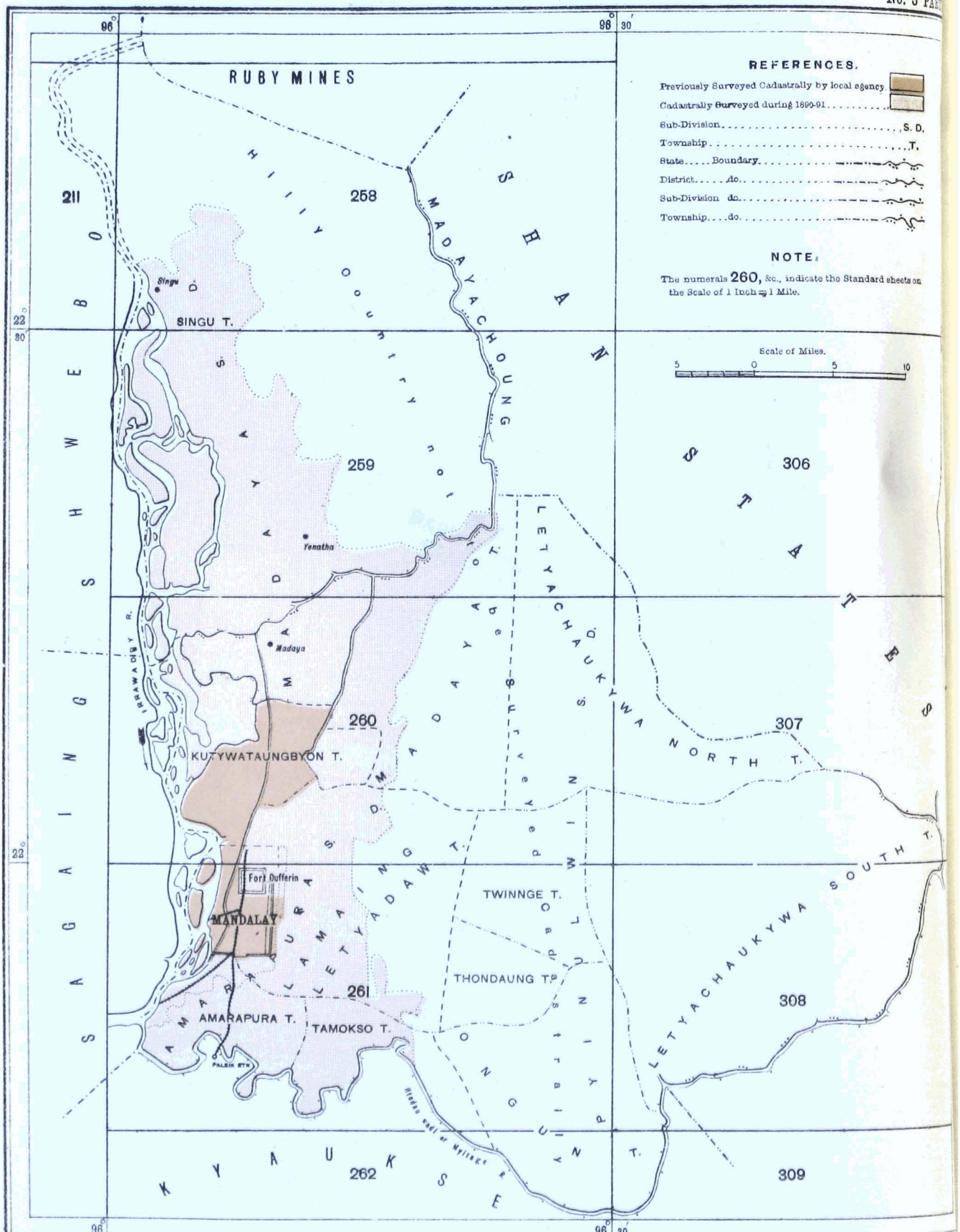
Reg. No. 337, S. I. D.—Sep. 91.—550. Rev. 1,000.

Photo., S. I. O., Calcutta.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT MANDALAY.

No. 3 PART



Reg. No. 358, S. I. D.—Oct. 01.—350.

Photo., S. I. O., Calcutta.

given, which were unheeded, some fines were inflicted; these were realised by the sub-divisional officer, and then the *rayats* became more amenable and complaints were not quite so frequent. Another cause of delay was the attempt to transfer the *mehal chaks* from the *thakbust* maps on to the field sheets; owing to the inaccuracy of the old maps, only an approximation of their shape, area and position could be given; this was very unsatisfactory, but nothing better could be done.

191. The nature of the country is a low flat plain intersected with large *bhils* or marshes in every direction, and is to a great extent flooded every rainy season. This is the case more especially in that portion of the *pargana* wherein lay the season's operations, which is consequently always submerged before any other part of the *pargana*.

192. The health of the party was good on the whole; there were two deaths, one from cholera while the men were marching to the field, and the other from general debility; the *pargana* is considered by some of the officials to be the healthiest part of Eastern Bengal.*

MANDALAY AND MEIKTILA DISTRICTS, UPPER BURMA.

No. 3 Party.

193. This party, having completed the survey of the Kyaukse district, resumed field operations in the Mandalay district, of which 173 square miles had been traversed in advance during the previous season. In addition to this, arrangements were made for the traverse and cadastral survey of the *sisa*, or royal lands, in Meiktila, for which a special requisition had been made by the Burma Government, and for which a grant of ₹90,000 was sanctioned. To enable the party to cope with the work allotted to it in Mandalay and Meiktila, the establishment was strengthened by the transfer of one European assistant from the Indus riverain detachment, and three sub-surveyors and computers from the Burdwan Khas Mahals detachment; a number of cadastral hands were also added to the establishment. The nature of the work was similar to that of last year, *viz.*, the field-to-field survey of culturable areas on the 16-inch scale. The traverse and cadastral sections commenced work both in Mandalay and Meiktila on the 1st of December 1890, and closed field operations during the first week in June 1891.

Personnel.

Mr. G. B. Scott, Deputy Superintendent, 4th grade, in charge to 11th June 1891.
Mr. B. G. Gilbert-Cooper, Officiating Deputy Superintendent, 4th grade, in charge from 12th June 1891.
Mr. J. Connor, Surveyor, 3rd grade.
„ J. Newland, „ 4th „
„ G. Campbell, Assistant Surveyor, 1st grade, to 16th March 1891.
Mr. O. D. Smart, Assistant Surveyor, 1st grade.
„ P. J. Serrao, „ „ 2nd „
„ F. P. Walsh, „ „ 2nd „
„ W. J. Baker, „ „ 3rd „
28 sub-surveyors and others.

Temporary Establishment.

16 inspectors.
180 field surveyors.

194. The demarcation in district Mandalay was completed before the traverse work began, and the plans of *kwins* were supplied by the Deputy Commissioner. The greater portion of the demarcation was well done, but that of the villages in the hills and of forest tracts to the north and east of the district was imperfect. This, however, made little or no difference, as the survey operations were confined to the more level portions of the country. In the Meiktila district only the demarcation of *diangs*, or circles, was completed in time for traverse survey; the *kwin* or village boundaries were demarcated during the progress of the cadastral survey, plans being received from the demarcation officer. The *amins* took up these boundaries in the course of the survey, and they have been shown on the sheets. In Mandalay district 3,000, and in Meiktila 3,316 theodolite stations have been permanently marked, at the time of survey, by baked clay cylinders sunk flush with the ground. For the preservation of these stations the *thugyis* have been served with notices under the Upper

* Mr. Grant speaks of Messrs. McHatton and P. C. H. Smart, who were in charge of camps, as having worked zealously and heartily, and of Mr. Lee as a thoroughly efficient Assistant Surveyor. Messrs. E. F. McGowan, F. A. R. Lucas, and J. McIntyre, of the temporary establishment, have also been well reported on by Mr. Smart, who was in charge of the Serail detachment. Of the native establishment, Mr. Grant selects Babu Ramji Lall, writer, Aagamathu Mokam Dutt and Balwant Vishnu, computers, Latifulla Khan Bindalal, Hamid Hussein and Narin Purshad, sub-surveyors, and Issan Hussein, draftsman, for special mention.

Burma Boundaries Act, and provided with 2-inch skeleton plots of their *kwins* showing the number of stations to be preserved.

195. Two main and fourteen sub-circuits were run in Mandalay, and four main and six sub-circuits in the Meiktila district. The angular work was checked by azimuth observations at 46 stations in the former and at 56 in the latter district. There were 1,016 linear miles of chaining run in Mandalay and 1,980 linear miles in the Meiktila district. Two sets of chains, *viz.*, one of 100 links and one of 93 links, were used throughout the work, and proved a most useful check.

196. In Mandalay district last year, 107 villages were traversed in advance, and this year 76 more villages were enclosed by traverse; these villages covered an area of 584 square miles, or more than 3 square miles on an average to each *kwin*. The large average is due to the large tracts of hilly and forest-clad country comprised in the *kwins* near the hills; the villages in open country near the river seldom cover more than a square mile. The whole of this area has been cadastrally surveyed and mapped on 507 sheets. In Meiktila the total number of square miles traversed was 563, all of which has been cadastrally surveyed and mapped on 492 sheets. In Mandalay 551 linear miles of check survey on field book forms were run after the sheets were received in office, and 241 linear miles on plane-tables during the progress of the work: several sheets had to be rejected, but on the whole the work proved to be very good. Five hundred and eighty-two linear miles of test lines on field book forms and 269 linear miles on board plans were also run in Meiktila, the work, as a rule, being found very good, except where the limits of fields were ill-defined.

197. The out-turn of work for the field season is given in the following statement:—

Districts.	Cadastral Survey. 16-inch Scale.			Traverse Survey.	
	Number of *kwins*.	Number of fields.	Area in square miles.	Number of *kwins*.	Area in square miles.
Mandalay	183	424,247	584	76	389
Meiktila	642	376,925	563	642	575
Sagaing	...	...	...	518	714
Total .	825	801,172	1,147	1,236	1,678

The average size of the field in the Mandalay district is ·89 of an acre; this is due to the large blocks of uncultivated land included in the area: in the Meiktila district it is ·95 of an acre.

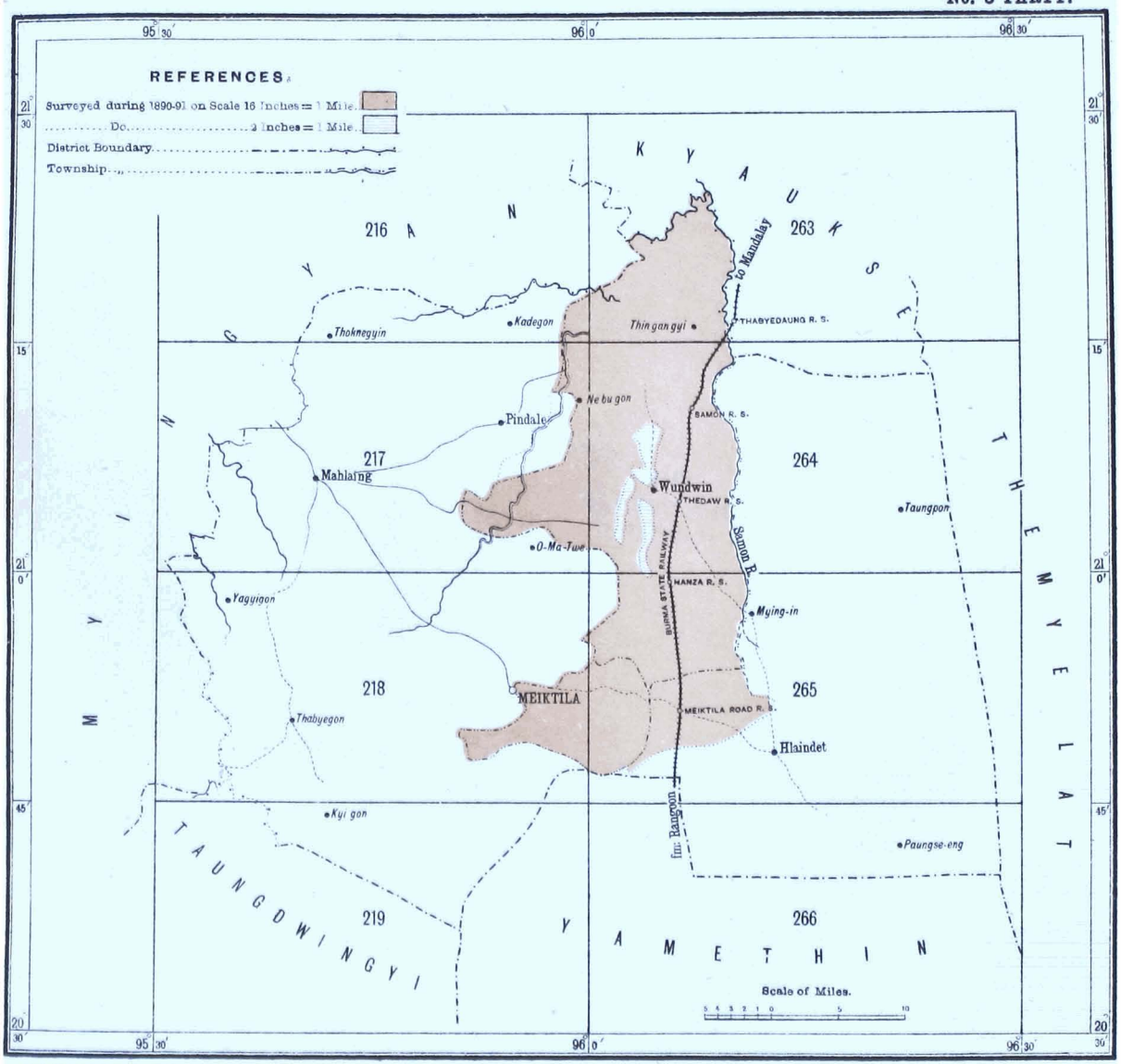
198. The average cost of cadastral survey, including demarcation, traverse, detail survey, and cost of mapping is ₹193 per square mile or 4 annas 11 pies per acre; the cost of the same items in Kyaukse last year was ₹291 per square mile or 8 annas 5 pies, showing a decrease in cost of this year's work of 3 annas 6 pies per acre. This great reduction is principally due to the following causes: (*a*) the partial employment of local labour for chainmen, whereby a saving in passage money of about ₹10,800 was effected; (*b*) these local men were paid daily wages per working day instead of monthly salaries, which represented a saving of about ₹7,200; (*c*) the increase of the native establishment in proportion to the European supervising staff, which allowed of a larger area being surveyed with no corresponding increase in the cost of supervision; (*d*) the cost of the work in Kyaukse was increased by the cost of the transfer of the party and equipment from the Central Provinces.

With regard to the first cause (*a*) it was not considered advisable to trust entirely to obtaining local labour for chaining, for fear of failure in getting men to take service, a result which might have led to serious delay or even perhaps to a stoppage of work; as an experiment it was determined to import two men with each *amin*, the other two to be obtained locally through the *thugyis*; this worked well, for when once the Burmans found that they could with confidence rely on receiving the pay promised to them, they came forward, and about 200 were employed in Mandalay at a daily rate of 4 annas, and in Meiktila of 6 annas.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. MEIKTILA.

No. 3 PARTY.



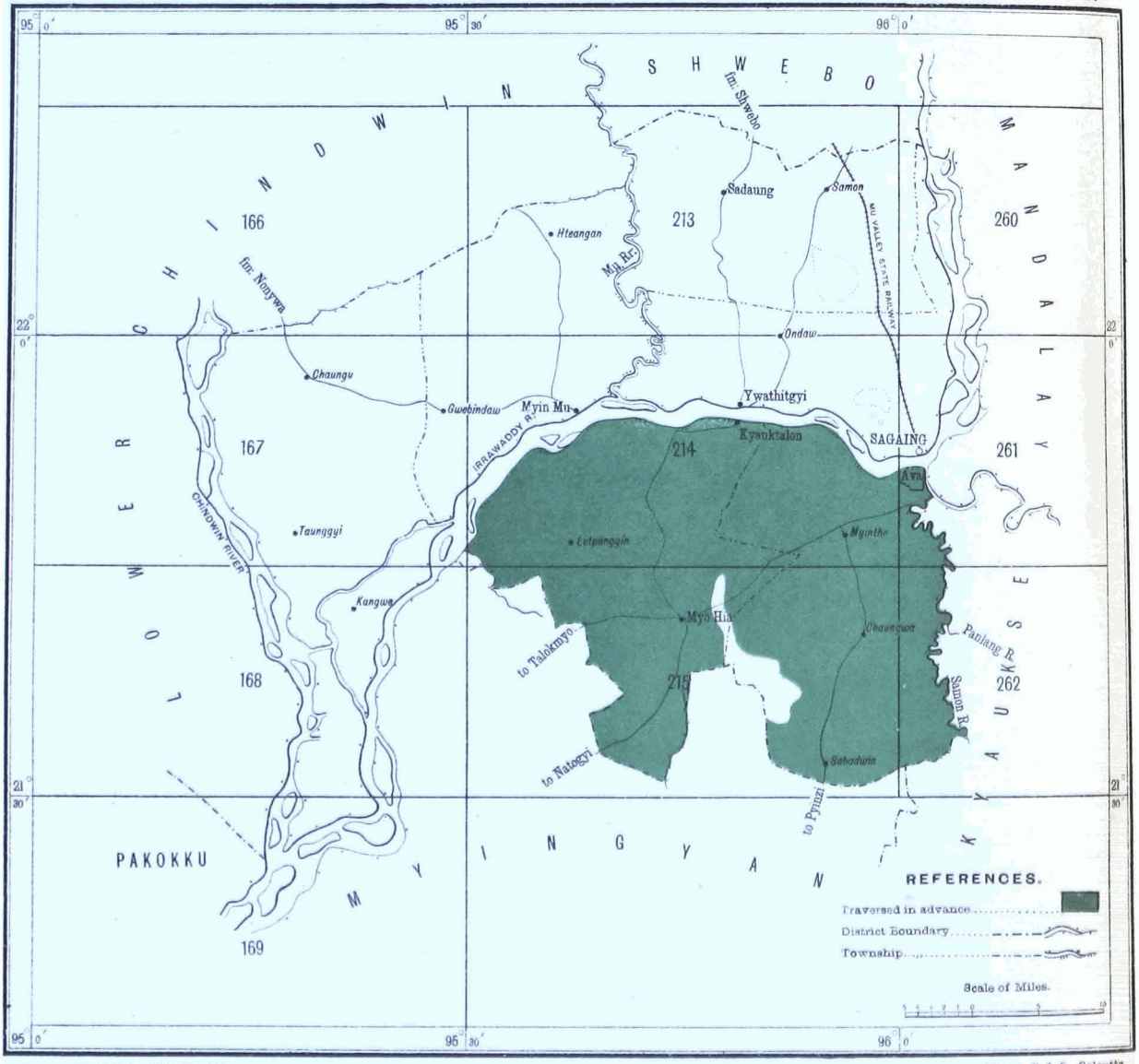
Reg. No. 721, S. I. D.—Feb. 92.—650.

Photo., S. I. O., Calcutta

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. SAGAING.

No. 3 PARTY.



Reg. No. 721, S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta

199. The health of the party was generally good throughout the season; the only serious sickness which occurred was an outbreak of cholera among the *khalásís* on their way from India, which resulted in five deaths immediately after their arrival at Mandalay.

200. Six Burman sub-surveyors with their squads were entertained at the commencement of the season. Of these only three have worked well, and they had much difficulty in keeping their Burman *khalásís* at work. Thirty squads of Burman *amins* were also formed from men trained either in local survey schools or in the party. As a rule, they worked well in open country and when within reach of European officers, but fell off considerably when working in the villages situated in the jungles, where a lot of their work had to be rejected and re-surveyed. The average monthly out-turn of Indian *amins* during the season was 699 acres, while the average of the Burmans was 498 acres. It is therefore evident that, even if a sufficient number of Burmans could be entertained, it would not be advisable to replace the Indian *amins*, to whom the Burmans can only be looked upon as subsidiary.

201. In April, the Deputy Surveyor-General inspected the party whilst in the field, visiting the camps at Meiktila and Kyauktalon and inspecting the central office at Mandalay. The traverse camp at Kyauktalon was in charge of Mr. Gilbert-Cooper, who has been lately transferred from the Bombay Revenue Survey Department. Although, when he joined, he was unacquainted with the system of survey adopted in this department, he has already gained sufficient knowledge to enable him to hold charge of a traverse camp with credit, and during the recess he has satisfactorily superintended the whole party whilst Mr. Scott was absent on furlough. The Deputy Surveyor-General reports that he was much pleased with the progress made by the party and with the state in which he found all the records, and he desires to call special attention to the energy and excellent management of Mr. Scott, by which the large out-turn and the consequent reduced cost rate have been obtained. As already explained this was also partly due to the fact of the operations being extended to two districts. Cordial relations with the district authorities were maintained throughout the season.

202. During the ensuing field season the cadastral survey of the Sagaing district, of which 714 square miles have been traversed during the season under report, and the topographical survey of the coal-fields on the Chindwin river, in district Kendat, will be undertaken by this party.*

WESTERN DOOARS, BENGAL PRESIDENCY.

No. 4 Party.

203. This year, in addition to the cadastral survey of the Western Dooars, which was carried on in continuation of former seasons' work, this party was engaged on the topographical survey on the 4-inch scale, of the reserved forests and arable waste lands. The recess office at Hazaribagh was closed early in November, and on the 15th the field establishment assembled at a spot in the eastern sub-division of the district, 5 miles to the east of Alipur Dooar, where rough huts had been erected during the previous season for storing the field equipment of the party during the recess. Mr. Hanby held charge of the party till the 16th November, when he made over charge to Captain Hodgson, who had been appointed to the party on return from furlough.

Personnel.

Captain G. B. Hodgson, S.C., Officiating Deputy Superintendent, 3rd grade, in charge from 18th November 1890.
Mr. H. T. Hanby, Surveyor, 2nd grade, in charge from 1st October to 17th November 1890.
„ W. H. Penrose, Assistant Surveyor, 1st grade, from 1st June 1891.
„ G. T. Hall, Assistant Surveyor, 1st grade.
„ G. A. Knight, Assistant Surveyor, 1st grade, from 1st November 1890.
„ W. H. D. Ewing, Assistant Surveyor, 1st grade, to 31st May 1891.
„ L. F. Berkeley, Assistant Surveyor, 1st grade.
„ W. E. Johnson, Assistant Surveyor, 2nd grade, to 18th November 1890.
„ C. G. S. Wood, Assistant Surveyor, 3rd grade.
37 sub-surveyors and others.

Temporary Establishment.

140 field surveyors, inspectors, &c.
76 computers, draftsmen, &c.

204. The remarks that were made last year as to the divisions into which the

* The officer in charge reports thus on the services of surveyors and others: Messrs. Connor, Newland, and Smart, who respectively supervised the cadastral camps in Mandalay and Meiktila and the traverse camp, performed their duties most satisfactorily, and Messrs. Serrao, Walsh, and Baker showed themselves to be trustworthy, hard-working and efficient assistants. Of the native establishment he specially mentions Bhugobutty Charan Chuckrabutty, Kedar Nath, Bhola Nath, Rohan Lall, Harpat Rai, Fushatulla, Alimsuddin, Karim Baksh, Maksud Ali, and Mansur Khan.

lands of the Western Dooars are separated may be recapitulated, as they will serve to explain the terms made use of in the report:—

"The only territorial divisions bearing definite names in the Western Dooars are *parganas* and *talukas*; the latter are sub-divided into plots of various sizes, called *jots*, which are distinguished by the name of the tenant (*jotdar*) or of his successor, and by serial numbers called *tauzi* numbers. The *taluka* is too large and the *jot* too small to serve as a survey unit, so it was decided to club together several *jots*, so as to make up areas approximating to the size of the *mauza* or village in the North-West Provinces, and to treat them as the unit for the traverse survey, but the *jot* is the unit recognised for settlement purposes. These blocks of congregated *jots* are called *chaks*, which have been numbered consecutively for each *taluka*."

205. During the season a further area of 420 square miles was traversed, which completes the entire district, with the exception of a large area to the west of the Torsa river, which has been recently surveyed by the local survey and blocked out for allotment as grants for tea cultivation. The total area traversed in the plains during the three seasons the party has been employed in the Dooars is 1,606 square miles, in addition to which, during the present season, an area of 25 square miles of the hilly portion of the district has been traversed and 18 square miles triangulated, making in all an area of 1,649 square miles prepared for detail survey. Of this area 759 square miles, consisting mostly of cultivated land, have been surveyed cadastrally, 525 during former seasons and 234 during the present season. The reserved forests cover an area of 487 square miles, of which 174 have been surveyed this season on the 4-inch scale, leaving 313 square miles for survey next season. The waste land consists of 43 square miles of hilly country and 360 square miles of arable land in the plains, which has been divided into blocks averaging 915·36 acres, for future allotment for tea or general cultivation: of the arable area 56 square miles have been surveyed topographically on the 4-inch scale during the present season.

206. As in previous seasons prism-shaped stones, about 2 feet in length, were employed to mark the tri-junctions of *chaks* in the cultivated lands and the triple or quadruple junctions of blocks in the waste lands, the number embedded being 274. Intermediate stations were marked with vitrified bricks as a rule, but in the forests a certain number of large bamboo stakes was employed for this purpose, and on the Bhutan boundary theodolite stations were generally marked by stones picked up on the spot and a cairn erected over them.

207. The cadastral survey was very much scattered, and comprised the completion of *parganas* Chakwakheti and Baxa (which had been partly surveyed the previous season), all existing cultivation of a permanent nature in Bhatibari and Bholka, Hidayat Ali's estate in Lakhipur, and detached plots in Moraghat and North Mainaguri, which had been omitted at the time these *parganas* were surveyed on account of their not having been demarcated. With the exception of a few detached plots, amounting to 5 or 6 square miles, which could not be surveyed before the advent of the rains, the cadastral survey has been completed of all cultivation of a permanent nature throughout the area allotted for survey. The writing of the records in the field, of 40 square miles surveyed last year, was done in addition to that of the whole area surveyed this season.

208. The procedure adopted last year for dealing with disputed boundaries was again followed. Tracings in duplicate of the localities in dispute were sent to the settlement officer, with notes to assist him in his decision. The boundary that agreed most nearly with the old records was adopted as a rule, and when the case was decided one copy was signed and returned to the survey office for record.

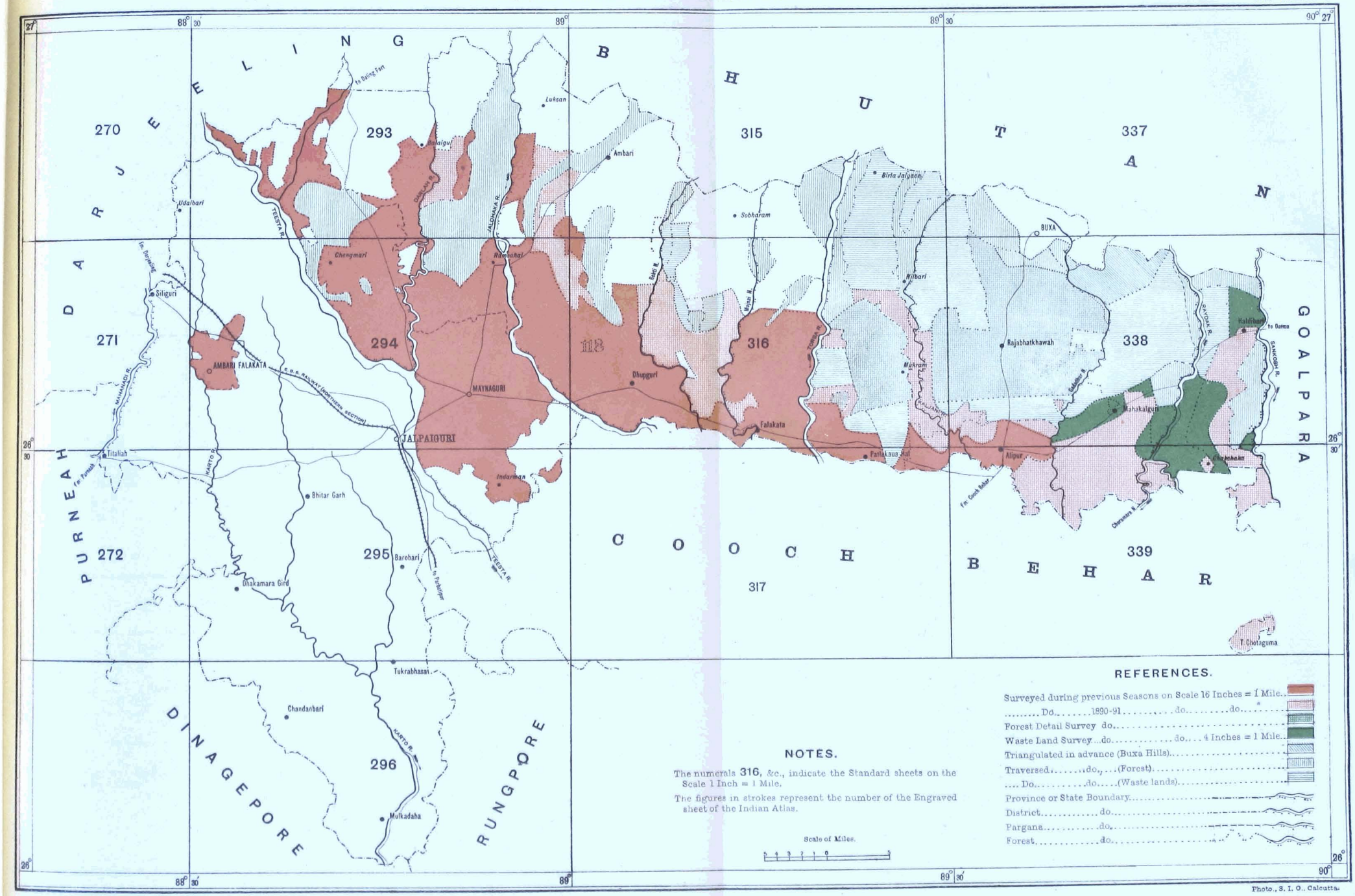
209. The forest survey was confined entirely to the Baxa and Borajhar reserves: of the former, as much as is situated in the plains; and of the latter, the whole of the southern block was completed and a portion of the northern block. The area surveyed was 174 square miles, which was checked by 59 linear miles of test lines and mapped on 26 sheets. The average number of plane-tablers employed was 10, and each man's average out-turn per month was slightly under 3 square miles.

210. *Pari passu* with the mapping of the topographical features, the limits of the various forest growths were delineated by the sub-surveyors as well as the different classes of soils. The forest growths are divided into five classes:— (1) Pure *sâl*, (2) *sâl* with mixed forest, (3) mixed forest without *sâl*, (4) *khair* and *sissu* forest, and (5) savannah or grass lands.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE WESTERN DOOARS (DIST. JALPAIGURI).

No. 4 PARTY.



NOTES.

The numerals 316, &c., indicate the Standard sheets on the Scale 1 Inch = 1 Mile.

The figures in strokes represent the number of the Engraved sheet of the Indian Atlas.

Scale of Miles.

REFERENCES.

Surveyed during previous Seasons on Scale 16 Inches = 1 Mile.
.....Do.....1890-91.....do.....do.....
Forest Detail Survey do.....
Waste Land Survey....do.....do....4 Inches = 1 Mile.
Triangulated in advance (Buxa Hills).....
Traversed.....do,....(Forest).....
....Do.....do.....(Waste lands).....
Province or State Boundary.....
District.....do.....
Pargana.....do.....
Forest.....do.....

Photo., S. I. O., Calcutta.

Reg No. 3[illegible], S. I. D.—Sep. 91.—550. Rev. 1,000.

There are four classes of soils—(*a*) very good, (*b*) medium, (*c*) dry, and (*d*) moist and swampy. These details are recorded on the field sheets merely by the figures and letters as given above, the limits being shown by dotted lines; but for the Forest Department tracings of each sheet have been prepared, in which the forest growths are shown by washes of colour and the soils by parallel lines drawn across the map, the direction in which the line is drawn indicating the class of soil. In accordance with the wishes of the Deputy Conservator of Forests, on each tracing the area has been entered separately for three classes of forests, *viz.*—(i) forest in which *sâl* is found, (ii) *khair* and *sissu* forest, (iii) forest without *sâl*. The tracings have been numbered in accordance with the field sheets, and an index map has been prepared, which will be sent with the tracings to the Forest Department.

211. The small area of waste land surveyed topographically on the 4-inch scale consisted mostly of detached portions in sheets in which the cultivation only had been surveyed cadastrally in *parganas* Bholka and Bhatibari. The area thus surveyed amounts to 56 square miles, comprised in 21 sheets, of which only 14 were completely and 7 partially surveyed; very few of these sheets have been checked as yet.

212. Field work was commenced about the 25th November 1890, and closed during the first week of June 1891. This year again an establishment for completing the 16-inch maps and vernacular records was left at Jalpaiguri under Mr. Hanby for convenience of communication with the settlement office.

213. The out-turn of cadastral work for the season is given in the following statement:—

Parganas.	Traverse Survey.		Cadastral Survey, 16-inch scale.					Remarks.
	Number of *chaks* and blocks.	Area in square miles.	Number of *chaks*.	Number of *jots*.	Number of fields proper.	Number of *kiaris* (sub-divisions of fields).	Area in square miles.	
Chengmari	...	...	2	14	132	...	1·06	
North Mainaguri	...	...	20	101	1,550	874	5·30	
Moraghat	...	...	34	688	15,063	4,940	33·50	
Lakhipur	102	65·96	93	774	38,472	8,164	52·20	
Madari, West	...	...	4	52	2,176	249	4·22	
,, East	...	...	13	24	1,449	315	10·22	
Chakwakehti	...	...	13	53	3,909	2,325	12·47	
Baxa	...	...	32	223	12,630	5,183	27·24	
Bhatibari	...	...	71	1,040	41,977	12,843	49·92	
Bholka	4	1·04	58	763	41,360	55,602	37·78	
Total ...	106	67·00	340	3,732	158,718	90,495	233·91	

The out-turn of other classes of work was as follows:—

Parganas.	Traverse Survey.		Detail Survey, 4-inch scale.	Remarks.
	Number of blocks.	Area in square miles.	Area in square miles.	
Waste land Survey	129	171·64	55·70	
Forest Survey	7	182·12	174·22	
Total	136	353·76	229·92	

In addition, 66·9 linear miles of the boundary between Jalpaiguri and Bhutan were traversed with a view to relaying the boundary.

214. The number of theodolite stations is 6,825, of which 274 were marked by stones, and the remainder by bricks, except in some places on the Bhutan boundary, where stones picked up on the spot were used, and in a few cases in the forest where wooden pegs were driven in. The average number of stones per square mile in the cultivated lands is 1·27 and in the waste lands 1·02. The average cost per square mile for permanent marks over the whole area traversed is R5·8.

215. The average size of the fields in the cadastral area is 0·94 of an acre, exclusive of the sub-divisions of the fields, and 0·60 of an acre including them. The sub-divisions of the fields, as they are called, are shown on the field sheets and also on the tracings by dotted lines as heretofore, the limits of the fields proper being shown with firm lines. These distinctions, however, are purely arbitrary, as the sub-divisions really show the fields proper as they appear on the ground, several of these being clubbed together under one number to keep the numbers within reasonable limits; the number of fields included in one number being limited to those which in one compact plot are all on one level, and so can be classed together under one soil head. This work is performed by the *mohurrir* when writing up the records, who, guided by the above considerations, decides how many fields shall be included under one number. The *amin* or field surveyor makes no distinction on his map, but shows all the field boundaries alike. Thus, this season, there were 158,718 fields numbered, while the actual number of fields surveyed was 249,213. The cost rate per field, for both survey and *khanapuri*, has been calculated on the actual number of fields surveyed.

216. No change has been made this year in the preparation of the records in the field, but the areas which had previously been entered in the *khasras* in English are now required to be entered in the Bengali character, and in the tracings the colour hitherto employed for tobacco land has been omitted according to orders received, and all such land shown merely as *farringhati*. In the estate of the late Colonel Hidayat Ali in Lakhipur *pargana*, where there are no *jotdars*, the holdings of *chukanis* or tenants have been shown as *jots* on the field sheets, with the difference that the limits are not shown with thick firm lines as in the case of *jots*, but by broken lines carried alongside of the field boundaries. Separate tracings and records have been prepared of each *chak* and not of each *chukani*.

217. The cadastral survey was tested by 428·73 linear miles of check lines, and the *khasra* entries of 69,611 fields were also checked either by European officers or by native inspectors. The season's out-turn has been mapped on 428 sheets, which cannot be finally disposed of or submitted for publication till settlement has been effected. Before the field sheets can be completed and the records prepared for the Settlement Department, all *jot* boundaries have to be compared with the old records of the district when such are forthcoming, and owing to the unsystematic manner in which these papers have been kept and various other causes, the hunting up and identifying of the *jots* has proved a most tedious and laborious task, involving as it does for each *jot* the looking through, time after time, of a vast number of maps in separate bundles. A great many of the old records bear no distinguishing number; many of the *jots* are shown as situated in totally different *taluks* to those in which they really lie, and many *taluk* names are given which are not to be found in the list of *taluks* now received from the settlement office. In the northern part of *pargana* Bhatibari much time was lost in looking for *jots* in heavy grass jungle, the survey of which was asked for, but which had not been demarcated. Eventually on a reference being made to the settlement officer, the *jots* were demarcated and men sent back to survey them. The difficulties are further increased in this district by the absence of localities bearing definite names, so that the situation of a *jot* is traced with great difficulty. The name of the original proprietor is recorded, but the changes in proprietorship are found to be frequent, and often all traces of the originally allotted area have disappeared, the land having been either sold to, or absorbed by, the adjoining *jotdars*, or having been abandoned, has been re-distributed to fresh applicants, while the old records are still preserved without any note on them of such transactions.

218. The writing of the records in the field was almost entirely done by Bengali *mohurrirs* in the vernacular of the province. A survey school was

established to provide a sufficient number of Bengalis for this purpose at the commencement of the field season under a Bengali inspector, who, at the end of a month, produced 15 men ready to take up *khanapuri* independently, after having learnt to read a map and to make small corrections therein if necessary.

219. The local difficulties met with in former seasons were intensified this year, as, in addition to the usual maladies incidental to the district, an outbreak of cholera occurred at the commencement of April which caused some deaths and many desertions both among *amins* and *khalásis*, and caused the field work to be prolonged throughout May, which it was hoped to avoid, as the district becomes very unhealthy then. The rains began early in the first week of May, but as so very little remained to be done to complete the cadastral survey of the entire area allotted for survey, the work was continued in the hope that every day would see that little finished. The rain and the consequent sickness however proved beyond all calculation—both *amins* and *khalásis* refused to work in localities where the cholera was raging, and in other places the inhabitants would not permit them to work for fear of their bringing the disease. At the very outset the want of *khalásis* had been much felt, a sufficient number not having been entertained prior to taking the field, as in the previous season a certain number of men had been obtained locally, and arrangements were made accordingly. As soon as it was found that more measurers were wanted, a fresh batch of 200 was sent for from Hazaribagh and 187 were entertained and started off. Out of these only 7 or 8 men joined the party, the rest having turned back when within a few days' march of Jalpaiguri. In addition to the drawbacks above enumerated, the very scattered nature of the work, consisting of detached plots in almost every *pargana* of the district, as well as the large amount of jungle that was met with interspersed with the cultivation, has tended to enhance the cost of the survey. The cost rate per acre on traverse and cadastral survey is 8 annas 3 pies.

220. Of the local civil authorities from whom assistance was required, Colonel Boileau, the Deputy Commissioner, Mr. Gouldsbury, the District Superintendent of Police, and Mr. W. M. Green, Deputy Conservator of Forests, were always ready to help the survey in every way, and so were the *tahsildars* of Falakata and Bholka, the latter especially. The sub-divisional officer at Alipur Dooar, however, not only made no effort to give assistance, but generally took no notice of letters addressed to him by Captain Hodgson or his assistants. The survey operations which lay principally in his sub-division were seriously hampered by his want of courtesy and the example he set to his subordinates, who took their cue from him. To Dr. Rivers Anderson of the 9th Bengal Infantry, the Forest Survey section was much indebted for his kindness in placing the services of the Hospital Assistant at Rajabhatkhawa and the dispensary there, at the disposal of the party.

221. In the recess office at Hazaribagh a small establishment was employed in finally examining the cadastral sheets, of which 212 were ready for despatch to head-quarters by the end of September, and it was expected that 100 more would be ready before the party left for the field, but none of these can yet be despatched, as they are required for the preparation of the 2-inch standard quarter sheets which were commenced during the recess. Of these the drawing of two sheets, Nos. 294 S. W. and 295 N. E., has been completed, and also of 6 sheets, as far as surveyed, Nos. 293 N. W., S. W., 294 N. W., 316 S. E., N. E., 338 N. W., while Nos. 293 S. E., 294 S. E., N. E., 316 S. W., and 338 S. W., are in hand, and the drawing, as far as materials are available, will be completed by the end of October.

222. It having been decided to fill up such portions of the 2-inch quarter sheets as have not been surveyed during the present operations, from the maps of tea lands locally prepared, 63 of these maps were obtained from the Deputy Commissioner, Jalpaiguri, for the purpose. These maps are generally on the 8-inch scale, and they have been fitted together and pentagraphed in a block on separate paper, and the topographical details will be traced on to the fair sheets, the exterior boundaries of the blocks having been traversed during the present survey.

223. The area of reserved forests surveyed was comprised in 14 sheets, of which the drawing of all has been completed for reproduction on the 4-inch scale. They have also been drawn on the 2-inch scale for incorporation into

the general map of the district, which is reduced and published on the 1-inch scale. The typing of the 4-inch sheets is in progress.

224. The following statement shows the quarterly despatch of complete records to the settlement officer at Jalpaiguri. The total area of which the records have been supplied up to the end of September is 462·3 square miles exclusive of 5·6 square miles revised; the areas of which the records have still to be despatched is 306·4 square miles:—

Quarters.	Records of seasons 1888-89-90.			Records of season 1890-91.		
	Number of *mists.*	Number of fields.	Area in square miles.	Number of *mists.*	Number of fields.	Area in square miles.
October, November, and December 1890	471	34,380	31·58	...	...	...
January, February, and March 1891	1,061	54,109	45·46	...	...	...
April, May, and June 1891	580	46,134	49·61	61	457	2·62
July, August, and September 1891	625	50,980	66·49	632	7,462	31·00
Totals	2,737	185,603	193·14	693	7,919	33·62
Remaining	859	32,957	64·42	3,689	185,113	241·98

225. The programme for the ensuing season is the completion of the topographical survey of the Western Dooars. The survey of the reserved forests will be continued on the 4-inch scale, but it has been decided by the Bengal Government that the classification of forest trees and soils shall not be done by the Survey Department: the area of forests remaining for survey is 313 square miles. The waste lands, covering an area of 323 square miles of plain country and about 43 square miles of hills, will be surveyed on the 2-inch scale, but the topographical features to be depicted will be confined to the details sufficient for a 1-inch map. One section of the party will be employed throughout the season in completing the records of the cadastral survey of former seasons which have to be furnished to the settlement office, and will also undertake the cadastral survey of several detached *jots*, aggregating about 5 or 6 square miles, which, for various reasons, were omitted previously. In addition, arrangements will be made for re-laying, in conjunction with the civil authorities, the boundary between the Western Dooars and Bhutan.

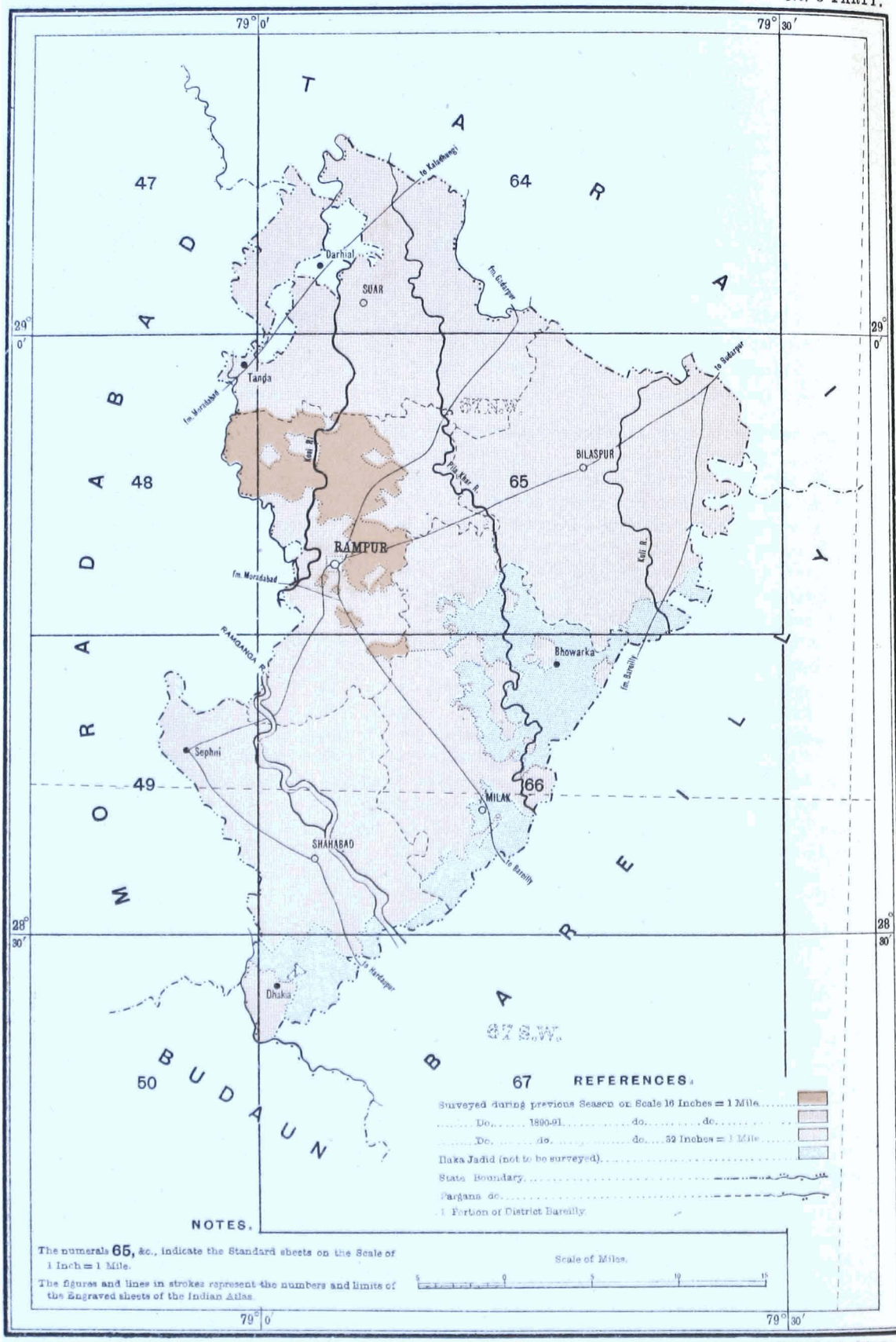
226. The Deputy Surveyor-General, Revenue Branch, inspected the cadastral section and office at Jalpaiguri on the 31st March, and on the 1st April attended a conference with the Lieutenant-Governor of Bengal, the Commissioner of the division, and the Settlement Officer, when the progress and the future work of the party was discussed and arrangements made for the more speedy supply of records to the Settlement Department. Again, on the 5th October the cadastral office was inspected; on both occasions the books of the party and the preparation of the records were inspected and approved of. On the second occasion complaints having been made by the settlement officer that the number of records which had been promised by the end of August had not been supplied, enquiries were made on the subject, and it was found that the complaints were greatly exaggerated, and that though there were still a few due, the actual number sent in was much in excess of what had been stated by the settlement officer, and it was not considered advisable to order any immediate increase of establishment to complete the very small number remaining. Mr. Hanby, who was in charge of the cadastral section, was authorised to entertain more hands if they could be procured and if he deemed it necessary, but he was at the same time cautioned against incurring extra expense without sufficient reason.*

* Captain Hodgson speaks in high terms of Mr. H. T. Hanby's ability and zeal; and states that his thorough knowledge of details and capacity for work have been of the greatest assistance to him: he has been in charge of the record section at Jalpaiguri all the year. He reports favourably of Messrs. W. H. Penrose, G. T. Hall, L. F. Berkeley, W. H. D. Ewing, and C. G. S. Wood. Of the sub-surveyors, he selects for special mention Jagneswar Bhattacharji, Irfan Ali, Ramjas Misr, Patandin, Abdul Karim, Ramnarain, Nand Lall and Durjan Ram.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE RAMPUR STATE.

No. 5 PARTY.



Reg. No. 337, S. I. D.—Oct. 91.—550.

Photo., S. I. O., Calcutta.

NORTH-WEST PROVINCES.

No. 5 Party.

Personnel.

Lieutenant-Colonel J. E. Sandeman, S.C., Deputy Superintendent, 2nd grade, in charge up to 30th June 1891.
Lieutenant R. T. Crichton, S.C., Assistant Superintendent, 2nd grade, in charge from 30th June 1891.

Rampur State Section.

Mr. A. W. Smart, Assistant Surveyor, 1st grade.
„ J. Murphy „ „ „ „
6 sub-surveyors.
16 inspectors.
169 field surveyors (*patwaris*).
63 field surveyors (*amins*).

Garhwal Section.

Mr. T. F. Freeman, Surveyor, 4th grade.
„ N. Bedford, Assistant Surveyor, 2nd grade.
„ W. V. Skilling, „ „ „ „
„ J. H. Murphy, „ „ „ „
15 sub-surveyors.
16 inspectors.
31 field surveyors (*patwaris*).

227. This party, of the strength shown in the margin, has continued cadastral operations in the Garhwal district and in Rampur State, North-West Provinces. It also undertook the survey, on the 4-inch scale, of the forest reserve in the Lansdowne cantonment. These operations will be reported on separately.

Survey of the Rampur State.

228. When the orders for the survey with record of rights were received, it was arranged with the authorities that it should be made on the 16-inch scale, and that the estate known as the *jadid ilaka* should be entirely excluded from the survey. Field operations were commenced on the 20th October 1890 and closed on the 10th June 1891. During the previous season 577 square miles of traverse survey had been completed, and the small remaining area was finished by 6 traverse surveyors by February 1891.

229. The following table gives the out-turn and details of the traverse survey :—

Number of village circuits.	Number of sub-traverses.	Number of traverse stations.	Number of permanent marks.	Area in square miles.
308	777	8,959	5,932	212·75

At the request of the Council, clay cylinders, in preference to stones, were embedded at the theodolite stations and covered over with substantial mounds of earth. The traverse survey was carried out under very favourable conditions, the country being quite level and the mathematical results are in consequence very satisfactory. A comparison between the two trigonometrical stations of the North-East Longitudinal Series which were connected with in the previous season, shows the traverse error in direct distance to be 1·18 feet per mile.

230. The services of 169 *patwaris* were made available for the cadastral survey; but as the area to be dealt with was large, this number was not sufficient, and it was found necessary to supplement the working agency by 63 *amins*. It is to be regretted that the State authorities could not spare a sufficient number of men to enable the services of the *amins* to be dispensed with altogether. The out-turn of cadastral survey during the season has been 723·75 square miles, containing 992 villages and 527,249 fields, the average size of the field being 0·88 acres. The cost rate of the cadastral work and record writing, excluding traverse, has been 1 anna 9 pies per acre, or ₹70-2-6 per square mile: during the operations 229 cases of disputed boundaries occurred and were disposed of.

231. The following tabular statement gives the statistics for the whole State

(excluding the *jadid ilaka*), the survey and record of rights of which has now been completed :—

Pargana.	Number of villages.	Number of fields.	Areas in acres.	Areas in square miles.	Cost.	Rates for complete survey and village records		Number of 16-inch sheets.	Number of 32 inch sheets of the city.	Number of 2-inch standard sheets.	Remarks.
						Per square mile.	Per acre.				
					₹	₹ a. p.	₹ a. p.				
Suar . .	272	131,500	122,607	191·57	75,530	95 10 2	0 2 4	1,341	7	16	101 villages, containing 40,716 fields, area 66 square miles, were surveyed in season 1890-91.
Bilaspur . .	225	135,365	123,736	193·34							
Rampur . .	265	140,536	112 695	176·08							
Shahabad .	192	89 716	91,010	142·20							
Milak . .	139	79,848	55,398	86·56							
TOTAL .	1,093	576,965	505,446	789·75	75,530	95 10 2	0 2 4	1,341	7	16	

232. To the cost, *viz.*, ₹75,530, as shewn in the above table, there are still some small sums to be added, such as cost of instruments and expenditure during October 1891, but the total cost will not exceed the estimate which was submitted for a survey to be made by a combined establishment of *patwaris* and *amins*: it has been made principally through the agency of *patwaris*, and if it had been possible to have dispensed altogether with the *amins*, the cost would have been greatly reduced. The total area of the Rampur State, including the *jadid ilaka* which contains 120·7 square miles, is 910·4 square miles.

233. In order to ascertain if encroachments have been made, the boundaries of the British districts which march with those of the State have been transferred from the latest settlement records, on to the sheets of the new survey and they have been found generally to agree with the surveyed boundaries.

234. On 13th December 1890, the Council decided to have a 32-inch scale survey of the city also made. This survey is based on small polygons 4·57 acres in size, which have been traversed with the theodolite; 2,189 stations, have thus been fixed, so that there is little room for error in the detail survey. The city is divided into 9 *thanas*, and has an area of 2·57 square miles. The scale being so small for the purpose, a group of houses has been made the unit of survey, masonry buildings being distinguished from mud huts; the interior courtyards to which there was no access have not been surveyed.

235. The 16-inch survey is mapped on 1,341 sheets and the 32-inch scale city survey on 7 sheets. The latter map is coloured and is under preparation for the State; tracings of the 16-inch sheets have been lodged with the State authorities. The work has been carefully tested, the check surveys averaging 4·35 linear miles in each square mile of survey, while the check lines aggregate 2,100 linear miles in length, of which 1,035 miles are independent *partals*, or were run by the European assistants. The Deputy Superintendent personally tested some of the *amins'* work and reported very favourably on it, and Mr. Smart describes it as being first class. The record of rights (*khasra*) which has been written during the progress of the survey contains 576,965 numbers. The tenants have no permanent rights but occupy their land on a yearly lease, and are not disturbed while they pay rent to the farmer to whom the *mauza* is leased. The rent levied depends on the rate per *bigha* which varies with the known fertility of the field. From the *khasra*, the *milan khasra* and the *jamabandi* have been extracted; these, together with a coloured trace of the 16-inch cadastral map, form the *misl* (file of papers) for each village.

236. The State is being mapped on sixteen 2-inch standard sheets. As the *jadid ilaka* has not been surveyed, it must either be omitted from the mapping, or the topographical details must be transferred from old non-professional maps.

Survey of District Garhwal.

237. It having been decided that the survey of Garhwal should be resumed, field operations were commenced early in October 1890, with a mixed establishment of Hindustani and *pahári* (hill-men) surveyors, and were continued until the 15th of June 1891. Many of the Hindustani surveyors who had promised to come did not do so, and the establishment of *paháris* was very inadequate.

NORTH WEST PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. GARHWAL.

No. 5 PARTY.

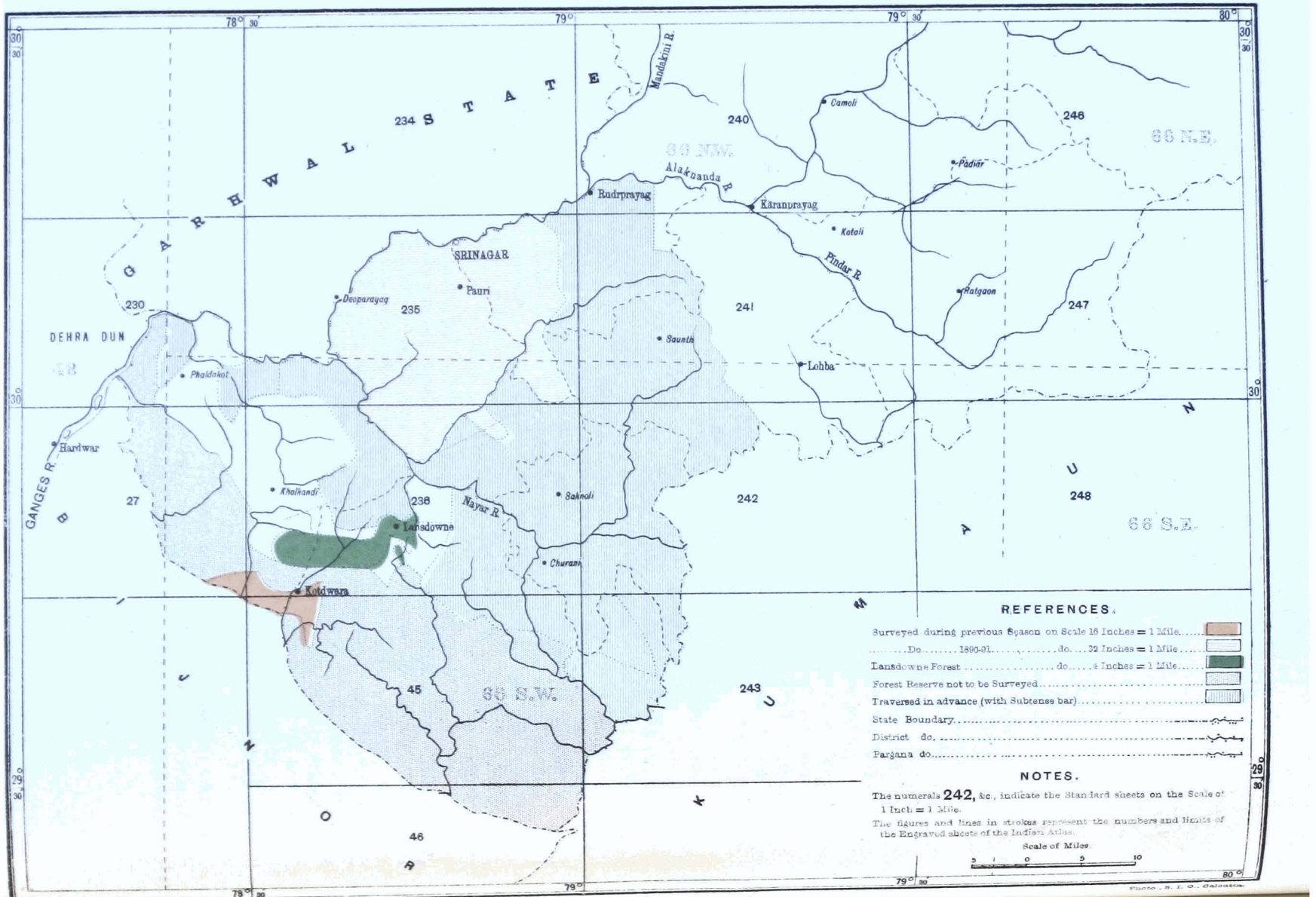


Photo., S. I. O., Calcutta.

Red. No. 357 S. I. O.—Dec. 91.—650.

238. The system of traversing with the subtense bar as described in the last Annual report was continued, stations being fixed all over the cultivated area from 15 to 30 chains apart. The traverse survey was carried over the rest of the Barasyun, Dewalgarh, and Chaund Kot *parganas* and over portions of Mala, Tala, and Ganga Salan and Chandpur *parganas*. The accompanying statement gives the out-turn of the season's traverse work :—

District.	Number of main traverses.	Number of sub-traverses.	Number of stations.	Number of permanent marks.	Area in square miles.
Garhwal	164	1,405	18,090	17,658	845

The traverses emanated from, and closed on, 373 trigonometrical stations, the azimuths to check the angular work being derived from these same stations. The linear miles measured aggregated 4,366.

239. The permanent marks embedded are rough uncut stones over which mounds of loose stones are piled. They have been placed in charge of the *padhans*, from whom receipts have been taken. The cost of the season's traverse out-turn has been ₹27,710, which gives a rate of ₹32-12-8 per square mile. The area remaining for traverse survey cannot be closely estimated: it may be 1,000 square miles and it may be 1,500 or even more. If it is not intended to carry the survey into the northern *parganas*, it should be completed in one season. Parts of the Tala, Mala, and Ganga Salan, Dewalgarh, Chaund Kot, and Chandpur *parganas* have been traversed in advance.

240. The season's out-turn of cadastral survey on the 32-inch scale embraces the whole of *pargana* Barasyun, and the total area of this tract is 299⅓ square miles. But leaving out of account large pieces of waste land, the cadastral survey covers an area of 189·17 square miles, comprising 131 square miles of assessable land, the balance consisting of small scattered patches of waste land. The surveyed area covers 9 *pattis* and 1,054 *mauzas*, which contain 770,804 fields. The size of the field calculated on the assessable area only is 0·11, and on the cadastral area it is 0·16 of an acre. The cost of the cadastral survey amounts to ₹53,466-9-7. The rates therefore are ₹282-10-2 per square mile, ₹0-7-2 per acre, and ₹0-1-1 per field. These rates have been obtained by distributing the cost over the cadastral area (assessable area *plus* small patches of waste) only; but for comparison with the cost rate of other surveys, it should be spread over 299⅓ square miles or the whole area of the tract surveyed, for the waste which has not been included in the surveyed area is so scattered, that it would certainly be included under the system of calculating cost rates in the plains. The rates, if the cost were thus distributed, would be ₹178-8-3 per square mile, ₹0-4-5 per acre, and ₹0-1-1 per field. The cost of this survey is much above the original estimate, but this was unavoidable; the reasons for it were explained in paras. 230 and 231 of the General report for last year. The principal ones are the physical difficulties of the country and the absence of any local establishments whose services it was hoped might have been employed on the survey, and the impossibility of inducing a sufficient number of good *amins* from the plains to take service in Garhwal, more particularly when they knew that there was no chance of more work after that was completed. The stoppage of the cadastral surveys in the North-West Provinces has had the effect of scattering the old trained hands so that when they were wanted, it was found difficult to get any of them. Another reason for the high cost is that the area under cultivation was enormously under-estimated as stated in para. 232 of last year's report, and in addition to this, the excessively minute sub-division of the land amongst different occupants added considerably to the labour of survey.

241. In consequence of the very small size of the field, areas have been extracted to the third place of decimals of an acre and converted into *bisis* (4,800 square yards), *nalis* ($\frac{1}{20}$ *bisi*), and *annas* ($\frac{1}{16}$ *nali*) whilst a suitable deduction is made for interior terrace walls. The differences in assessable area as found to exist by the present survey and as recorded by the old settlement are very great. For instance, the approximate assessable area (the final area cannot

be given yet) of the tract under survey is 130½ square miles, but of this only 52½ square miles are at present assessed. The loss to Government in revenue over this area is therefore very nearly 150 per cent., owing to short measurements or to unmeasured increase of cultivation.

242. The assessable area all over the district at last settlement was returned as 232½ square miles. The Deputy Superintendent's estimate is that now it is not less than 800 square miles, of which 670 square miles have still to be surveyed.

243. A Deputy Collector was attached to the survey camp to settle boundary disputes of which there were 199. The Board's rules of procedure have been somewhat modified to suit the peculiar conditions of the country. It has been found necessary to classify the soil into irrigated 1st and 2nd class, dry, and *katil* (unterraced slope). Irrigation is easily recognised, owing to the construction of the fields; but as it is highly assessed, efforts may be made to conceal it if supervision is slack. The Settlement Officer has also issued rulings as to the status of occupants of land which was not measured at last settlement, and of which there is no record. Every piece of waste between fields of over 8 links width has been given a separate number, but as no one is in possession of these strips, the proprietor's column is left blank, which is a good rule, and overcomes many difficulties.

244. Inspections by the European officers of the party have been continuously made. Their check surveys and the independent *partal* lines amount to 93 and 325 linear miles respectively, whilst the check lines run by the inspectors amount to 828 miles. This gives an average of 6·4 miles of *partal* per square mile of survey. In eleven cases the survey had to be rejected and re-done, elsewhere the work proved good.

245. The season's out-turn is mapped on 1,996 sheets, on the scale of 32 inches = 1 mile, which has been found sufficiently large as a rule, and the maps show the true relative positions of all patches of cultivation. An index map (4-inch scale) to the cadastral survey has been prepared for each *patti*, which shows the relative positions of the villages to each other.

246. The physical and other difficulties encountered have been almost insuperable, one of the chief being to reconcile village boundaries in cultivation, for the theodolite stations could not be fixed on the boundaries, and accurate chain measurements over such hilly country are most difficult to make. The minor divisions of the villages called *odas* were insufficiently marked and were often changed or were shewn differently at different times. The Hindustani *amins* were most discontented on account of the cold, the high price of provisions and for other reasons: they threatened to strike in a body, and did actually do so at times in small numbers throughout the season, which caused much anxiety. The *paháris* also worked unsatisfactorily. Progress was still further impeded by the unusual amount of rain during the field season.

247. The following is a list of the records to be supplied to the Settlement Officer:—

(1) *Khasra*, (2) Dispute List, (3) *Phant*, (4) *Muntakhib*, (5) *Khatauni* slips, (6) *Jamabandi*, (7) *Milan khasra*, (8) Crop statement, (9) Tracing in duplicate of the village map (on one the soils are coloured).

248. The traverse portion of the party was located at Naini Tal and the cadastral portion at Pauri, where the accommodation was most inadequate.

249. Colonel Sandeman acknowledges the co-operation of Mr. Partridge, the Senior Assistant Commissioner, and states that his own task has been considerably lightened by the assistance he has received on all occasions of difficulty, and by the clear instructions given as to procedure in making the record of rights.

250. During the absence of Colonel Sandeman on three months' privilege leave, the superintendence of the party devolved on Lieutenant Crichton, Officiating Deputy Superintendent, who, although with but little departmental experience, has carried out his duties quite satisfactorily. Mr. T. F. Freeman, surveyor, 4th grade, has supervised the operations of the Garhwal detachment throughout the field and recess seasons, and has overcome many difficulties which seemed almost insurmountable. Of Mr. Freeman, Colonel Sandeman thus writes: "He has now worked under my orders for the last eight years, and I have such a high opinion of his capacity as a surveyor, of his steadfastness and capacity for hard

work, that it has given me great pleasure to see him placed in independent charge of the detachment which is to continue the cadastral survey in Garhwal."

Survey of the Lansdowne Forest Reserve.

251. The survey of the forest reserve in the Lansdowne cantonment was sanctioned by the Government of India at an estimated cost of ₹3,500. According to the desire of the Conservator of Forests, Central Circle, North-West Provinces, the scale was fixed at 4 inches = 1 mile. The reserves which consist of several blocks with numerous patches of village cultivation dotted among them, are situated in *pattis* Sila and Ajmere of the Tala Salan *pargana* of district Garhwal, the new Lansdowne cantonment being a continuation of the reserves, although outside their limits.

252. The approximate area of the reserve, inclusive of village lands which have not been separated yet, is 34·7 square miles. The survey has cost ₹3,007, and the mileage rate is ₹86-10-6. The survey is based on 25 trigonometrically fixed points of the Garhwal topographical survey, supplemented by 16 new stations. The forest boundaries and those of the 117 scattered patches of cultivation have been traversed with the theodolite and subtense bar, the stations being fixed on the masonry pillars of the demarcation. The detail survey has been carefully made with the plane-table. The streams were all traversed and fixings made at all bends and prominent changes of slope along spurs and ridges. The details of village sites and cultivation limits which are outside the reserves, but are required to complete the map, will be obtained by reduction from the 32-inch cadastral survey maps. The heights of 769 plane-table fixings were obtained by the clinometer in addition to 41 trigonometrical heights, by which means the hills were contoured at 50 feet vertical intervals.

253. As there was no establishment in this party competent for work of this kind, sub-surveyors had to be obtained and trained by Lieutenant Crichton, who executed the triangulation and the contouring, and checked the detail work of these men. The survey was begun on 22nd February and field work closed on 20th June. The four final sheets cannot be completed till the cadastral survey has been made, but in the meantime a preliminary tracing is being prepared for the use of the Forest Department.

254. Lieutenant Crichton deserves credit for the manner in which he has executed the survey, which is his first piece of work of the kind, and for overcoming great difficulties, due to heat, sickness and desertions of menials, the frequency of which threatened to stop the survey at one time. The Deputy Superintendent personally checked four field sheets of different surveyors in the field and was satisfied with the accuracy of the work.

Miscellaneous work.

255. As the materials for the preparation of the Jhansi 2-inch standard sheets were not available during the season of 1889-90, they were accordingly left to be drawn during the past recess. Owing to lack of draftsmen the work is not out of hand yet, as ten sheets still remain to be drawn. The field sheets on the 8-inch scale of the Jhansi forests have been traced on bank post paper during the past recess. The scattered patches of forest have been so mapped that the number of sheets for reproduction has been reduced from 44 to 29. But as the patches of forest are not mapped in their respective geographical positions, an index map of all the forest blocks in their relative positions is under preparation on the 2-inch scale.

256. The 2-inch standard sheets of the Tarai survey, 14 in number, were completed and examined during the past season: a village by village statistical statement of the Tarai district has also been compiled from the materials of the surveys made since 1873.

257. The Kumaun Bhabar has been mapped on 30 sheets on the 4-inch scale, which will be available for the use of the Forest Officers, and will serve for reduction to the 1-inch scale.

258. The following junior Civilians went through a course of two months' instruction with the survey party:—

Messrs. R. W. Gillan, H. B. Bruce, J. H. Simpson, J. Mardon, W. H. Moreland, and H. K. Gracey, during November and December 1890, Messrs.

P. Harrison, W. R. G. Moir, B. Lindsay, O. G. Arthur, H. Duperneux, and C. E. Wild, during January and February 1891; and Messrs. L. H. Turner, P. Wyndham, H. T. Hoare, Rai Khushwakt Rai, and Syed Mohamed Mehdi, during March and April 1891. Owing to the limited survey establishment to be maintained in the North-West Provinces in future, the Deputy Superintendent has recommended that the instruction should in future be given at Roorkee College.*

ASSAM.

No. 6 Party.

Personnel.

Mr. E. C. Barrett, Officiating Deputy Superintendent, 2nd grade, in charge.
„ J. H. O'Donel, Surveyor, 3rd grade.
„ C. W. Wilson, Assistant Surveyor, 1st grade.
„ J. Smith, Assistant Surveyor, 2nd grade.
23 sub-surveyors and others.

Temporary Establishment.

75 inspectors, draftsmen, computers, etc.
70 field surveyors (imported).
68 *mandals* and candidates (local).

259. This party, of the strength noted in the margin, left its recess quarters at Shillong on the 20th October 1890. Field work was started in the Assam valley and in district Sylhet during the first week of November 1890. Field operations were continued till the 18th May 1891, when the office establishment returned to Shillong.

260. Cadastral operations in the Assam valley were carried on in districts Nowgong, Kamrup and Darrang, and comprised the survey of detached blocks of fairly well cultivated land adjoining the tracts that had been surveyed by the party in those districts in seasons 1883 to 1888. The field-to-field survey was carried on, as in previous years, by local and imported *amins*, but it was not found possible to maintain anything like the same proportion between the different agencies employed, the local administration having found it impossible to allot more than 50 men for survey work owing to the large number of *mandals* (village headmen) required as census enumerators. The local and Bengali *amins* wrote up their own village records, but it was found necessary, as in former years, to allow each Hindustani *amin* a writer to assist him in preparing the Bengali records. In *pargana* Partabgarh (Sylhet), Bengali *amins* only were employed in field-to-field survey, and Hindustani *amins* and sub-surveyors in the survey of grants.

261. A training school was established at Mangaldai on the 1st of October 1890. Instruction in practical surveying was given to 57 *mandals*, of whom 50 were retained for work; and to 49 candidates, 8 of whom were considered fit for work. The *mandals* worked satisfactorily as long as operations were confined to district Nowgong, but great difficulty was experienced in persuading those who did not belong to Kamrup to enter that district, which has an evil reputation on account of the prevalence of the disease known as *kala ajar*; no less than 7 *mandals* threw up appointments rather than take up work there. The *mandals* during the whole period of their stay with the survey party received the pay of their respective grades from their districts, and they were paid, in addition for the survey work they did, at one-third the contract rates allowed to Hindustanis. Candidates were paid at two-thirds of the same rates. The average areas accomplished by each of the different agencies employed in the field survey are as follows:—

	Acres.
By Hindustani *amins*	3,470
„ Bengali „	2,737
„ *Mandals* (old)	2,469
„ „ (new)	1,100
„ Candidates (old)	2,924
„ „ new	1,150

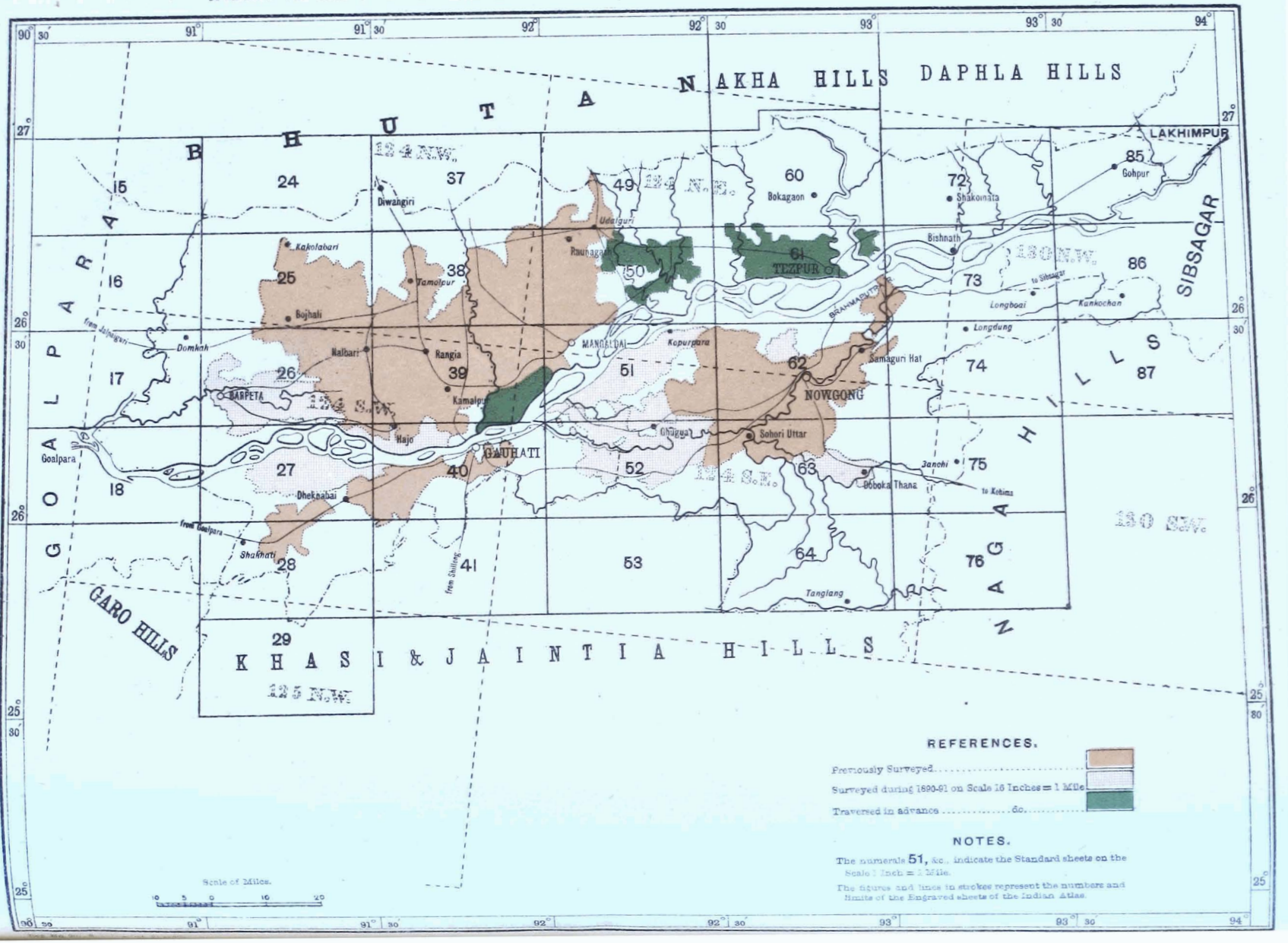
262. Traverse survey was carried on in districts Kamrup, Nowgong, Darrang, and Sylhet. The work was particularly arduous owing to the operations being extended over very widely scattered areas. Kamrup is the only district in the

* Colonel Sandeman thus reports of his Assistants:—Mr. A. W. Smart, in his conduct of the Rampur survey, has proved his capacity, resource and discretion. Messrs. N. Bedford, W. V. Shilling, and J. H. Murphy have all done their best. Of the native surveyors the following are deserving of mention:—Badr Pershad, Nidha Lall, Golam Gaus, Joala Pershad, Dhanpat Rai, Ganga Pershad, Waris Ali, Abdul Had i Parnia Nand, Ram Sohai, Salamat Ali, Kurbai Ali, Dilshad Ali.

ASSAM SURVEY.

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

No. 6 PARTY.



REFERENCES.

Previously Surveyed.....

Surveyed during 1890-91 on Scale 16 Inches = 1 Mile.

Traversed in advance .....do.....

NOTES.

The numerals 51, &c., indicate the Standard sheets on the Scale 1 Inch = 1 Mile.

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT SYLHET.

No. 6 PARTY.

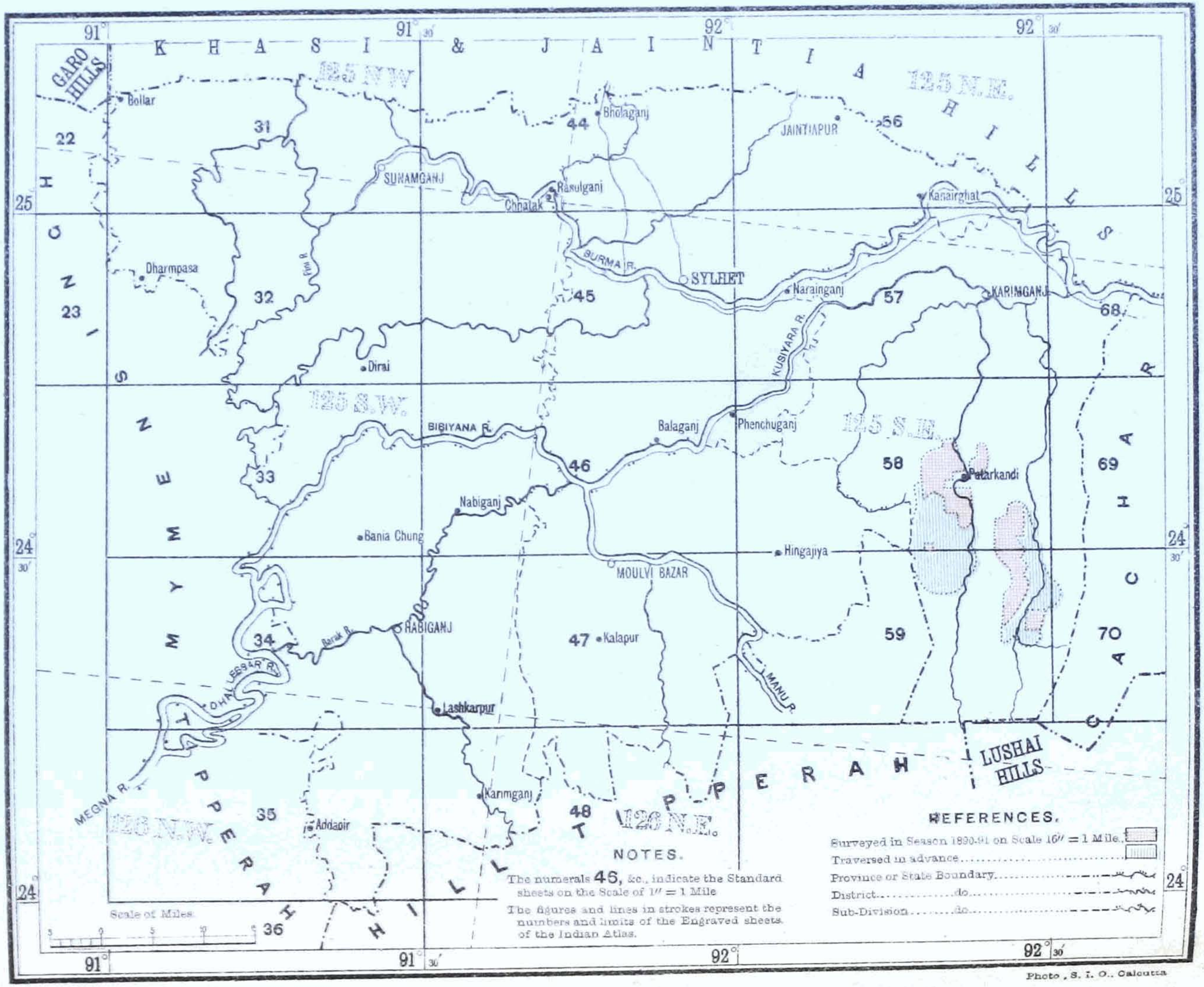


Photo., S. I. O., Calcutta

Assam valley in which the unit known as the "village" existed prior to the arrival of the survey party. These villages varied in size from plots a few acres in area to large tracts several square miles in extent. To ensure something like uniformity in size, as many of the smaller villages as could be plotted on to a cadastral sheet were amalgamated, while the larger villages were sub-divided into blocks, averaging about a square mile in area. Each of these blocks retains the name of the village of which it forms a part, and receives a distinguishing number. In districts Nowgong and Darrang the *mauzas* have been cut up into village blocks, averaging about a square mile each. In *pargana* Partabgarh small contiguous villages have been amalgamated after the manner of Kamrup.

263. The season's out-turn of traverse and cadastral survey is given in the following statement :—

Districts.	Traverse Survey.			Cadastral Survey.		
	Number of *mauzas*.	Number of villages.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Nowgong . .	12	309	270·23	501	73,752	413·95
Kamrup . .	16	485	393·52	451	88,644	364·60
Darrang . .	16	248	235·79	2	336	2·45
Sylhet . .	1	124	116·46	46	18,398	46·92
TOTAL .	45	1,166	1,016·00	1,000	181,130	827·92

The area completed contains the following tea and other estates :—

Districts.	Grants.				*Lakhiraj* (rent-free).		*Nisf-Khiraj* (half-rent).		*Ilam* (temporarily settled.)	
	Fee simple.		30 years' lease.							
	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.
Nowgong . . .	2	407·95	2	407·60	...	...	1	2·14	...	...
Kamrup	...	...	1	1,000·00	21	3,604·67	126	17,313·39	...	...
Pargana Partabgarh (Sylhet)	...	...	20	16,471·00	...	...	...	...	10	552·35
TOTAL .	2	407·95	23	17,878·60	21	3,604·67	127	17,315·53	10	552·35

264. The cadastral work has been tested by 2,984 linear miles of check survey run through it by European and native agencies, giving on an average 3·60 linear miles of check to the square mile of detail survey. Village sites were tested by a re-survey of about ten per cent. of the area of each site. The entries in the records of 54,758 fields were tested in the presence of the *rayats* concerned by European officers and inspectors ; and the sub-deputy collectors and *munsarims* of the Settlement Department were occupied throughout the field season in checking the *khasra* entries. The traverse measurements have been tested by connections with five Great Trigonometrical and nine topographical survey stations, and the angular work by observations for azimuth taken at 94 stations.

265. Twelve revision squads, each composed of a survey *amin* and a settlement *munsarim*, were employed in district Sibságar from the 1st of November 1890 to the 1st of March 1891, in enquiring into objections raised by the *rayats* against the disposition of their holdings by the survey of the previous season. The total number of objections raised, all of which have been adjusted, was 5,434 against 10,409 of last year. Of the 599 villages representing the out-turn of 1889-90, no less than 289 villages or nearly half the total number were finally passed as surveyed, which shows that the work of the year was particularly good.

266. The season's operations, both in Sylhet and the Assam valley, were marked by the absence of obstruction on the part of the *rayats*. In the

villages close to Barpeta, in district Kamrup, the *rayats* refused for a time to assist the surveyors, but a reference to the Deputy Commissioner speedily set matters right.

267. The field season was unusually unhealthy, especially in Sylhet, where the establishment suffered very much from malarial fever. Of the five traverse sub-surveyors who were sent into *pargana* Partabgarh, two had to be invalided before the close of the field season, one dying shortly after arriving at his home. In the Assam valley a traverse sub-surveyor died of cholera in April.

268. The season's out-turn has been mapped on 1,067 sheets. The settlement officer has been provided with tracings of all the cadastral sheets and with the original *khasra* and *aag chitta* (village record) books of the area completed in the Assam valley. He has also been furnished with separate tracings of all *nisf-khiraj*, *lakhiraj*, and other estates. Tracings of the cadastral maps and the original village records of the area completed in *pargana* Partabgarh have been forwarded to the Deputy Commissioner of Sylhet.

269. The Hon'ble J. W. Quinton, C.S.I., the late Chief Commissioner of Assam, inspected the field offices of the party at Mangaldai on the 6th February 1891.

270. The Deputy Commissioners of Kamrup and Darrang, and the sub-divisional officers of Karimganj in Sylhet, afforded the members of the survey party every necessary assistance. The Deputy Superintendent expresses himself under particular obligations to Mr. Gordon, the Deputy Commissioner of Kamrup, for the effectual manner in which he overcame the tendency to obstruction on the part of certain *rayats* of the Barpeta sub-division.

271. The Deputy Surveyor-General, Revenue Branch, inspected the party during the month of September and thoroughly scrutinised the books and records. He was well satisfied with all that he saw. Mr. Barrett deserves much credit for the way in which, through good management, he has year after year succeeded in gradually reducing the cost rate of the work until now it may be considered to be as low as it is possible to make it without running the risk of impairing the accuracy.*

THONGWA AND AMHERST DISTRICTS, LOWER BURMA.

No. 7 PARTY.

272. This party was employed during the season in both the Thongwa and Amherst districts. The traverse section left Rangoon on 9th November, two sub-surveyors being sent off to complete the boundary survey remaining in the Kyonton circle of the Thongwa district, and the main body to continue the work which had been begun the year before in the Amherst district. The two cadastral sections left Rangoon on 3rd December, and all returned to recess quarters between the 15th and 18th of May 1891.

Personnel.

Mr. C. Wood, Officiating Deputy Superintendent, 4th grade, in charge from 1st December 1890.
Mr. A. E. Spring, Officiating Assistant Superintendent, 1st grade, from 17th March 1891.
Mr. H. R. Littlewood, Officiating Assistant Superintendent, 1st grade, up to 27th June 1891.
Mr. G. W. Jarbo, Surveyor, 4th grade.
Mr. J. S. Swiney, Surveyor, 4th grade.
Mr. F. B. Powell, Assistant Surveyor, 2nd grade.
Mr. J. A. T. Haddock, Assistant Surveyor, 2nd grade.
21 sub-surveyors and others.

Temporary Establishment.

61 inspectors, draftsmen, computers, &c.
81 field surveyors.

273. The work in Thongwa comprised the following:—(1) the cadastral survey of 320 square miles in the Tawhla, Tomayan, Kyonton, and Taungbogyi circles of the Dedaye and Pyapon townships; (2) the interior traverse survey of 106 square miles, of which the outer boundary was formed by part of a main circuit executed in 1889-90; (3) the detail survey, on the 4-inch scale, of 164 square miles in the western portion of the Kyonton circle, based on 93 square miles of the traverse work referred to under head (2), and of 59 square miles executed in 1889-90. With regard to this last portion of the work, it may be men-

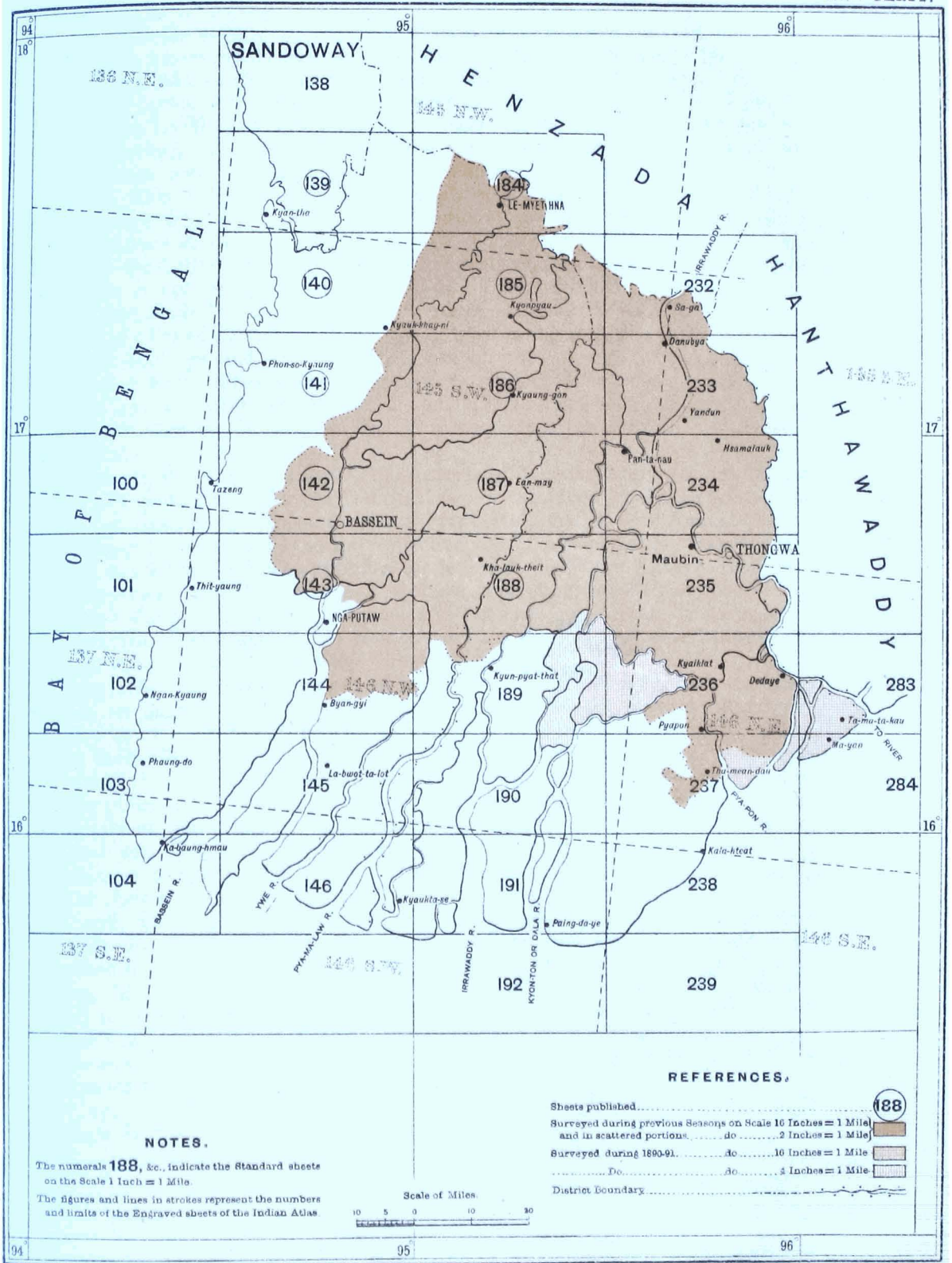
---

*Mr Barrett again brings the excellent services of his senior assistant, Mr. J. H. O'Donel, prominently to notice. He commends Mr. C. W. Wilson for the manner in which he has brought up the work of the traverse section, and favourably mentions Sakhawat Hossein, Khursed Hossein, Dilawar Khan, and Mohamed Ismail, sub-surveyors; Krishnaji Mahadeo Raj and Gunga Ram, computers; and Golam Hyder draftsman, of the Professional Establishment; and Sitanath Chuckerbutty, Jhuni Lal, Harakhnarain, and Bahadur Sing of the Cadastral Establishment

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. BASSEIN & THONGWA.

No. 7 PARTY.



NOTES.

The numerals **188**, &c., indicate the Standard sheets on the Scale 1 Inch = 1 Mile.

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

Scale of Miles.

10 5 0 10 30

REFERENCES.

Sheets published ..... (188)

Surveyed during previous Seasons on Scale 16 Inches = 1 Mile
and in scattered portions ..... do ..... 2 Inches = 1 Mile

Surveyed during 1890-91. ..... do ..... 16 Inches = 1 Mile

..... Do. ..... do ..... 4 Inches = 1 Mile

District Boundary .....

Reg. No. 325 R., S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta.

tioned that, partly from want of provision in the budget, but chiefly because cultivation had not made much head in that tract, the Financial Commissioner decided that cadastral operations should not be extended into the western portion of the Kyonton circle, and directed that the traverse work already done therein should be utilised and extended sufficiently to enable a 4-inch detail survey of the tract to be executed.

274. On the party commencing field operations, a larger proportion of cultivation than was expected was met with, and the officer in charge of the survey camp found the country opening up so fast that he expected ere long to hear that a 16-inch survey was ordered. This expectation has already been realised; and as the Local Government has given orders for its execution by the supplementary survey, that department has been allowed to take a transcript of all the traverse data, and a tracing from the 4-inch survey of the tract.

275. This season's work has brought to a close the survey of all the tracts assigned for survey in Thongwa, extending over 2,910 square miles, which has been done at a total cost of Rs. 580,769. It may be also mentioned here that, as the Settlement Department was anxious that its operations in Thongwa should be completed during the first half of the financial year 1891-92, arrangements were made to supply preliminary 16-inch tracings as soon as a sufficient number of villages had been surveyed, to admit of the men who marked out the different holdings and who followed close on the survey, to be themselves followed up by the revision survey, where necessary, with the least possible delay. In this way the work was advanced; and all the final village maps and area statements were in the hands of the Settlement Department by the third week in August.

276. In the Amherst district, the traverse or boundary survey of 815 square miles was completed, while the cadastral survey embraced an area of 408 square miles, as against an expected out-turn (*vide* para. 291 of the Annual Report for 1889-90) of 630 and 225 miles, respectively. The former class of work covers all the tracts that had been assigned for survey in the Wagaru, Zaya, Bilugyun, Gyaing-Ataran, and Haungtharaw townships, and about one-half of that in the Gyaing-Salween and Martaban townships. The cadastral section has completed all that had been assigned for 16-inch survey in the two first named townships, and all but 25 square miles of the Bilugyun township.

277. All the traverse stations were marked in the usual way, and measures taken, as detailed in para. 283 of the Report for 1889-90, for their protection. It may be mentioned that the *kyedangyis* (head watchmen) did not in all cases show their willingness either to go round and see the stations or to sign receipts for them; but it is a satisfaction to know that this class of underlings is fast giving place to the *ywathugyis* (minor village revenue officials) who are being appointed in Lower Burma. The preparation of census returns, and collection of revenue were, in some instances, adduced by *thugyis* (revenue officers of circles) as excuses for not helping in the matter of enforcing the *kyedangyis*, or of going out of their way to show their boundaries, where not demarcated.

278. The angular results of the season's traverse survey have been checked by star observations for azimuth at 105 stations, and the linear results were checked by connection with 9 stations of the Trigonometrical Survey: in both cases, the smallness of the corrections (*viz.*, 4 seconds per angle and 3 feet per mile) shows that the work was very satisfactorily done. The detail survey on the 4-inch scale was checked by five miles of *partal* and numerous *in situ* fixings; while that on the 16-inch scale was checked by 1,612 miles of *partal*, of which 320 miles were run by Europeans.

279. The following statement shows the results of the season's work, both as regards traverse and detail survey:—

District.	Traverse Survey.		Cadastral Survey, 16 inches = 1 mile.			Detail Survey, 4 inches = 1 mile.	
	Number of kwins.	Area in square miles.	Number of kwins.	Number of fields.	Area in square miles.	Number of kwins.	Area in square miles.
Thongwa . . .	43	106	175	1,33,000	320	71	164
Amherst . . .	594	815	308	3,70,632	408	...	...

280. The area surveyed in each district is classified as below:—

Classification.	Thongwa.		Amherst.	Total.
	16-inch scale.	4-inch scale.	16-inch scale.	
	Square miles.	Square miles.	Square miles.	Square miles.
Cultivation	141·5	40	265·5	447
Jungle and waste, including water	178·5	124	142·5	445
Total .	320·0	164	408·0	892

It will be seen that the cultivation comprises half the total area surveyed; and that while the proportion of cultivation to jungle (on the 16-inch scale) in Thongwa is about 3 to 4, or somewhat less than it was in 1889-90, it is over $7\frac{1}{2}$ to 4 in Amherst. The average size of the fields this year in Thongwa is 0·95 of an acre against 0·78 in the year before; while in Amherst it is only 0·48 of an acre. The small size of the field and the greater proportion of cultivated lands to jungle in Amherst both tend to increase the cost rate; the first because the smaller the field the slower the progress, and the second because the field surveyors are paid four times as much for the cultivated lands as for the jungle tracts.

281. The season's detail area is mapped on 1,016 sheets of the 16-inch and 14 of the 4-inch survey. Of the 1,458 sheets of the past season, over 900 have already been sent to Calcutta for printing: the remainder are well in hand, and it is hoped that most of them, if not all, will be despatched before the party next takes the field. The unusually large number of these sheets—about half as many again as in previous years—has seriously taxed the energies of the party, more especially as Mr. Littlewood had to be transferred to take charge of No. 8 party during Mr. Patterson's absence on leave, and so his valuable assistance was lost for a period of three months during the recess. The 2-inch sheets of the entire Thongwa survey, prepared for reduction to the standard 1-inch scale, have also been satisfactorily pushed on; but this work, too, has been unusually heavy owing to the party having been ordered to complete all the sections up to margin, by incorporating the results of recent surveys with those of previous seasons, so as to render the maps as complete as possible. The drawing of nearly the whole of the sections has been so far advanced as to warrant their completion during the next three or four months, when the 2-inch mapping of the Amherst district will be taken up. It having been finally decided that the sub-division of certain *kwins* which were surveyed in 1888-89-90, referred to in paragraph 286 of last year's report, was unnecessary, no extra drawing on this account had to be done.

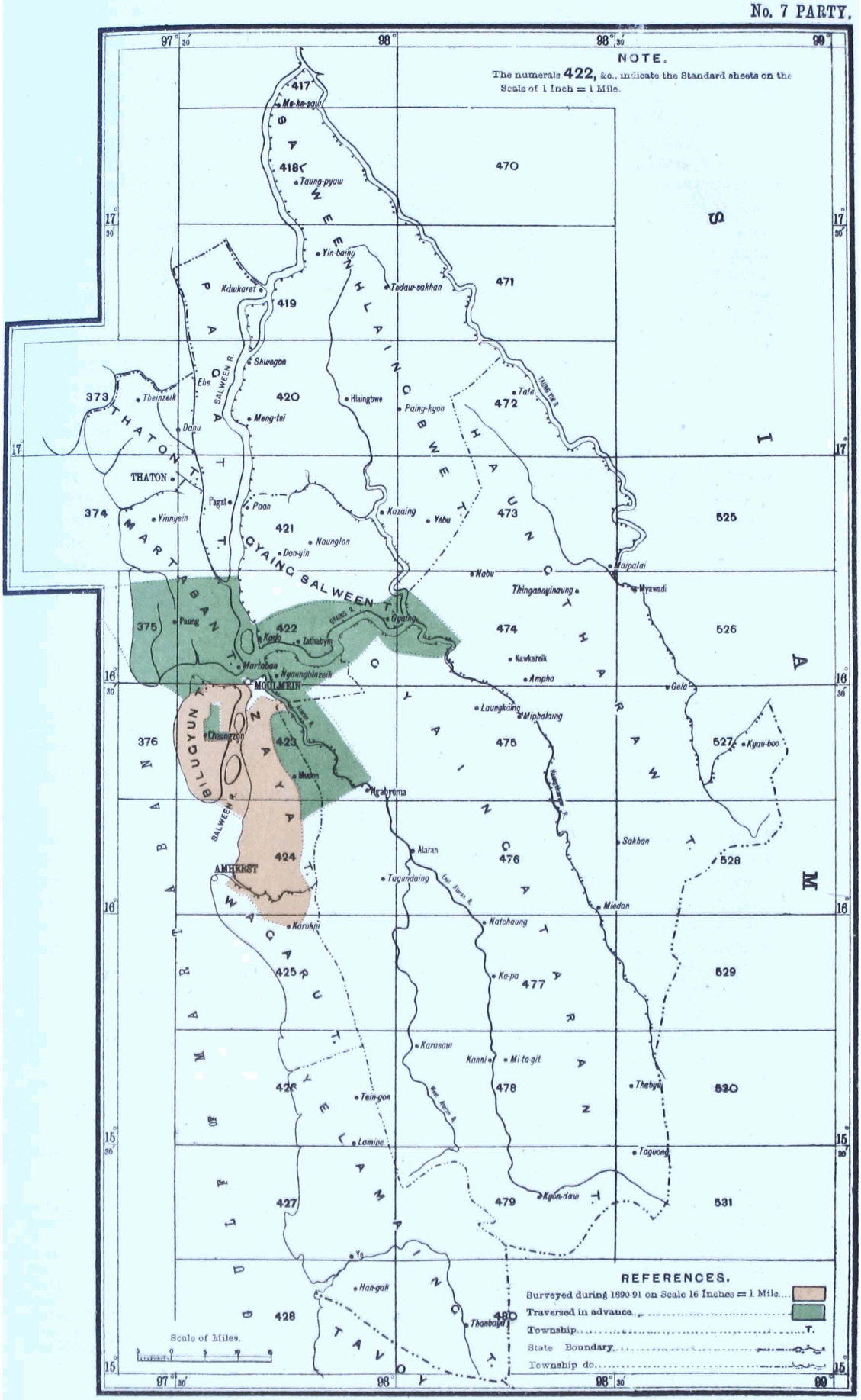
282. The records of the present season's work have been indexed and bound; and nearly the whole of those appertaining to Thongwa, since its survey was taken up, will shortly be despatched to the head-quarters office for final deposit.

283. The scheme for the employment of Burmans and Karens as field surveyors has worked satisfactorily during the year. Owing to a diminished budget, employment could only be given in the party to 49 of the 69 men mentioned in para. 288 of the report of the previous year; but similar work was found for 16 others with the supplementary survey: one man out of the 69 did not rejoin, having secured a post as *thugyi*, and three others were found too weak for field work and were allowed to return home. Of the 28 pupils of 1889-90, the party gave field work to seven men, and found employment in the supplementary survey for five more; whilst others were given office work. Of the 49 old men who were given employment, one had to retire from the field on account of sickness, but all the others, with only a single exception, secured a bonus, while two of the pupils of the previous year also qualified for a small bonus. The rate of progress, and consequently the amount of earnings and bonus, shows an advance

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT AMHERST.

No. 7 PARTY.



Reg. No. 340, S. I. D.—Oct. 91.—550.

Photo., S. I. O., Calcutta.

over the previous year: the average earnings this year being ₹185, as against ₹168 and ₹114 in the two preceding years, respectively.

284. Of the 728 square miles surveyed cadastrally, 54 Burmans have contributed 404 square miles, and 27 Hindustanis 324 square miles besides 164 square miles of 4-inch work: this gives the average out-turn of the Burman as four-sevenths of that of the Hindustani against three-sevenths in 1889-90. This is the fifth year of service for some of the men, and two inspectors and eighteen field surveyors have now qualified for the certificate and deferred pay which has been accumulating to their credit in the Savings Bank. With the certificate, under Mr. Bridges' scheme, dated 26th February 1886, they would, *cæteris paribus*, be entitled to "the first claim to appointment as *teiksayès*, *thugyis*, or inspectors of supplementary survey, and might also receive higher appointments in the survey, and appointments as superintendents of supplementary survey." The usual report on the working of this project was submitted some months ago, but final orders for the issue of the certificates and deferred pay have not yet been received. In order to give a real value to the certificate, and thus to allay some fears which seem to be getting possession of the men's minds that the certificate is worth much less than they were led to expect, from the fact that the market is becoming overstocked with men trained in the supplementary surveys, the executive officer specially recommended two of his most deserving men for posts as settlement inspectors, and it is hoped that his recommendations will be acted upon; for otherwise, in his opinion, some defection in their ranks will be sure to ensue; as the Burman values the possession of immediate advantages above prospective higher advantages in which he believes there may be some uncertainty, and he is therefore ready to transfer himself to any new employer who will offer him a few rupees a month more, even at the risk of eventual loss. At the close of last field season, the number of men on the rolls and their length of service were as below:—

Of 2 years' service	. . . . .	7 men.
„ 3 „	. . . . .	18 „
„ 4 „	. . . . .	26 „
„ 5 „	. . . . .	18 „

285. The field office of the party was inspected at Moulmein in April by the Deputy Surveyor-General in charge Revenue Branch, who was thoroughly satisfied with the progress of the work, and the general state of the books and records of the party.

286. During the ensuing season, the operations of this party will be extended to Tavoy and Mergui. At a conference held at Rangoon on the 25th of April 1891, at which the Financial Commissioner and the Deputy Surveyor-General were present, it was decided that all the cultivated and culturable lands in these districts should be surveyed by the party in addition to the work in Amherst: the cultivated areas had been "notoriously much understated" at 200 square miles, and it was thought that by a small addition to the strength of the party it might be able to furnish "correct areas (and possibly new maps) before June 1892 in time to allow of revised assessments coming into force in 1892-93." It is expected that the work will turn out a far greater undertaking than was at first thought, but nothing will be wanting to endeavour to secure the end in view. In addition to the foregoing, traverse work will be carried on in Amherst so as to complete the Gyaing-Salween, Pagat, and Martaban townships, and as much as possible in Thaton also; while the cadastral operations will comprise the survey in detail of the 572 square miles traversed in advance during the year under report, in which, however, about 100 miles of hilly ground will be done on the 2-inch scale.*

* The executive officer referring to the work of his assistants says:—Mr. Littlewood's help is cordially acknowledged, and he is commended as "very judicious in his management of natives, and combining sound judgment and a thorough knowledge of cadastral work with remarkable evenness of temper." Mr. Jarbo is "an excellent assistant, and to his persistent and methodical efforts is due the large out-turn of traverse work." Mr. Swiney too is a "very capable assistant," with a thorough practical knowledge both of traverse and cadastral operations. Messrs. F. B. Powell and J. A. T. Haddock are both well spoken of as hardworking and useful assistants. The following members of the native establishment have done well:—Nand Lall Chatterjee, Ishan Chander Ghosal, Shoshi Bhushan Ghosal and Preonath Banerjee, computers; Abren, Faiz Baksh, Mahomed Umar, Mahbub Ali and Mahomed Ali, sub-surveyors; Wahid Ali, draftsman, Mahtab Khan, supervisor; Maung Hpo Ka and Do Khine, writers; Maung Chein, Maung Hpo Thin, Lal Bahadur and Karim Baksh, inspectors.

ORISSA.

No. 8 Party.

287. This party resumed operations in the districts of Pooree and Cuttack, and was under the charge of Mr. W. H. Patterson throughout the field season and up to the 10th July, when Mr. H. R. Littlewood was appointed to the charge, Mr. Patterson being placed on special duty before taking privilege leave. The party was divided into three sections as detailed in the margin, two being for cadastral operations, and the third for traverse work.

Personnel.

Mr. W. H. Patterson, Officiating Deputy Superintendent, 3rd grade, in charge, up to 10th July.
Mr. H. R. Littlewood, Officiating Assistant Superintendent, 1st grade, in charge, from 11th July.

Pooree Section.

Mr. R. C. Ewing, Surveyor, 4th grade.
„ E. F. Berkeley, Assistant Surveyor, 2nd grade.
65 computers, draftsmen and *mohurrirs*.
28 inspectors and instructors.
229 field surveyors (*patwaris* and other local men).

Cuttack Section.

Mr. S. O. Madras, Surveyor, 4th grade.
„ J. B. Barker, Assistant Surveyor, 2nd grade.
56 computers, draftsmen and *mohurrirs*.
24 inspectors and instructors.
212 field surveyors (*patwaris* and other local men).

Pooreee and Cuttack Traverse Section.

Mr. C. S. Kraal, Assistant Surveyor, 1st grade.
„ C. S. Gasper, Assistant Surveyor, 3rd grade.
22 sub-surveyors.
12 computers and draftsmen.

288. The traverse section commenced operations in both districts simultaneously, leaving recess quarters on the 10th November 1890, and continuing work till the 6th July 1891. The camp office under Mr. Kraal returned to recess quarters on the 22nd June, leaving a detachment of 13 sub-surveyors and their squads under the supervision of Mr. Gasper to complete the required area.

289. The cadastral section employed in Pooree commenced field work on the 6th December 1890, and returned to recess quarters on the 17th June 1891, leaving some inspectors till the 9th July to complete the final *partals* and the checking of *khasra* entries.

290. The third section left recess quarters on the 24th November 1890, and continued in the field till the 1st July 1891, when the camp office returned to Cuttack, leaving a portion of the field establishment at work till the 15th of that month.

Survey of Pooree District.

291. Traverse operations were carried on over an area of 481 square miles, of which 313 square miles have been surveyed in detail, leaving 168 square miles traversed in advance for next season. In addition to this 313 square miles of detail survey, 53 square miles, which had been traversed in 1889-90, were also completed. The areas traversed and cadastrally surveyed are detailed in the following statement:—

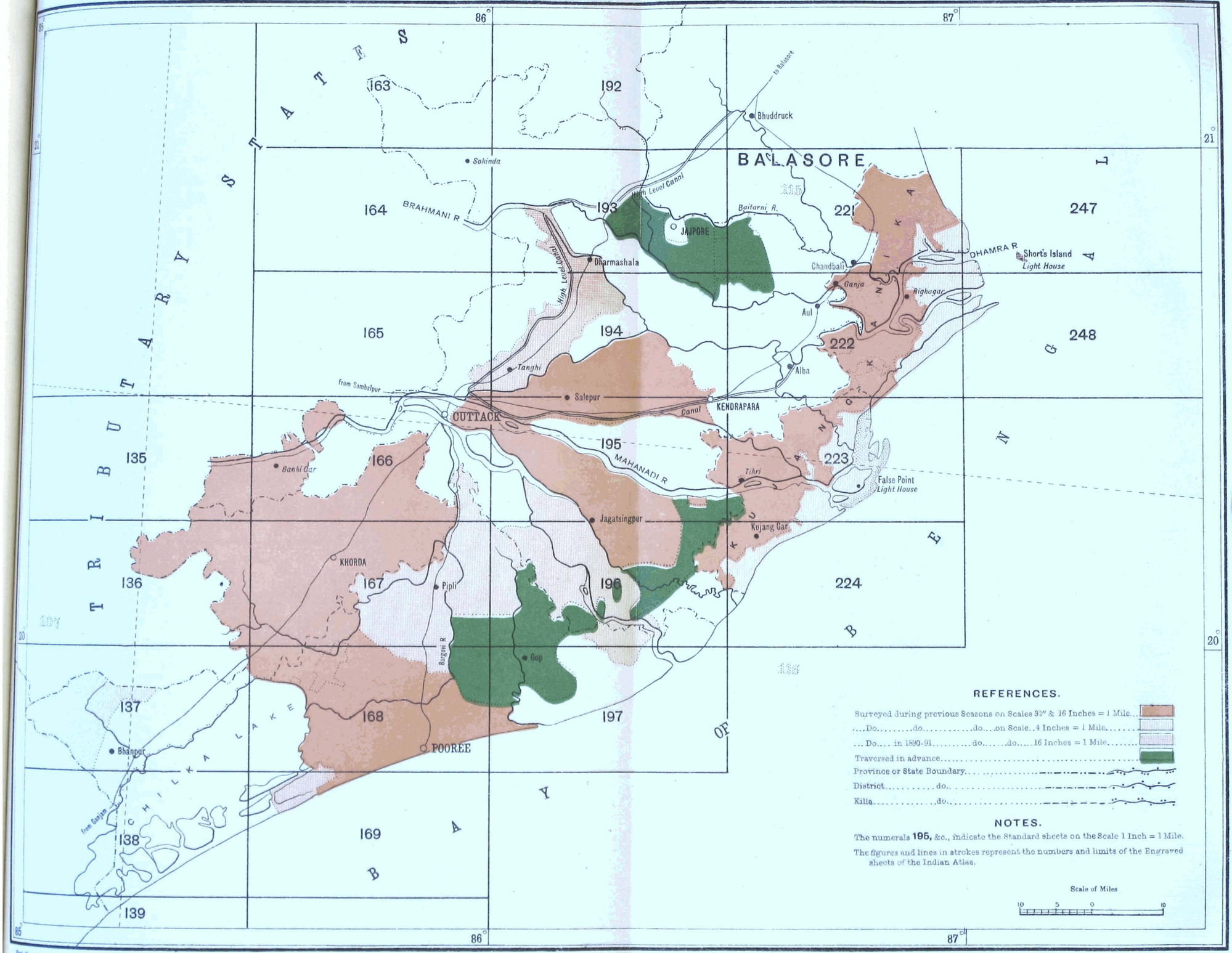
District.	Cadastral Survey, 16 inches = 1 mile.			Traverse Survey.			
	Number of villages.	Number of fields.	Area in square miles.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Pooree . .	818	667,487	366	1,108	676	12,516	480·68

292. The number of linear miles traversed was 2,049, contained in 3 main and 18 sub-circuits. The average size of the field is 0·35 of an acre, calculated on the total, after excluding sand waste in *parganas* Andhari and Manikpatna. The unit of measurement was the field as described in para. 315 of the General Report for last year. The *kittas* within the fields, formed by sub-dividing ridges for the convenience of agriculture, were also surveyed and amounted to 10,20,984, which gives a percentage of 1·5 *kittas* to each field. The accuracy of the angular work was tested by 65 observations for azimuth. Permanent marks

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY OF ORISSA, DISTS. CUTTACK & POOREE.

No. 8 PARTY.



REFERENCES.

Surveyed during previous Seasons on Scales 32" & 16 Inches = 1 Mile.

....Do.....do.....do....on Scale..4 Inches = 1 Mile.

... Do.... in 1890-91.....do.....do.....16 Inches = 1 Mile.

Traversed in advance.

Province or State Boundary.

District.....do.

Killa.....do.

NOTES.

The numerals **195,** &c., indicate the Standard sheets on the Scale 1 Inch = 1 Mile.

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

Scale of Miles

10 5 0 10

Reg. No. 364. S. I. D.—Sep. 91.—353. Rev. 1,700.

Photo., S. I. O., Calcutta.

were embedded at 12,516 points; 7,271 of these were stones and 5,245 baked clay-cylinders, which have been used so as to reduce the cost, the stones being placed at trijunction points and satellite stations, the clay-cylinders marking all other theodolite stations; this procedure was adopted from March 1891. The traverse survey was connected with the survey of Khurda, made in 1875-78, the stations of which, with very few exceptions, were identified and incorporated with the season's work.

293. Training schools, for instruction in field surveying to *patwaris* and other local men, were established at twelve centres in the Pooree district and at two centres in Balasore. In the former district the schools were kept open from the 5th November 1890 to 15th June 1891. Five hundred and sixteen men were trained, but only 267 of the number could be employed; the remainder will doubtless be given an opportunity for employment next season, when the villages in which they reside come under survey operations. The schools in Balasore remained open from the 18th April to the 15th August, when, owing to the impracticability of outdoor training during the rains, they were, with the approval of the settlement officer, closed. Eighty-seven men were trained in this district, and will in all probability be employed in cadastral work next season. An average number of 229 local *amins* were employed monthly on field surveying and *khasra* writing under the supervision of four head inspectors (Hindustanis), eleven Hindustani and eleven Uriya inspectors The average daily out-turn of work performed by newly trained *amins* was four acres, while the men of one or two years' experience did 9·5 acres; this is much below the average out-turn to be obtained from a second-rate Hindustani *amin*. The *khasra* writing was, as a rule, completed by the *amin* or *patwari* who surveyed the village: 44,676 *khasra* entries were checked by European assistants, and 125,113 by native inspectors, which gives a percentage of 25 on the total number of fields surveyed.

294. The area cadastrally surveyed by this section has been mapped on 931 sheets. It was tested by 1,224 linear miles of check survey, of which 394 miles were measured by Europeans and 830 miles by native inspectors. The records and tracings of 443 villages had been supplied to the Settlement Department up to the 30th September, and there is every reason for supposing that the remaining villages will be furnished in proper time, if the boundary disputes which are about 150 in number, are settled.

295. The drawing of the standard sheets on the 2-inch scale has been commenced, six sheets have been projected, and the pentagraphing and mapping of details in each of the sheets is in progress.

Survey of Cuttack District.

295. As no demarcation was ready in the high-level canal tract, traverse operations could not be carried on in continuation of the portion traversed in advance during the past season. Work was commenced to the south of the district, which adjoins the portion being traversed in Pooree. In April, a detachment was sent to the north of the district to traverse the area that had been demarcated near Jajpur. The demarcation by Babu Damodar Patnaik, Assistant Settlement Officer, in the tracts traversed during the season, was very good, and no difficulty was experienced by the sub-surveyors in tracing the boundary, as prominent mud pillars, 3½ feet in height, were erected at all the bends of boundaries; trijunctions of villages were also so marked as to be readily recognisable. Of the area traversed, during the season *viz.*, 500 square miles, 202 square miles in addition to the 119 square miles prepared in advance during 1889-90, have been surveyed in detail, leaving a balance of 298 square miles traversed in advance for next season. About $\frac{5}{6}$ths of the survey stations of 1877-78 were identified and incorporated with the work of the current season.

297. Permanent marks were embedded at 13,039 stations; of these 5,975 were stones fixed at trijunctions of villages and satellite stations; and 7,064 were baked clay-cylinders to mark other theodolite stations. In addition, the permanent marking of 1,292 stations, in the tract mentioned in paragraph 320 of the General Report for the previous year as having been left unfinished, owing to the early setting in of the rains, was completed. Owing to the difficulty this season of transporting stones when the high-level canal was closed for repairs, the permanent marking of the stations in a portion of country about 56 square miles in

area and containing 119 villages was obliged to be left unfinished: clay-cylinders have been embedded at every station, and early during the ensuing season, stones will be substituted at all necessary points. Azimuths were observed at 90 stations as a check on the angular work.

298. The out-turn of area traversed and surveyed cadastrally is tabulated below:—

District.	Cadastral Survey, 16 inches = 1 mile.			Traverse Survey.			
	Number of villages.	Number of fields.	Area in square miles.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Cuttack . .	863	485,691	321·23	1,242	542	13,039	500 59

The average size of the field is 0·42 of an acre. The number of *kittas* surveyed amounted to 12,15,496, of an average size of 0·16 of an acre. The average number of *kittas* to each field is 2·5. The detail work was tested by 1,543 linear miles of check survey, 345 of which were surveyed by the European assistants and 1,198 miles by native inspectors.

299. Training schools for the instruction, in field surveying and plotting, of *kanungos*, *patwaris* and other local men were established at ten convenient centres; these were supervised by seven Uriya instructors, *i.e.*, three inspectors and four selected *amins*: nine *kanungos*, 58 *patwaris* and 288 local men, making a total of 355, were trained. During the season, 58 *patwaris* and 164 newly trained men were employed, and in addition 6 *patwaris* and 118 *amins*, who had been previously trained in Banki, Kujang and Kanika, were also employed. The average number of all classes employed monthly, after making allowances for absentees, was 212. The field surveying was done by local agency alone, supervised by two Hindustani head inspectors and 24 Uriya inspectors. The average daily out-turn by newly trained men was two acres, and that by previously trained *amins* five acres. The comparative statement given below shows the increased expenditure incurred on account of coolie labour, consequent on the employment of newly trained indigenous agency; this materially affects the cost rate:—

	Number of acres.	Time employed, days.	Contract earning.	Cost of coolie labour.	Average daily out-turn, in acres.	Rate per acre.
			₹ a. p.	₹ a. p.		₹ a. p.
Patwari . . .	183	47	...	14 11 0	3·9	0 1 3
2nd rate Hindustani *Amin.*	183	12	5 7 10	3 12 0	15·	0 0 9
Local *Amin* . .	117	32	3 9 3	10 0 0	3·7	0 1 9
2nd rate Hindustani *Amin.*	117	8	3 9 3	2 8 0	15·	0 0 9

The *khanapuri* or record-of-rights was in every instance completed by the same *amin* or *patwari* that surveyed the village; 18,362 *khasra* entries were checked by European assistants and 130,887 by native inspectors, which gives a percentage of 31 on the total number of fields surveyed.

300. The area surveyed cadastrally during the season has been mapped on 979 sheets. The records and tracings of 347 villages have been supplied to the Settlement Department up to the 30th September. Boundary disputes on 103 villages still remain unsettled, and these prevent the adjoining villages from being completed and the records supplied to the Settlement Department. The projection of six standard sheets on the 2-inch scale has been completed; the reduction by pentagraph of details from the 16-inch scale plans and the mapping is in progress.

Survey of the Wards' Estate of Killa Kujang, Cuttack.

301. The records of the 15 villages mentioned in paragraph 300 of the General Report for 1889-90, as remaining to be supplied to the Settlement Department, have been completed and made over.

As revisions are now being received, the records of this estate, which were ready for despatch to the Head-Quarters Office, Calcutta, have been necessarily retained.

Survey of the Wards' Estate of Kanika, Orissa.

302. Of the number of disputed boundaries of villages, *viz.*, 55, mentioned in paragraph 307 of the General Report for last year, nine cases have been settled, leaving a balance of 46 still in dispute; owing to these, the records and maps cannot be completed.

A survey, on the scale of 16 inches to a mile, has been made during the season of Shortt's Island, which had been left in abeyance for reasons given in paragraph 310 of last year's report.

303. The office of the party was inspected in July 1891 by the Deputy Surveyor-General, Revenue Branch. The preparation of the cadastral sheets and the state of the records was all that could be desired. A meeting was also held at the survey office with the Director of Land Records, Lower Provinces, and the Settlement Officer, Orissa, when the estimates and future programme of the party were discussed. A conference was also held at the Commissioner's house, when the system to be pursued in the revision survey of the irrigated lands, and other minor questions were decided.*

BURDWAN KHAS MAHALS, BENGAL.

DETACHMENT.

304. This detachment was to have been absorbed into No. 8 party (Orissa), but, owing to representations made by the Manager, Burdwan Raj Estate, it was decided to retain the services of Mr. Shaw and a small staff for a further period of one year.

Personnel.

Mr. T. Shaw, Assistant Surveyor, 1st grade, in charge.

9 field surveyors and others.

305. The programme for the field season's work consisted of—

(*a*) The relaying of the boundaries, as shown on the old *thakbust* maps of 1854, of 21 *mauzas* in district Bankoora, which were admitted by the Manager to have been permanently leased.

(*b*) The cadastral survey of all lands in district Burdwan that had been omitted from measurement during previous seasons.

306. The field office of the detachment was opened at Raneegunge on the 20th December 1890; and, until the arrival of instruments on the 5th January 1891, the necessary comparison of the old 4-inch revenue survey maps of 1855, with the *thakbust* maps of 1854-55 and the boundary surveys executed in 1889-90, was being made prior to starting the demarcation in district Bankoora.

307. The relaying of boundaries of the 21 *mauzas* was completed on the 20th January. The demarcation of each village was tested by independent surveys of the boundaries of each *mauza* on the 4-inch scale. The salient points on the boundaries of the *mauzas* so relaid were marked by 400 drain pipes of 3-inch diameter, obtained from Messrs. Burn & Co. of Raneegunge. The cost of these pipes as well as the cost of embedding them was borne by the *raj* management, and forms no part of the amount shown as survey expenditure, although the work was done by the detachment.

* Messrs. Ewing, Madras and Kraal, in charge of the three sections of this party during the season, are mentioned as deserving credit for the manner in which they supervised the work of their respective sections.

The Junior Assistants, Messrs. Berkeley, Barker and Gasper are said to have rendered efficient aid.

Mr. Pyster, Supervisor on the temporary establishment, is commended for the energy displayed by him and the satisfactory way in which he worked.

The following sub-surveyors, &c., are specially mentioned:—

Sheik Abdulla, Monohar Lall, Sheonarain, Jowalapershad, Gajadhar, Raghubir Saran, Futteh, Mohamed, Runglal, Mohamed Taki, Lalji Sahai, Jagobandhu, Kanungo, Nazir Hassan, Fariduddin Dianydhi Dass.

308. Much unsatisfactory delay was caused in starting the field-to-field survey of lands omitted during previous operations, owing to the ignorance of the *raj* officials about the situation and extent of the lands to be measured. They are very much scattered and situated in 99 villages, extending from Culna on the Hooghly river to Sainthia station on the East Indian Railway, a distance of nearly 70 miles. The average size of the blocks measured is 4·73 acres only, and that of the fields 0·34 of an acre. The cost of surveying such small and scattered areas has necessarily been high, being R1-4 an acre, including maps, records, tracings, etc. The lands were known to be situated in nearly 100 villages; but as they were pointed out for measurement in a most desultory manner by the *tahsildars*, it was not known what the area would ultimately prove to be. The lands, too, are situated in villages not in *khás* possession, and tenants were with difficulty induced to attend when the necessary entries were being made in the records. The cost of this work cannot, therefore, be compared with that of similar operations in other parts of the country.

309. The following statement shows the out-turn of cadastral survey during the season under report:—

District.	No. of villages.	No. of blocks.	No. of fields.	Area in acres.
Burdwan	89	535	7,091	2,510
Beerbhoom	10	50	934	259
Total . .	99	585	8,025	2,769

310. The measurement of the smaller blocks and isolated fields was tested by an inspector in the field, while through the larger blocks test lines were run over selected portions of the maps and recorded in a field book, the results being plotted and compared with the maps which had been kept in the office.

311. During recess the work performed by the detachment was somewhat different from that usually done by cadastral parties. In district Midnapore, the *mahal* comprises 66 villages, which constitute *pargana* Sujamutha. These villages, although all belonging to the *raj*, are made up of 13 different *tauzis* or properties; seven paying revenue to Government and six being revenue-free. The Manager pointed out, at a conference held at Burdwan on the 29th June, when the Director of Land Records and the Deputy Surveyor-General were present, that these had all been measured as one estate, and that the record of rights had been similarly treated. It was necessary, he said, to have these separate *tauzis* marked on the survey maps and the records corrected to agree with the maps. The Manager further brought to notice that the boundaries, as pointed out by the *raj* officials at the time of cadastral survey in 1888-89, did not, in all cases, correspond with the boundaries, as they existed at the time of *thakbust* survey in 1854; and that the *zamindári* papers were based on the limits of villages as they existed at this latter mentioned period. The old boundaries were consequently entered on the original plans and on the tracings supplied to the Settlement Officer and the Manager. The different *tauzis* were also shown on the tracings by means of distinguishing colours in accordance with the *thakbust* maps. This method of showing different *tauzis* on the tracings, as also revenue-free, *ghatwali*, and other lands marked on the *thakbust* maps, was extended to districts Burdwan and Bankoora; the old *thakbust* boundaries being likewise shown on the tracings. Although in district Burdwan the boundaries of *mauzas*, as now pointed out, differ in many places from the old boundaries, yet the number of *mauzas* has remained the same; but in district Bankoora very few indeed of the *mauzas* now recognised on the ground correspond with those shown on the old revenue survey and *thakbust* maps. The comparison of boundaries and colouring of *tauzis* in district Burdwan have all been completed; and it was anticipated that the same would have been done for all the *mauzas* of Bankoora; but the difficulties in this district were greater than was expected. The *mauzas* are so mixed up that portions of six, seven, and sometimes ten

original villages now go to form one village according to the statements made by the villagers to the sub-surveyors.

312. The following statement shows the number of village tracings to be compared and coloured and the number actually completed up to date of report :—

District.	Total villages.	Compared and coloured.	Remaining.
Burdwan	62	62	...
Sujamutha	68	66	2
Midnapore			
Bankoora	366	150	216
Hooghly	24	...	24
Nuddea	1	...	1
Total	521	278	243

313. For district Midnapore, the *khasras*, *safawar*, and *milan khasras* of 62 villages have also been corrected to agree with the map, and corrected records of 56 villages were returned to the settlement officer. The rectification of boundaries in Sujamutha has involved correction of the following :—

(*a*) Original field plans.
(*b*) Two sets of tracings.
(*c*) Offsets in village traverse tables.
(*d*) English area statement.
(*e*) *Khasras*.
(*f*) *Safawar* and *milan khasras*.

314. The work remaining for this detachment during 1891-92, according to the wishes of the Manager, consists of—

(1) Cadastral survey of lands gazetted in November 1889, but not carried out through want of demarcation.
(2) Cadastral survey of lands gazetted on 11th November 1891.
(3) Cadastral survey of lands already gazetted, but found on the comparison of old and recent maps to have been omitted from measurement ; either through ignorance on the part of the *raj* officials, or connivance on their part with opposing interests.
(4) Traverse survey of *tauzis* Nos. 1, 2, and 3, district Bankoora, area about 650 square miles.

Of these four items only the fourth has as yet been sanctioned by the Government of Bengal, but it is believed that the other three will also receive sanction. After this it is to be hoped that the detachment will be available for more remunerative work, as the scattered and desultory nature of its operations has made the work costly and unsatisfactory. The Manager has also sent up a proposal for a survey training school, and this will probably be opened during the coming field season.

315. On the 29th and 30th June the Deputy Surveyor-General, in charge Revenue Branch, visited Burdwan and held a conference with the Director of Land Records and the Manager of the Burdwan Estate, at which the results of the previous work and the necessity of retaining the detachment another year to make the boundary survey of *tauzis* Nos. 1, 2, and 3 of district Bankoora, were discussed. It was then decided that if the Manager could prove that he had been able to resume possession of any of the missing villages in consequence of the survey operations already completed, that the detachment should again be allowed to remain in Burdwan. With reference to this the Director of Land Records, in his report for 1890-91, has written thus :—

"The present Manager, Lala Bun Behary Kapur, reports that the work done is valuable to the *raj* ; that he has been enabled to resume possession of some of the missing villages, and that though opposed to the undertaking of the survey at the beginning, now asks for the extension of it to *tauzis* Nos. 1, 2, and 3 of the Bankoora district."

316. Mr. Shaw has been two years in charge of this detachment, during which he has carried on the work required of him with diligence and skill. His work has been of a scattered and peculiar nature and the results cannot be gauged by the area turned out. That his work has been of use and the results satisfactory to the manager of the estate is proved by the fact that his services have been asked for, for two years more than was originally intended.

TRAVERSE SURVEYS.

MANDLA AND BETUL DISTRICTS, CENTRAL PROVINCES.

No. 9 PARTY.

317. This party of the strength shown in the margin having completed, during the previous season, the traverse survey of the Chanda and Bhandara districts of the Central Provinces, left its recess quarters Kamptee and assembled at Jubbulpore on 10th November 1890 to arrange for the survey of the district of Mandla. Field operations were commenced at the latter end of the same month, and continued until the 1st of May 1891. A detachment was started from Kamptee at the same time for the revisionary survey of the Betul district, and continued operations there until the end of June, when the work was completed. The Mandla party returned in May, and the Betul detachment in July, to recess quarters at Jubbulpore.

Personnel.

Mr. G. H. Cooke, Officiating Deputy Superintendent, 2nd grade, in charge.
„ C. F. Erskine, Assistant Superintendent, 2nd grade, from 15th December 1890 to 1st August 1891.
„ H. Dowman, Surveyor, 2nd grade.
„ A. George, Assistant Surveyor, 1st grade.
„ C. H. G. Johnson, Assistant Surveyor, 3rd grade.
„ G. Rae, Assistant Surveyor, 3rd grade (on probation).
35 sub-surveyors and others.

318. At the request of the Commissioner of Settlement and Agriculture, a block of 46 villages, covering an area of about 70 square miles, was taken up by traverse survey in Makrai Feudatory State within the borders of the Hoshangabad district by this party. A small detachment was told off for this at the latter end of the field season, and it completed the work just as the monsoon set in.

319. The traverse survey in the above districts has been of the same character as that undertaken in previous seasons, and the procedure in carrying on the work similar in every way, the object of the survey being to provide skeleton plots for the Settlement Department. Out of the total area of 5,200 square miles in the Mandla district an area of 3,069 square miles was completed during the season under report, leaving a balance of 2,131 square miles for season 1891-92.

320. In Betul, the traverses of upwards of 500 villages have been revised and extra sub-traverses run through the patches of cultivation in jungle tracts; 66 outlying *malguzari* villages scattered in Government forest reserves have also been surveyed, thereby completing the district. The plots and areas of all these have been furnished to the Settlement Department.

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

DISTRICT.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Mandla	1,369	1,840	45,521	3,069
Betul	66	70	1,980	92
Makrai State	46	76	2,289	68
TOTAL .	1,481	1,986	49,790	3,229

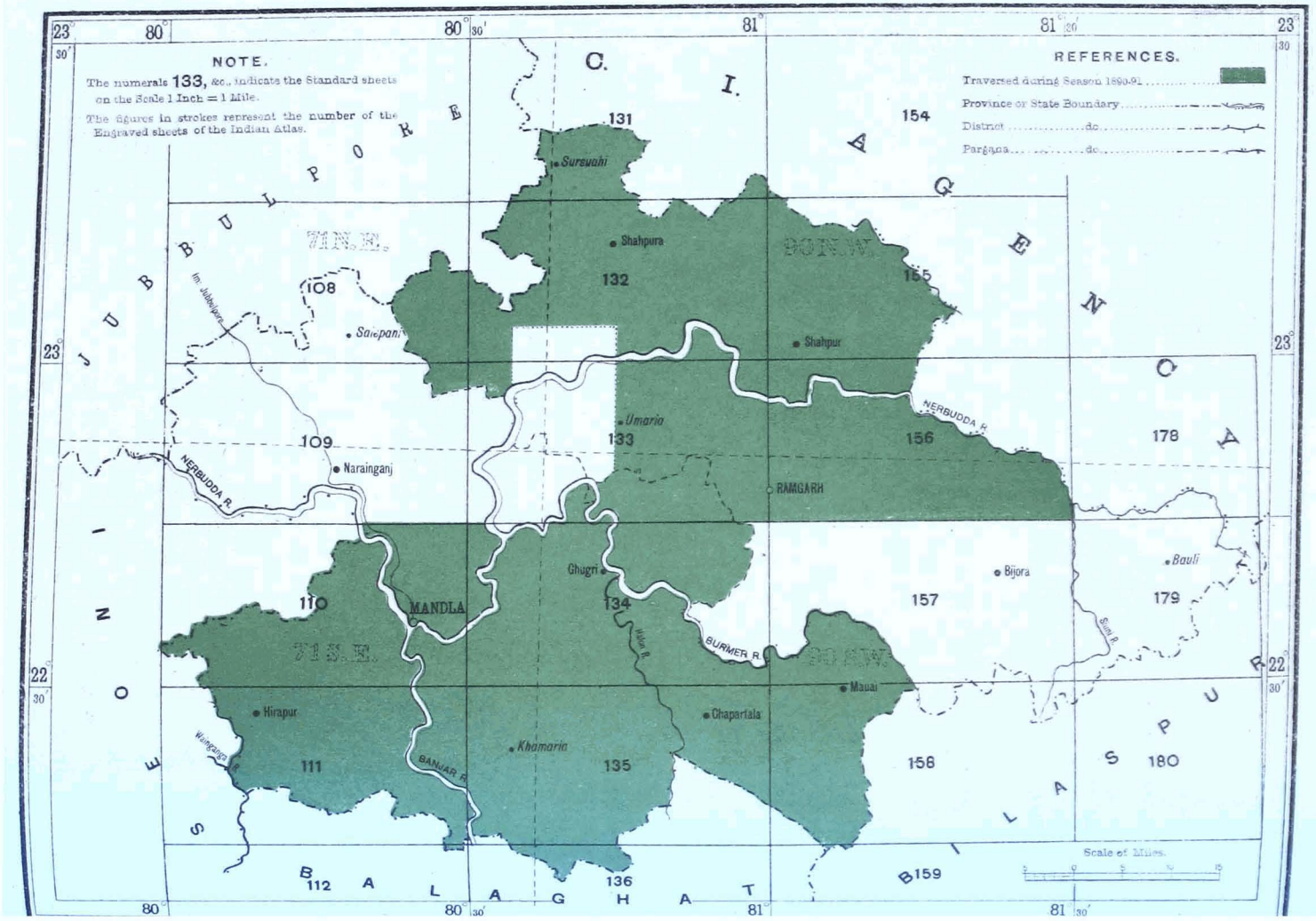
322. Traverse stations have been marked by dressed stones of the usual dimensions, embedded along the village boundaries between tri-junctions, as well as on the sub-traverse lines in the interior of villages; 38,935 of these marks have been laid down during the season at a cost of 3 annas 9 pies each, or R2-15-6 per square mile.

323. The demarcation of some of the villages in Mandla, at the time the survey operations commenced, was in a very backward state, and a smaller out-turn was effected than might have been done had the demarcation been complete. This, however, was impracticable, owing principally to the conversion of Government waste lands into *rayatwari* villages, which were being demarcated

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT MANDLA.

No. 9 PARTY.



and allotted out to tenants at the time the survey passed over the ground. As there were no maps of the Mandla district showing village boundaries which could be utilised to frame an index to the traverse survey, it was found necessary to prepare, as the work advanced, skeleton plots on the 2-inch scale, showing the positions of all the survey stations. These skeleton plots will eventually be handed over to the Settlement Department as a record for their use. A trace from these plots has been made for the use of the *malguzars*, as a guide to the positions of the marks for the safe preservation of which they are held responsible.

324. The country traversed this season in Mandla to the south and south-east is level and well cultivated, and composed of rich black cotton soil, whilst the northern and eastern portion is wild and rugged, intersected by numerous streams running at a great depth below the surface of the ground and flowing between steep banks, which make them almost impassable and difficult for traverse work. The country also is very hilly, with a great variety of features composed principally of plateaux ranging from 100 to 2,000 feet in height. The climate from November to February is very malarious, and the members of the party suffered very severely from a bad type of fever during those months, caused by the heavy dews and cold nights, and excessive heat during the day, but the sickness decreased as the season advanced. Altogether 12 deaths occurred and many men were invalided.

325. Skeleton plots on the 16-inch scale have been prepared of the whole season's work, comprising 1,369 villages on 2,475 sheets: these with area statements and traverse data have been made over to the Settlement Department.

326. The party during the season of 1891-92 will be divided into three sections: the first working in Mandla, the second in Bálághát, and the third in Bhandára. The Mandla district in which 2,131 square miles remain will be completed next season, but in Bálághát, where 1,772 square miles of forest lands and *zamindari* villages, and in Bhandára where 1,127 square miles of *zamindari* villages have to be traversed, completion cannot be guaranteed as the aggregate area to be traversed amounts to over 5,000 square miles. Every endeavour, however, will be made to complete the three districts during the coming season.

327. The Deputy Surveyor-General inspected the office of the party on the 5th and 6th of September, and on the 8th idem he met Mr. Fuller, the Settlement Commissioner, with whom he conferred as to the general progress made by, and the future programme of the party, as well as on other matters. The books and records of the party were found in good order, and to Mr. Cooke much credit is due for the large areas he has turned out in a very difficult country.*

LOWER BURMA.

No. 12 Party.

328. The object of the work of this party was the same as that of last year, namely, the supplying of skeleton plots of traversed points to serve as a basis for the field-to-field survey, to be undertaken by the local survey agency under the Settlement Department.

Personnel.

Mr. E. J. Jackson, Officiating Deputy Superintendent, 2nd grade, in charge up to 21st July 1891.
Mr. F. Grant, Officiating Deputy Superintendent, 4th grade, in charge from 22nd July 1891.
Mr. W. S. Buttress, Surveyor, 2nd grade.
,, E. G. Little, Surveyor, 2nd grade.
,, R. B Smart, Surveyor, 3rd grade, from 1st November 1890.
Mr. J. Newland, Surveyor, 4th grade, up to 31st October 1890.
Mr. P. J. Serrao, Assistant Surveyor, 2nd grade, up to 31st October 1890.
Mr. W. E. Johnson, Assistant Surveyor, 2nd grade, from 1st November 1890.
Mr. T. W. Babonau (Junior), Assistant Surveyor, 2nd grade.
Mr F. S. Bell, Assistant Surveyor, 2nd grade.
45 sub-surveyors and others.

329. The tracts in which operations were carried on are situated in the districts of Prome, Hanthawaddy, Tharrawaddy, and Henzada, and are hilly and covered with dense jungle, and of such a nature that traverse lines could only be run with great labour and at great expense. To still further add to the difficulties, the portions to be surveyed were much scattered, rendering the superintendence of the field work laborious; thus there was one tract of 300 square miles in Henzada, another of 325 square miles in

* Mr. Cooke favourably mentions Mr. C. F. Erskine, who was attached to his party for a few months only, and reports that Mr. H. Dowman has shown his usual zeal and energy in turning out a large area, also that Messrs. A. George and C. H. G. Johnson have given satisfaction. Of the Native establishment the following have merited approval:—Lall Mohun Gangopadhya, Narsoo Dinkar, Tara Prosonno Roy, Behari Lall, Upendra Nath Mukerjee, Manohar Daji, Kesho Vaijnath, Gopal Setaram, Ganpat Rai, Murli Manohar and Karim Ulla Khan.

Tharrawaddy, and in Hanthawaddy and Prome, three separate areas of 74,15 and 651 square miles respectively, besides 182 square miles of revision work in these last two districts.

330. In order to deal effectively with these scattered areas the party was divided into three distinct camps, each camp being placed under an experienced surveyor with an assistant to help him; the European supervision was therefore costly for the area turned out, but this was unavoidable under the circumstances. The three camps took the field on the 23rd, 25th, and 27th November respectively, returning to the recess quarters in Rangoon on the 29th May, 19th and 21st June. The head-quarter camp took the field on the 8th December, returning to recess on the 14th June; it remained at Prome during the field season.

331. Of the area surveyed, only about one-fifth was under cultivation, the cultivated portions extending along the banks of the rivers up valleys, and on low lying lands. The boundaries of the *kwins* (villages) along which traverses had to be run, generally passed through jungle or along creeks, and the line clearing was this year again very heavy. The demarcation of these boundaries was very deficient in some parts of Prome, and as the *thugyis* in many places could not, or would not, point them out, much delay was incurred. In other places there was no demarcation at all, and the traverse surveyors ran their lines along the boundaries shown them by the villagers; these were accepted and subsequently marked out by the local authorities. The denseness of the jungle and the labour of traversing through it is proved by the fact that in such parts the average length of each traverse line was only 3 chains, whilst the average throughout the whole work, including the open portions, was only 8½ chains. This shows that the country was even worse for survey operations than that surveyed last year, but in consequence of the larger size of the *kwins*, the number of stations per square mile was only 20 as against 27 of the previous year. Out of the 26,937 new stations, 24,798 were marked with burnt clay cylinders. The following table gives the out-turn of traverse work for the season, in the different districts:—

Name of District.	Number of *kwins*.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.	Remarks.
Hanthawaddy . .	52	...	779	73·72	This area includes 84 square miles of forest land, of which the 16-inch plots are not required.
Tharrawaddy . .	116	23	2,365	114·44	
Prome . . .	361	65	14,655	665·73	
Henzada . . .	200	39	9,138	510·45	
Total .	729	127	26,937	1364·34	

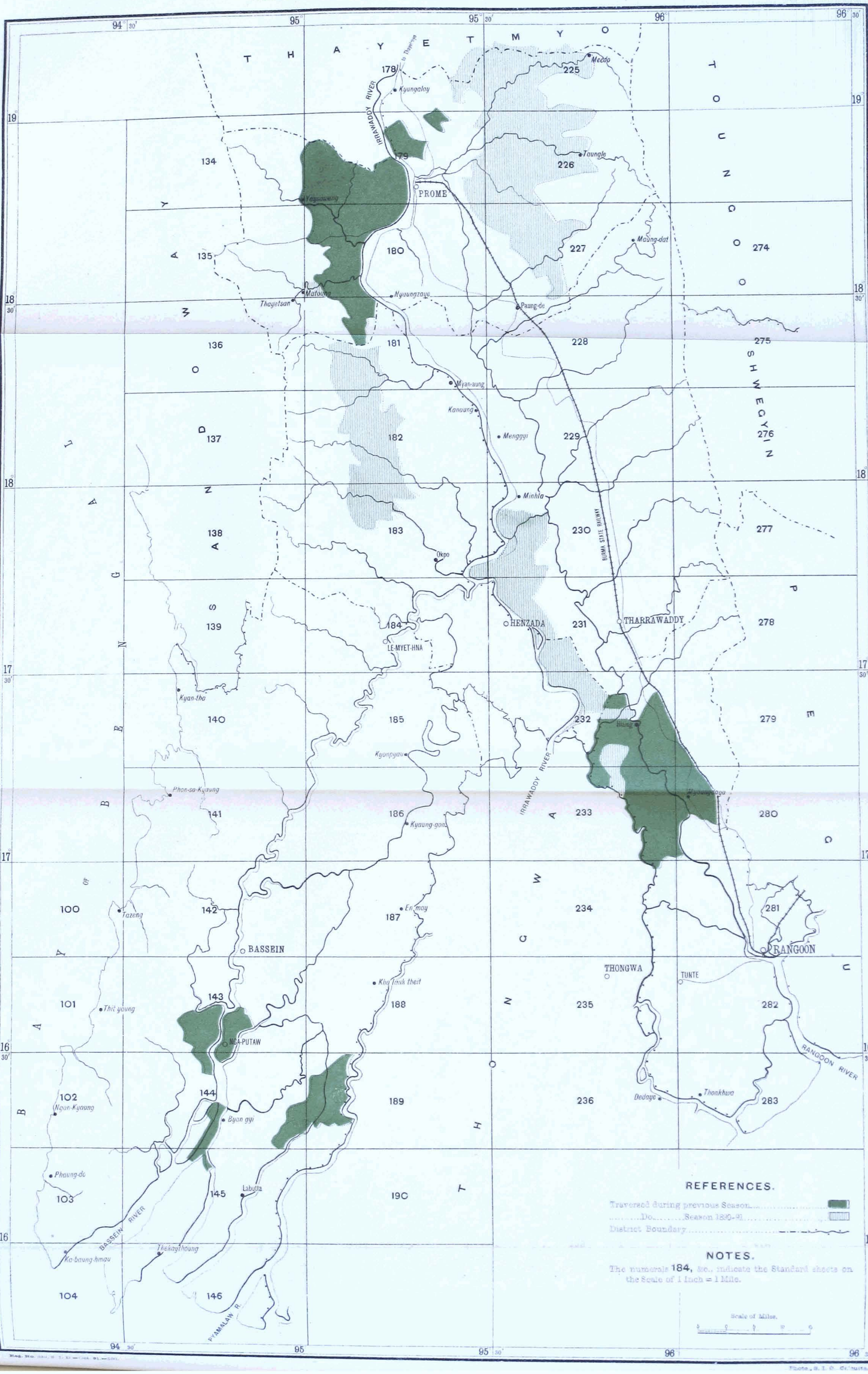
332. The preservation of the traverse stations of the survey of 1882-83 does not appear to have been attended to in all places. Two circuits which had been originally surveyed as forest reserves were this year divided up into *kwins*; in one of them some of the old stations could be found. Several efforts were made to identify a few on which to close the new traverses, but without success, and it will now be necessary to re-traverse the whole of that forest reserve to allow of this being done. The searching for these old traverse stations caused a considerable loss of time. Another source of delay was, that in many cases the sub-surveyors had to be sent back to ground which they had already worked over, as it was found, after the traverses had been completed, that the *kwins*, as originally laid out, were too large, and these had to be sub-divided; in some cases the original *kwins* were cut up into four or five smaller ones.

333. During the field season, the 16-inch plots of *kwins* were supplied to the Superintendent of the field survey agency as soon as they could be got ready. One hundred and three *kwins* of the work of last year, the survey of which had had to be revised, and 495 *kwins* of the current season's work were thus sent to the field survey camp. The plots of the remaining *kwins* which do not require revision will be submitted before the party takes the field. Besides the 16-inch skeleton sheets, others on the 4-inch scale were plotted, and tracings of these in duplicate were made on the notices supplied to *kyedangyis*; the *kyedangyi* kept one copy and sent the other to the Deputy Commissioner's office after having

BURMA SURVEY.

INDEX TO THE TRAVERSE SURVEY IN LOWER BURMA.

No. 12 PARTY.



REFERENCES.

Traversed during previous Season........

......Do..........Season 1890-91.......

District Boundary..........

NOTES.

The numerals 184, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

Scale of Miles.

Photo., S. I. O., Calcutta.

signed it. Plots on the 2-inch scale were also made of all the *kwins* on the regular standard-sized sections, and these were supplied to the Settlement Department for the purpose of inserting thereon the topographical details obtained from the cadastral survey.

334. The health of the party generally was good; there were altogether 10 deaths, four of which occurred at one place and at one time; these last were supposed to be from cholera, but there is reason to believe that they were caused by some poisonous food.

335. The head-quarter camp at Prome was inspected by the Deputy Surveyor-General on the 8th of May, and a conference was held at Rangoon with the Director of Land Records on the 11th idem, when the question of the more rapid supply of plots to the field survey party was discussed. There is no doubt this party had very great difficulties to contend with, inasmuch as the country surveyed was of such a nature that during the former operations it was declared to be impracticable to make a regular connected survey of it. This has, however, now been done, at considerable cost no doubt, but that could not be avoided. Mr. Jackson and his assistants deserve credit for having turned out an area of 1,364 square miles in such a country.

336. It has been decided that whatever traversing remains in these districts shall be done by the supplementary survey under Mr. Clancey, and an assistant surveyor from this department has been temporarily deputed by the Local Government, with a view to assist in training and supervising the natives who are to run the traverse lines. This party is therefore free to take up cadastral work in Upper Burma according to the fixed programme of survey operations for the next year which was agreed upon at a conference held at Rangoon on the 25th of April, and at which the Chief Commissioner, the Financial Commissioner, the Director of Land Records, and the Deputy Surveyor-General, Revenue Branch, were present. Instructions have been issued for the party to commence work in the district of Minbu.*

GEODETIC.

LATITUDE OPERATIONS.

NOS. 22 & 23 PARTIES.

337. Owing to Captain Burrard having taken furlough on medical certificate, it was found necessary to relinquish the electro-telegraphic longitude operations, for which two officers are required, and to proceed with the latitude operations.

Personnel.

Lieutenant G. P. Lenox-Conyngham, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Dhondo Balwant Joshi, Sub-Surveyor.
Govind Balwant Joshi, Lall Singh, and Hanuman Prasad, Recorders.

338. Lieutenant Lenox-Conyngham, who had been the second observer on the longitude operations of the previous season, was therefore placed in charge of the latitude work. The instrument used was the new zenith telescope by Troughton and Simms (designed for the application of the so-called Talcott's method) which had been received in September 1890.

339. The latitudes of seven stations between the parallels of 13° and 15° 56′ north latitude were determined, situated on the Madras meridional series of the Great Trigonometrical Survey, which runs approximately along the meridian of 80°. The results obtained show that the instrument, notwithstanding its comparatively small size and weight, is capable of giving results very nearly as good as those obtained by the zenith sector. The probable errors of the

* Mr. Jackson speaks very highly of Messrs. Buttress, Little, and Smart, who were each in charge of one of the camps. Of Messrs. Babonau, Johnson, and Bell, he says that they are hardworking, deserving, and well-behaved assistants. He especially mentions Babu Rajendra Chatterjee, Rheedoy Chunder Dass, Gulam Hyder, Moti Lall, Vishnu Sitaram, Tej Ram, Abdul Wahid (1), Abdul Wahid (2), Makhil Hosein, and Abdul Karim.

latitudes of the several stations varied between ±0.″077 and ±0.″041, the average being ±0.″056; as compared with ±0.″048 and ±0.″050 with the zenith sector for the two last seasons in which it was used.

340. It is noteworthy too, that the probable error of the deduced result steadily decreases from that at the first to that at the fourth station, and then it becomes very steady, with an average for the last four stations of ±0.″047. This points rather to the larger probable error of the first three being due to inexperience in the use of the instrument. By a scrutiny of the deduced latitudes with their probable errors it will be seen also, that an increase of the number of stars observed is more valuable for obtaining precision in the result, than an increase in the number of observations.

341. The programme of observations at all but one station consisted of taking two sets of 20 pairs of stars each, each set being observed four times. At one station three sets of 20 pairs were observed, each twice; this procedure would have been more frequently adopted had it been possible to obtain more pairs of stars. It is hoped that in more northern latitudes this difficulty may not be so great.

342. The system of determining latitude by what is known as Talcott's method, though well known in America, had not been tried in India before this season, and it is a matter for congratulation, that the excellent results obtained thereby, fully justify its adoption for the future in all latitude operations in this country. The zenith telescope is not $\frac{1}{10}$th the weight of the old zenith sector designed by Colonel Strange; it is far less complicated in its use and adjustments, and can be set up ready for use in a mere fraction of the time required for the latter. There is one drawback, and one only, to its use and that is, the paucity of stars in the catalogues of the southern heavens, suitable for combining into pairs at approximately equal zenith distances. This is a matter that may occasionally somewhat tax an observer's patience, but it is otherwise of little consequence.

343. The zenith telescope does not seem to have any of the idiosyncrasies which were noticed in the zenith sector, nor were they much to be apprehended in so small an instrument. Lieutenant Lenox-Conyngham reports favourably of the make and general convenience of the instrument, but states that the levels which were supplied with it were by no means as good as they should have been. The larger of the two, on which the accuracy of the method in great measure depends, he took off and replaced by one made by Holmes, which was in store in the Dehra office; of this level he speaks very highly. As there was no spare level of suitable size obtainable, the transit axis level was allowed to remain, but will be replaced by a better one before the instrument is again used.

344. The following table shows the results of the season's observations and gives a comparison between the astronomical and geodetic latitudes:—

Station.	No. of pairs observed.	No of observations.	Astronomical latitude=λ_o and probable error.	Geodetic latitude=λ_c	$\lambda_o - \lambda_c$ = apparent deviation of plumb-line.
Saint Thomas' Mount	40	122	13° 0′ 20″·66±·077	13° 0′ 14″·79	+5″·87
Madras Observatory	40	136	13° 4′ 9″·88±·067	13 4 2 ·06	+7 ·82
Gudali	45	172	14° 1′ 10″·65±·056	14 1 9 ·45	+1 ·20
Kistama	45	168	14° 27′ 12″·30±·050	14 27 14 ·56	−2 ·26
Darutippa	61	121	15° 0′ 33″·52±·041	15 0 36 ·47	−2 ·95
Ongole	47	171	15° 29′ 52″·90±·051	15 29 56 ·85	−3 ·95
Dánapa	45	172	15° 55′ 59″·70±·050	15 56 0 ·14	−0 ·44

345. The very large number of stars which had to be observed in consequence of employing Talcott's method made the computations somewhat heavier than usual, but they have been successfully completed. Some details of the season's work will be found in Lieutenant Lenox-Conyngham's narrative report in the appendix.*

* Lieutenant Lenox-Conyngham mentions favourably Babu Hanuman Prasad, a new hand, whom he considers a promising recorder, and speaks highly of the services of Kali Deen, tindal.

TIDAL AND LEVELLING OPERATIONS.

No. 25 Party.

346. The charge of these operations since the commencement of last field season has been in the hands of Lieutenant-Colonel J. Hill, R.E., who returned to India from furlough and relieved Mr. Wood, who had been acting for him for nearly eleven months, and who was then transferred to the charge of No. 7 Party in Rangoon.

Personnel.

Lieutenant-Colonel J. Hill, R.E., Deputy Superintendent, 2nd grade, in charge from 18th November 1890.
Mr. C. Wood, Assistant Superintendent, 1st grade, in charge up to 17th November 1890.
Mr. G. Belcham, Surveyor, 2nd grade.
„ E. J. Connor, „ 3rd „
„ J. Bond, „ 3rd „

Sub-surveyors, etc.

Narsing Das and Dhondu Vinayek, 2 native mechanics, and 18 recorders and computers.

Tidal Operations.

347. The recording of the tidal curves by means of self-registering tide gauges, their reduction, and the publication of the predicted times and heights of high and low water have been continued, and tidal observations have been carried on during the year at seventeen stations, *viz.*, *Aden*, *Kurrachee*, Bhávnagar, *Bombay* (*Apollo Bandar*), Bombay (Prince's Dock), Cochin, Minicoy, Tuticorin, Trincomalee, Madras, Cocanada, *Kidderpore*, Chittagong, Akyab, *Rangoon*, Mergui, and *Port Blair*. The eleven tidal stations whose names are not italicised are minor stations, where observations, as a rule, are taken for five years only. The others are *permanent* stations, where the minimum duration of observations is for nineteen years, and where observations should be continued until the whole scheme of tidal operations has been completed.

348. Since the date of the last report, work has ceased at three stations, *viz.*, Madras, Cocanada, and Chittagong. At Madras the observatory worked for ten days only, the Madras Government having decided, as mentioned in the above report, to discontinue the tidal registrations. At the minor stations of Cocanada and Chittagong the observatories were closed on the 18th April and 22nd July respectively after the completion of five years' observations. Two new tidal observatories have been established, one at Trincomalee and the other at the island of Minicoy, where observations were commenced on the 10th of November 1890, and on the 12th January 1891, respectively.

349. Thus, since the resumption of systematic tidal operations in 1877, observations have been taken at 31 tidal observatories, of which 17 (including Madras) have been closed on the completion of their registrations, and 14 are now in operation.

350. The commencement of tidal observations at the four following new minor stations have been sanctioned:—Diamond Island, Sálbet, Muscat, and Bushire. At Diamond Island the work connected with the erection of the observatory is in progress. At Sálbet there has been an unexpected delay in the local arrangements for commencing work, but it is hoped that the Bhávnagar authorities will have the observatory built at an early date. It is expected that the establishment of the tidal observatories at Muscat and Bushire will be undertaken about next February.

351. All the tidal observatories, excepting Bhávnagar, have been inspected, and a detailed account of the working of each will be found in the appendix. If the discontinuance of tidal registrations at Madras and the unsatisfactory nature of the recent observations at Aden be excepted, the results obtained at the various tidal stations may be pronounced very satisfactory. This is to a great extent due to the assistance received from the local officials, whose kind co-operation has been acknowledged by Colonel Hill.

352. The reduction of the tidal observations has been carried on steadily during the year. Observations for one year at twelve stations and for two years at three stations have been reduced, the total calculations being thus equivalent to the reduction of 18 years' observations at one station. The tabulated values of the tidal constants so obtained will be found in the appendix. In addition to them, constants to be employed in setting the tide predictor were calculated for

the year 1892 and sent to Mr. Roberts of the Nautical Almanac office ready for use; he was also furnished with tabulated comparisons for the year 1890 between the predicted times and heights of high and low water published in the Tide Tables for that year and their values obtained by actual measurement, thus giving him in a convenient form information to enable him to improve subsequent predictions where necessary.

353. The Tide Tables for 1892 will contain predictions for 31 tidal stations, no new station having been added since the last issue.

354. In addition to the usual tables a second instalment of the completed tidal work is given this year. The first instalment was contained in Tables Nos. 1 and 2, page xlii of the appendix to the report for 1886-87. The tables now given, which are similarly numbered, give the values of the tidal constants at eight stations closed since that report was submitted. Table No. 1 gives the values in feet and degrees of the mean amplitudes and epochs of the tidal components, and Table No. 2 their values in terms of the Main Lunar Tide M2 for comparison with the equilibrium theoretical values.

355. The results of the predictions for 1890 may be summarised as follows:—

Percentage of Time predictions within 15 minutes of actuals.

	High water, per cent.	Low water, per cent.
13 Open coast stations	69	70
4 Riverain stations	60	59

Percentage of Height predictions within 8 inches of actuals.

	High water, per cent.	Low water, per cent.
13 Open coast stations	95	93
4 Riverain stations	65	64

Percentage of Height predictions agreeing with actuals within $\frac{1}{10}$th of mean range at springs.

	High water, per cent.	Low water, per cent.
13 Open coast stations	91	91
4 Riverain stations	90	86

These figures show a slight falling off, chiefly in the time predictions, from the exceptionally good results obtained in 1889; they are nevertheless above the average, and may be considered on the whole to be very satisfactory.

Spirit-Levelling Operations.

356. The levelling operations of the last field season comprised the following lines of double levelling:—

Section from Rajkot to Bhávnagar.

Section from Sanosra (Bhávnagar-Gondal-Junagad-Porbandar Railway) to Chachúda Temple, opposite Sálbet, with branch line to Port Albert Victor.

Section from Naydongri (Great Indian Peninsula Railway) to Málkhed (Nagpur line).

The total out-turn amounted to 425 miles of double levelling, in the course of which the heights of 435 permanent bench-marks and three stations of the Great Trigonometrical Survey have been determined. This is a good out-turn, and it would have been larger had all the sections been continuous; but three weeks were lost in changing ground. Every assistance was given to the levelling detachment by the Railway and local officials, for which Colonel Hill has expressed his obligations.

357. It is intended to extend the levelling operations continuously during next season along the Nagpur line in the direction of Burdwan.

358. In addition to the regular departmental work of the tidal and levelling party, the Calcutta Municipal Corporation were furnished with the actual time and height of every high and low water at Kidderpore for the 15 months extending from 1st August 1889 to 30th November 1890, for use in connection with

the important works contemplated for the improvement and extension of the drainage of Calcutta. Reports were furnished, on the operations in the Bombay Presidency and in Burma, to the Local Governments.

359. The recess office of this party at Poona was inspected by the Deputy Surveyor General, Trigonometrical branch, in August 1891, and was found to be working satisfactorily in all respects. The tidal work entails a vast quantity of arithmetic, the dealing with which requires much care and method. The system followed by Colonel Hill seems to leave nothing to be desired on this score. Arrangements were entered into to enable the office of this party and that of No. 10, to be located under the same roof in future, by which a considerable saving in house-rent will be effected.*

GEOGRAPHICAL SURVEYS.

OPERATIONS IN UPPER BURMA.

No. 11 Party.

360. On Captain Jackson's departure on furlough in October 1890 this party was placed in charge of Mr. Ogle, who superintended the field operations and remained in charge of the party until the 1st of July 1891, on which date Captain Renny-Tailyour relieved him.

Personnel.

Captain T. F. B. Renny-Tailyour. R.E., Officiating Deputy Superintendent, 4th grade, in charge from 1st July 1891.
Mr. M. J. Ogle, Officiating Deputy Superintendent, 4th grade, in charge up to 30th of June 1891.
„ A. J. Wilson, Surveyor, 1st grade.
„ F. Kitchen, „ 3rd „
„ P. J. W. Doran, „ 4th „

Sub-surveyors.

Ikbaluddin, J. Sebastian, Kudrat Ulla, Ramsabad, Mowni Ram, Sita Ram, and Nuruddin

361. The operations were of a similar nature to those carried on during the previous year, *viz.*, geographical surveys in Upper Burma, south of the parallel of 22° N. latitude, on the scale of four miles to one inch. The work lay chiefly in the districts of Meiktila, Myingyan, Yamethin, and Magwé, and the survey of these districts was completed. In addition, portions of Pyinmana and Thayetmyo were surveyed.

362. The party left recess quarters at Bangalore on the 23rd of October, reaching Mandalay on the 5th of November, and field head-quarters were established at Magwé about the end of the month. The distribution of work for the field season was as follows :—

Mr. Wilson, with one sub-surveyor, to carry on the triangulation northwards from the Great Trigonometrical bases, Minbataung-Kabantaung and Kabantaung-Beyountaung, and to connect on with his last season's work. This was accomplished, and later in the season when the weather became hazy, he executed 536 square miles of topography.

Mr. Doran, with one sub-surveyor, to take up both the triangulation and detail survey in sheet No. 2 S. E. in the Magwé and Yamethin districts. This portion of the work was successfully completed.

Mr. Kitchen's original instructions were, with sub-surveyor Ikbaluddin, to take up work in sheet No. 5 N. W. in the Shan hills, but on its being notified that a column was to operate in the Baungshé country he, with the sub-surveyor, was detailed to accompany it. He accordingly proceeded to Pakokku by steamer, and marched thence to Gangaw, where he heard that the expedition had been abandoned. He succeeded, however, in making a rough reconnaissance of the country and in effecting a junction with the triangulation carried out by Captain Renny-Tailyour, whilst with the Burma column of the Chin-Lushai expedition of 1889-90 on the north, and also with Mr. Kennedy's work of the same year on the south. The area reconnoitred amounts to about 2,200 square miles, though, from the fact that the Baungshé country was not entered, the map is necessarily defective in the matter of the correct positions and names of villages.

* Colonel Hill reports most favourably of Messrs. Belcham and Connor in the Tidal Division, and of Mr. Bond and sub-surveyor Narsing Das in the Levelling Division. Mr. E. Bond and Mr. G. H. Belcham, temporarily attached to the party, are also favourably noticed. Sub-surveyor Dhondu Vinayek is specially mentioned; and the native mechanics and other sub-surveyors and computers have worked well and given satisfaction.

Mr. Kitchen and Ikbaluddin were subsequently employed in the Thayetmyo district, west of the Irrawaddy.

363. The field season closed on the 27th of May, when the party returned to Rangoon, embarking for Madras on the 31st and arriving at recess quarters in Bangalore on the 6th of June.

364. The total out-turn of work amounts to—

Triangulation . . .	12,470 square miles.
Topography	11,964 „

Of the area mapped about 6,000 square miles are in the districts of Meiktila, Magwé, Myingyan, and Yamethin, which were completed, and about 3,800 square miles in portions of the Pyinmana and Thayetmyo districts and in the Shan States bordering on Meiktila. The remaining area was in the Baungshé country.

365. The programme for the next field season's work consists in the completion of sheets Nos. 5 N. W., 5 S. W., and 6 N. W., and as much of No. 5 N. E. as can be taken up. Triangulation will be carried on in the whole of the above tracts.

366. The Surveyor-General inspected the recess office of the party at Bangalore in September. It is located in the same building as the office of No. 21 party, with the work of which it is closely connected. The establishment was found to be in an efficient state, and the progress of the work in every way satisfactory.*

No. 21 Party.

367. The party under the charge of Major Hobday left recess quarters at Bangalore on the 23rd of October 1890 and proceeded to Mandalay. Major Hobday's services being required for the special expedition to explore the Upper Irrawaddy valley, Captain Longe assumed charge of the party on the 1st of December, and has retained it throughout the year. Captain Renny-Tailyour was also detached from the party at about the same date, for special duty with the expedition under Lieutenant Daly, which was to proceed along the eastern frontier of the Northern Shan States.

Personnel.

Major J. R. Hobday, S.C., Officiating Deputy Superintendent, 3rd grade, in charge up to the 30th November 1890.
Captain F. B. Longe, R.E., Officiating Deputy Superintendent, 3rd grade, in charge from the 1st December 1890.
Lieutenant P. J. Gordon, S.C., Assistant Superintendent, 2nd grade, from 1st December 1890.
Mr. H. T. Kitchen, Surveyor, 4th grade.
„ W. C. G. Barckley, Assistant Surveyor, 1st grade.
„ C. George, Assistant Surveyor, 1st grade.

Sub-surveyors.

Sher Shah, Alladad Khan, Mahomed Latif, Mahomed Alum, Mahomed Wazir, Mahomed Nawaz Khan.

368. The operations were similar in character to those carried on during the past five seasons, *viz.*, geographical surveys, on the scale of 1 inch = 4 miles, north of the parallel of 22° N. latitude.

369. The following programme of work for the field season had been arranged:—

Captain Longe and Lieutenant Gordon to extend the triangulation northwards from Bhamo and to join any expeditions that might proceed from Bhamo in the same direction.

Mr. Kitchen, with one sub-surveyor, to complete the unsurveyed portions of the Ruby mines and Mandalay districts, and to fill in several blanks in sheets No. 4 S.W. and No. 4 N.W.

Mr. Barckley and two sub-surveyors to complete such portions of the Upper and Lower Chindwin and Yeu districts as fall in sheets No. 1 N.E. and No. 1 S.E.

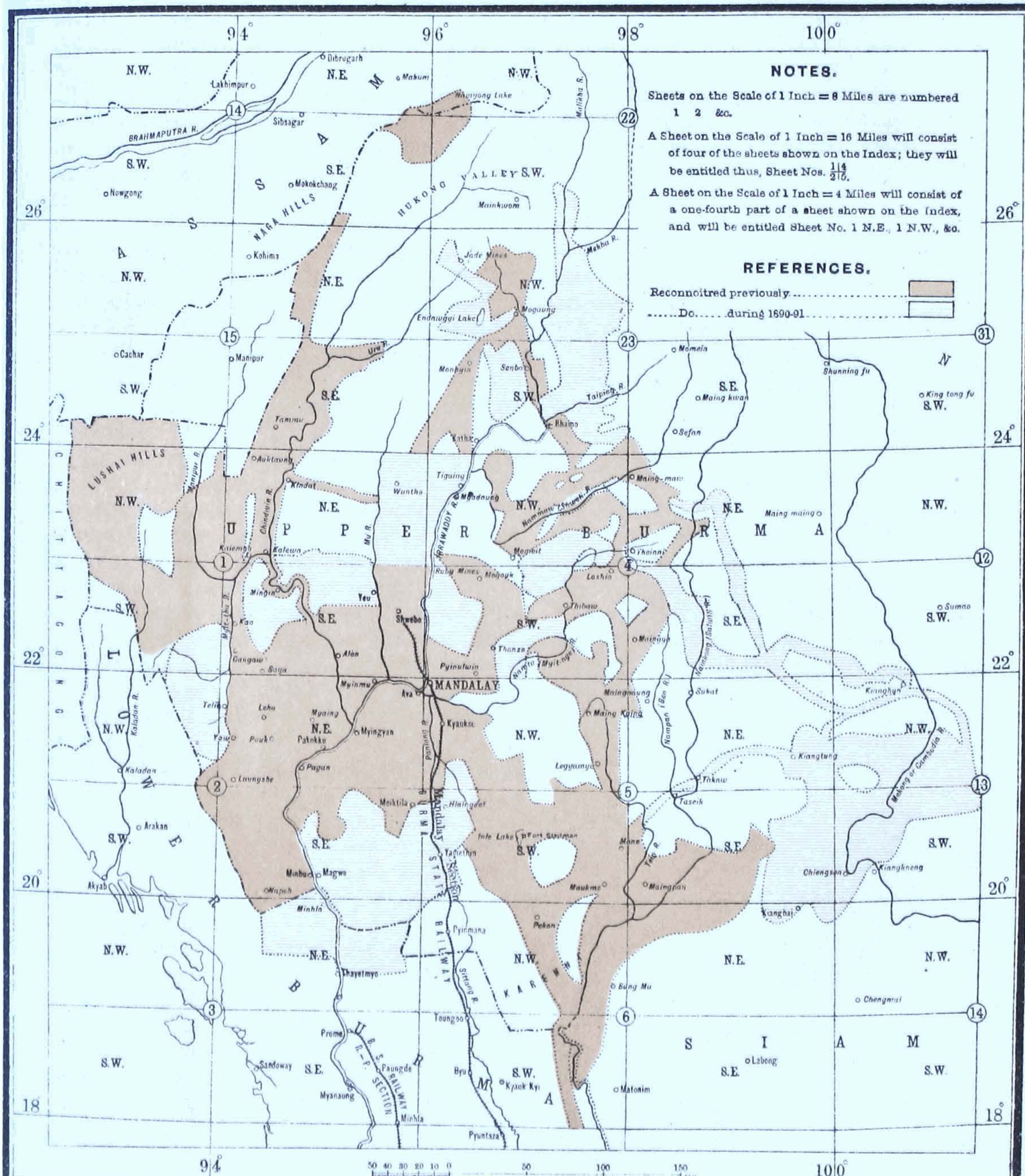
Mr. George and two sub-surveyors to complete such portions of the Katha and Shwebo districts, and of the Wuntho State, as fall in sheets No. 1 N.E. and No. 4 N.W. between the Mu and Irrawaddy rivers.

* Mr. Ogle reports favourably on the services of the European assistants. All the sub-surveyors also are mentioned as having worked well throughout the field season.

NORTH EASTERN & SOUTH EASTERN FRONTIER SURVEY.

INDEX TO THE GEOGRAPHICAL SURVEY IN UPPER BURMA.

Nos. 11 & 21 PARTIES.



Reg. No. 424, S. I. D.—Feb. 92.—550.

Photo., S. I. O., Calcutta

By the 25th of November the above detachments had all left Mandalay to take up the work allotted to them, and on the 5th of the same month Captain Longe, with Lieutenant Gordon, transferred head-quarters to Bhamo, arriving there on the 8th.

370. During December, Captain Longe and Lieutenant Gordon extended the triangulation from Bhamo through Senbo to Mogaung, reaching the latter place early in January. From Mogaung, Captain Longe accompanied a small reconnaissance under Captain O'Donnell, which proceeded northwards to Thama. He was enabled to make a few additions and corrections to the survey made of this country previously by Mr. Ogle, but could visit no hills from which triangulation could be carried on, except one near Thama itself. The column remained in the vicinity of Thama until the 2nd of March, when it returned to Mogaung; meanwhile Lieutenant Gordon had proceeded up the Endaw Chaung to Endawgyi, sketching the river and the country in the immediate neighbourhood on both banks *en route*, after which he rejoined Captain Longe, in time for both officers to accompany a force under Captain O'Donnell which was to proceed to Taungton Lon hill, and near there, at a place called Payani, to meet troops sent from the south under Colonel MacGregor.

371. This expedition started from Mogaung on the 9th of March and, proceeding *viâ* the Nam Yen valley and across the hills, reached Endawgyi on the 14th. During a halt here of three days, observations for latitude were taken each evening, a base line was measured, and some hills were fixed on ahead, in the direction to be followed by the column. Leaving Endawgyi on the 17th, the village of Mansain, on the Namsang river, was reached on the 19th and Payani on the 25th, where a small body of Colonel MacGregor's troops was met, and on the 29th Captain Longe rode to Na-aw to meet Brigadier-General Wolseley. Further details of the operations with this expedition will be found in the narrative report by Captain Longe in the appendix.

372. It was arranged at Na-aw that Lieutenant Gordon should accompany the column under Brigadier-General Wolseley to Kamaing and the Jade Mines, whilst Captain Longe returned to Bhamo. The expedition to the Jade Mines left Payani on the 1st of April, reaching Endawgyi on the 6th, where a junction was effected with the remainder of Colonel MacGregor's column. Arrangements were at once made to advance on the Jade Mines in two columns, one to proceed *viâ* Sakaw and the other by the direct road from Endawgyi. Lieutenant Gordon accompanied the former column, and Colonel MacGregor kindly promised to give him a sketch of the route followed by the latter. The Jade Mines were reached on the 17th of April, and a durbar was held the same day, and next morning the column retraced its steps to Kamaing and Lieutenant Gordon reached Mogaung on the 22nd. Extracts from Lieutenant Gordon's report will be found in the appendix.

373. Sub-surveyor Sher Shah had been detached from the party early in the field season to accompany Lieutenant Burton's expedition into the Kachin hills to the north-east and east of Bhamo. He returned with the creditable out-turn of 1,300 square miles, mapped on the $\frac{1}{4}$-inch scale, of previously unexplored country.

The head-quarters of the party were moved to Mandalay on the 14th of April, the several detachments arrived there by the 24th of May, and recess quarters at Bangalore were reached on the 6th of June.

374. The programme, as laid down, was completed during the field season, though the work was considerably retarded, in the case of Mr. George's detachment by the Wuntho rebellion, and by sickness in that of one or two others.

375. The total out-turn of work for the field season amounts to 11,330 square miles of topography on the $\frac{1}{4}$-inch scale, made up as follows:—

	Square miles.
Ruby Mines, and Mandalay districts	1,150
Yeu, Upper and Lower Chindwin and Pakokku districts	3,430
Katha and Shwebo districts, Wuntho State	2,965
Bhamo district	1,300
Yatsauk and Thibaw States	985
Mogaung and Jade Mines	1,500
TOTAL	11,330

376. During the recess, new editions of the following sheets were compiled and drawn, *viz.*:—No. 1 N.E. and S.E., No. 2,3 N.W. and S.W., No. 4 N.E., N.W., S.E. and S.W., and in addition three sheets, embracing the work of Captain Renny-Tailyour and Mr. Kennedy, were also completed.

377. The field office of the party was inspected at Mandalay in May by the Deputy Surveyor-General in charge Revenue Branch, and the recess office at Bangalore in September by the Surveyor General. The recess work was found to be well advanced, the professional records in good order, and the mapping sufficiently good for the purposes of a preliminary survey. A very large amount of drawing devolved on the party during the recess, for, in addition to the mapping of the areas surveyed by the party, special maps had to be prepared of the surveys done under Captain Renny-Tailyour and Mr. Kennedy on the Siam frontier, and which were urgently required by the Foreign Department. Owing to the constant and urgent demands in Upper Burma for the latest geographical information, new editions of the standard sheets have to be brought out yearly, and to enable the work to be reproduced as quickly as possible, the drawing and printing is of necessity of a more rough character than in the regular publications of this department. At the same time they are quite clear and legible, and the advantage of obtaining quickly geographical maps of first surveys justifies a want of refinement in their drawing. The whole of the mapping in hand was completed by the end of the recess, and comprises new editions of eight standard sheets and the special map in three sheets previously referred to. Captain Longe and the members of the party are entitled to credit for the energetic manner in which they have accomplished the heavy task they had.*

OPERATIONS WITH MILITARY EXPEDITIONS ON THE NORTH-WEST FRONTIER.

378. The columns which operated on the Miranzai border, and on the Hazara frontier during the cold season of 1890-91, were each accompanied by small survey detachments. The survey officer with the first Miranzai expedition, under Brigadier-General Sir W. Lockhart, K.C.B., which commenced operations early in January 1891, was Captain Wahab, R.E. In spite of considerable difficulties in the way of exceptionally inclement weather, a considerable area was reconnoitred and mapped on the 1 inch scale, most of which was hitherto unsurveyed, or had been only mapped in parts on the $\frac{1}{4}$-inch scale.

379. On the breaking up of the Miranzai Field Force, Captain Wahab was detailed to accompany the force under Major-General Elles, C.B., which was to operate on the Hazara frontier. He joined at Darband on the 6th of March 1891, and carried on survey operations until the force was broken up on the 14th June, during which time the whole area covered by the military operations and a good deal beyond it, was surveyed on the scale of 2-inches to a mile : in addition, a large tract was reconnoitred on the $\frac{1}{2}$-inch scale, taking in the Indus valley up to near Kabalgram, and parts of the Chamla and Itai valleys, which join the Indus on the west.

380. Meanwhile events on the Samana range having necessitated the despatch of another force to the Miranzai border, Captain Mackenzie, R.E., was detailed to accompany the second expedition thereto, as Captain Wahab's services could not be spared from the Hazara Field Force. Captain Mackenzie with one sub-surveyor joined the force at Hangu on the 28th of April 1891, and was engaged on survey operations therewith until the 11th of June, when the force was broken up. The operations carried on by the parties attached to the different columns will now be described.

* Of the Assistants Captain Longe reports as follows :—

"Lieutenant Gordon, who was quite new to the work, accompanied me for the greater part of the season and reconnoitred about 850 square miles of new country. He proved himself to be very zealous, and has shown considerable aptitude for the work. He has received further instruction in triangulation and plane-tabling during the recess, and should now be quite capable of carrying on a survey independently."

Messrs Kitchen and George are also favourably reported on. The last named is mentioned as follows by Brigadier-General Wolseley, C.B., Commanding the Wuntho expedition, in his dispatch dated 6th June 1891 : "I would here also mention the good services rendered by Mr. George, Survey of India, who volunteered to remain in Kawlin during the trying times when it was in a state of siege, and who actively employed himself in the defence of the place.

Sub-surveyors Sher Shah and Mahomed Latif are also favourably reported on.

I.—The Operations with the Miranzai Field Force.

381. The survey detachment arrived at Kohat on the 12th January 1891, where it was detained by wet weather until the 19th. Hangu was reached on the 20th, and whilst the force remained there, every opportunity was taken, by ascending the Samana range at different points each day, of sketching all that could be seen of the Khanki valley and hills beyond. The party then moved to Darband with the 3rd column, crossing the Samana range on the 28th and reaching Gwada next day, where survey work was continued, and the Khanki valley from Inzaur downwards mapped as far as possible On the 3rd of February, Captain Wahab accompanied a reconnaissance to Daradar, and on the 4th marched to Kasha and thence to Khanrai, and thus completely sketched all the country south of the Shekhan range.

Personnel.

Captain R. A. Wahab, R.E., Deputy Superintendent, 3rd grade, in charge.
Duffadar Puran Singh, soldier surveyor.

382. From the 5th to the 8th February, the party worked with the second column, visiting the Shekhan valley and surveying it up to the Kharai Kotal which leads into the Mamozai valley. From the 9th to the 12th the Zera valley and the Sturi Khel country, as far as it could be seen from the hills within reach of camp, was reconnoitred and mapped On the 14th Captain Wahab returned to Kohat to complete the mapping and prepare tracings. The soldier surveyor was detailed to survey the part of the Samana range west of Sangar, which had not been previously visited, and this completed the reconnaissance of the whole country visited by the expeditionary force.

383. In all 95 square miles of country have been mapped on the scale of 1 inch to a mile, the greater portion of which had been hitherto unsurveyed or only partly mapped on the $\frac{1}{4}$-inch scale. The heights of all camps and important villages, passes, &c., have been fixed by clinometric observation to trigonometrically fixed points.

384. No triangulation could be done, though the detail survey would have been materially assisted, had some additional points been fixed. Constant bad weather during the few days spent at Hangu and Darband, with deep snow on the only points suitable for stations, and the want of the time necessary to clear them, effectually prevented the carrying on of any triangulation. After the advance beyond the frontier, Captain Wahab was fully occupied in the detail survey.

II.—The Second Miranzai Expedition.

385. Owing to Captain Wahab's services being still required on the Black Mountain expedition, Captain Mackenzie, R.E., was detailed to accompany the force operating on the Miranzai border for the second time.

Personnel.

Captain R. J. H. L. Mackenzie, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Hussein Baksh, sub-surveyor.

386. The party joined the force at Hangu on the 28th April, and on the 30th reached the Samana range, where work was commenced. Captain Mackenzie detailed the sub-surveyor to carry on a regular survey on the scale of 1 inch to a mile of the country in the immediate vicinity, whilst he himself paid special attention to the country ahead. On the 2nd May the party reached Gulistan, the most westerly station on the Samana occupied by the troops, and a sketch map of the Upper Khanki valley was got ready by the time the General Officer Commanding ordered an advance in that direction During this advance the 1 inch survey was carried up the valley as far as Khanki Bazar, and on the day the force reached this place a reconnaissance, which Captain Mackenzie accompanied, pushed on as far as the Marghan Kotal, and he was able to extend the survey up to that point on the $\frac{1}{2}$-inch scale. From this kotal, bearings were taken down the Kurmana Dara, and to various villages mostly situated on the spurs running down to the stream.

387. After the return of the troops from the Khanki valley, the survey of the Samana range was completed, and a large scale plan of the Mastan plateau was made. Observations were also taken to fix points trigonometrically on the ranges to the north. This completed the survey work, and the party left Hangu on the 11th of June. In all an area of some 160 square miles of country was surveyed on the 1-inch scale (part of which was revision), 23 square miles were reconnoitred on the same scale, and 20 square miles on the $\frac{1}{2}$-inch scale.

The services of the Survey Officers, with the Miranzai Field Force, have been acknowledged in the following terms by the Brigadier-General Commanding in his despatch dated 8th June 1891 :—

"Captain R. J. H. L. Mackenzie, R.E., has satisfactorily conducted the survey work of the expedition. He has been successful in extending the survey of the Orakzai country to the Tsappar range, south of Tirah, and to the Marghan pass and Kurmana valleys, thus completing the excellent work of Captain Wahab, R.E., whose name I brought to notice at the end of the last expedition."

III.—The Operations with the Hazara Field Force.

388. On the completion of the first operations on the Miranzai border, Captain Wahab was appointed Survey Officer with the Hazara Field Force, which was to operate on the Black Mountain. This officer had been attached to the previous campaign there in 1888 in the same capacity, and was therefore specially fitted for the duty. Accompanied by two native surveyors he reached Darband on 6th March 1891. Sub-surveyor Abdul Ghafur was attached to the 2nd Brigade, whilst Captain Wabab and the soldier surveyor accompanied the Head-Quarters and 1st Brigade.

Personnel.

Captain R. A. Wahab, R.E., Deputy Superintendent, 3rd grade, in charge.
Abdul Ghafur, sub-surveyor.
Duffadar Jowala Singh, Guides Cavalry, soldier surveyor.

389. The force advanced across the frontier on 11th March, but little survey work could be done for several days as the detachment with the Tilli column was much hindered by wet and cloudy weather, while the River column was still on ground previously surveyed during the expedition of 1888. On the 21st March the Head-Quarters reached Palosi and remained there till the 8th April. Shortly after arriving there, Captain Wahab considered it desirable to adopt a larger scale for the survey than was at first thought feasible, as it appeared that the operations of the force would probably be confined to the limits of the Hasanzai and Akazai country, instead of being extended over a larger area; and on the 24th the survey was commenced on the scale of 2 inches to a mile, on which scale the whole of the ground covered by the expedition was eventually mapped.

390. On the 28th March, Captain Wahab accompanied a reconnaissance towards Baio, where a large tribal gathering had taken place, and on that and subsequent days succeeded in sketching all the eastern slopes of the Baio range and the approaches to Baio itself. Unfortunately no opportunity occurred of reaching the crest of the ridge which commands an extensive view to the westward over the Chamla and Buner valleys.

391. The 1st Brigade moved from Palosi on the 8th April and marched to Tilli; during the halt there theodolite observations were taken at Tilli and at a point near Pabal Gali to connect the triangulation already done in the Indus valley, with the Great Indian Triangulation, and to fix additional points for the extension of the detail survey further up the Indus.

392. On the 11th April the party marched from Tilli to Rib, and on the 13th to Seri, sketching the country passed over *en route*. While at Seri the survey of the Hasanzai, and upper part of the Akazai country was completed by the 1st Brigade party, the surveyor with the 2nd Brigade working in the meantime in the lower Akazai country around Darbanzai and sketching in all that could be seen of the Chagarzai country. After completing all the survey practicable from Darbanzai, Abdul Ghafur was sent to Pabal Gali to survey the eastern slopes of the Black Mountain towards Tanawal, and to complete the survey of the Indus valley between the frontier and Towara.

393. On the 31st May Captain Wahab moved to Nimal, taking with him the soldier surveyor to survey the crest of the Black Mountain and the slopes towards Agror. The 2-inch survey was continued systematically until the final breaking up of the force on the 14th June.

394. The general results of the survey are as follows :—

(*a*) Theodolite observations have been taken at eight stations, from which their positions and those of 30 other points have been trigonometrically fixed and their heights accurately determined, and from these the heights of a large

• Captain Mackenzie reports that sub-surveyor Hussein Baksh "worked with the utmost zeal throughout."

number of positions, such as villages, river junctions, spurs, &c., have been deduced.

(*b*) An area of 184 square miles has been surveyed on the scale of 2 inches to the mile, a scale large enough to show every hamlet and every feature of importance. This survey includes the whole of the Hasanzai and Akazai country on both sides of the Indus, and parts of the Madakhel and Chagarzai country, as well as a large area on the eastern or British side of the Black Mountain, showing all the lines of communication between Agror and the crest of the range and the Shergarh valley, with the new road between Oghi and Darband.

(*c*) An area of 360 square miles has been sketched on the $\frac{1}{2}$-inch scale. This comprises portions of survey done during the previous expedition which has been thoroughly revised and a considerable area of new country in the Chamla and Itai valleys, west of the Indus, which was sketched from commanding points on the Black Mountain range. There was no possibility of reaching any high point on the range west of the Indus, from which alone any great extension of new work could be made.

(*d*) The survey of the Seri cantonment was made at the request of the Military authorities on the scale of 400 feet to an inch ; the area so surveyed being 730 acres or about 1·14 square miles.

395. These results are exceedingly satisfactory and creditable to Captain Wahab, who has, on several previous occasions, rendered excellent services with Military expeditions on the North-West Frontier, and though these services have been invariably brought to notice in Military despatches, he has received no special reward for them. He is an accomplished surveyor in all branches, and has been indefatigable in any duty with which he has been entrusted.*

SPECIAL OPERATIONS ON THE EASTERN FRONTIER OF BURMA.

396. The expeditions, which proceeded to the eastern and north-eastern frontiers of Upper Burma, during the cold weather of 1890-91, were each accompanied by a small survey detachment. Lieutenant Eliott, Assistant Commissioner, with an escort of 70 Gurkhas of the Military Police of the Mogaung levy, started on the 24th of December from Senbo, above the first defile of the Irrawaddy, on his way to the north with the view of exploring the tract of country lying to the north and north-east of the Bhamo District. Major Hobday, with one sub-surveyor and a native soldier-surveyor, accompanied this small column, whilst another sub-surveyor was detailed to accompany an expedition under Lieutenant Burton, which penetrated into the Kachin hills, east of Bhamo. The total area reconnoitred by these two columns amounts to 5,600 square miles, and as this work joins on to Major Hobday's reconnaissance surveys of previous years, further south towards Namkham and Meungmao, a very fair knowledge has been gained of the eastern frontier between the 24th and 26th parallels of north latitude.

397. Another expedition under Lieutenant Daly, Superintendent of the Northern Shan States, started from Lashio on the 21st December 1890, with the object of visiting some of the head villages of the outlying States to the eastward, to ascertain, if possible, the relations between these States with Burma and China. Captain Renny-Tailyour, R.E., and one sub-surveyor, accompanied this party. A sub-surveyor was also attached to a small party under Mr. Saunders, which was to visit the villages in the Taungbaing State and the Kachin country lying near the Chinese frontier to the north of the Theinni State. An area of some 5,250 square miles was reconnoitred during the course of these two expeditions.

398. Mr. Kennedy, Assistant Surveyor, who was on deputation to the Foreign Department, was detailed to accompany the Kyaington-Chiengmai frontier mission under Mr. Archer, British Consul at Zimmé. Two sub-surveyors were also attached to the party, and an area of 9,000 square miles was reconnoitred by this survey party, chiefly of the country lying to the north of that traversed in 1889-90 by the Anglo-Siamese Boundary Commission.

*Captain Wahab has brought to notice the excellent work done by both the native surveyors. Sub-surveyor Abdul Ghafur has done much good work during his long service in the Survey Department, and a great part of it has been spent on the frontier in military surveys.

399. The operations carried on by the parties attached to the different columns will be described separately.

I.—The Operations on the Upper Irrawaddy.

400. The detachment left Bhamo on the 22nd of December 1890, arriving at Senbo the same day, where it joined Lieutenant Eliott and the escort. The march northwards from Senbo was commenced on the 24th of December, and Hokat was reached on the 26th: the road up to this point had been previously traversed, and the country was known. The march was continued on the 28th along the right bank of the Irrawaddy; Myitkyina being reached on the 31st of December, and the confluence of the two main branches of the Irrawaddy (the Malikha and the 'Nmaikha) on the 5th of January; the total distance by land from Bhamo being about 151 miles.

Personnel.

Major J. R. Hobday, S.C., Officiating Deputy Superintendent, 3rd grade, in charge.
Mahomed Sayid, sub-surveyor.

401. Owing to the dense nature of the jungle through which the track lay, it was found impossible to carry on the triangulation, as a wall of primeval forest shut out all view of the surrounding country, and necessitated the cutting of a track for the mules. This difficulty was experienced throughout the march as far as Pumlum Pum, the most northern point reached by the column in latitude 26° 15′.

402. At the bifurcation of the Irrawaddy it was decided to send back the boats which had been bringing up the bulk of the supplies, and to continue the march up the right bank of the Malikha, or western tributary with six weeks' rations carried on mules. Some rough measurements taken here to determine the volumes of the respective branches, gave 33,500 cubic feet per second for the 'Nmaikha or eastern branch, and 23,000 for the Malikha or western branch. These results can only be rough approximations owing to the great rate of the current, from 3 to 5 miles an hour. The temperature of the water in the 'Nmaikha was found to be some 5° to 6° colder than that of the Malikha, from which it may be assumed that the 'Nmaikha receives a greater volume of snow water than the western branch. The Malikha was found to be navigable for boats when the water is low, as far as Sawan, some 24 miles north of the confluence, and probably is so for a much greater distance; whereas the 'Nmaikha is not navigable for any distance owing to a succession of formidable rapids which exist some 6 to 8 miles from the junction. The width of the Malikha at the confluence was found to be 150 yards, and greatest depth of water about 17 feet; the 'Nmaikha being 165 yards wide, with greatest depth of 19 feet. Thus the 'Nmaikha having also the greatest discharge of water, may be entitled to be called the main source of the Irrawaddy.

403. From the bifurcation, the track led into the hills, where between the villages of Paukkaw and Changyang, the main road from Mogaung to the Upper Irrawaddy was met and followed northwards. Seven marches north of the confluence, and at a distance of 57 miles therefrom, a hill known as Pumlum Pum was reached. From here a fine view was obtained: the course of the Malikha was plainly discernible through the low intervening hills almost to the Kanti country, which was reconnoitred by Colonel Woodthorpe, R.E., in his trip there from Assam during 1884-85. Major Hobday was able to map the principal features of the country up to within some 10 or 15 miles of the southernmost parts fixed by Colonel Woodthorpe, and to obtain the names of the principal villages and streams from native information, and has thus been able to connect the surveys from Assam and Burma in a fairly reliable manner. The course of the Malikha is thus fairly accurately known throughout its length. The party was prevented from advancing further northwards by the hostile attitude of the inhabitants all around Pumlum Pum, and in order to avoid an inevitable collision, it was decided to withdraw. The expedition then turned back and retraced its steps as far as Pumwai, whence a different route was taken eastwards to Sabaw on the Malikha, and thence south along its right bank to Kwitao. Here the river was crossed and a track followed which struck the 'Nmaikha at Lekennoi ferry, some 20 miles east of the confluence. From the ferry the column returned in three marches, *viâ* Mailompum to Maingna, the most northern Shan village on the left bank of the Irrawaddy.

404. From here, on the 5th of February, the party started on a second trip to endeavour to ascend the 'Nmaikha valley to the north, but the attempt to explore the valley had to be abandoned owing to the passive opposition shown by the Sadan tribe of Kachins at Kwitao and Lakapyang, three marches from Maingna.

405. Thus our knowledge of the sources of the eastern branch is little or no further advanced, and the information that was obtained thereon was so vague as to still leave the matter in the realms of conjecture. On this subject Lieutenant Eliott, who was in political charge of the expedition, gives the following information in his report to the Burma Government:—

"As regards the 'Nmaikha, however, the information to hand is by no means so satisfactory. During our later explorations, the 'Nmaikha was mapped in accurately from the confluence as far as 'Nsentaru, where the river makes a sudden turn to the west after flowing from the north. Above 'Nsentaru, the general direction of the 'Nmaikha as it comes down from the north is known, but the river itself is shortly lost behind high mountains, and north of this any really reliable information is not forthcoming. The old idea was that the river bifurcated some way higher up, and that one of its branches flowed from the Naungsa lake lying to the east. This was the version given by the explorer "Alaga," who was sent up in the year 1880 to try and discover the sources of the Irrawaddy. He, however, only got a very few days inland in the country between the two rivers, when he was turned back by the Kachins. Repeated enquiries made by us failed to get any information worthy the name about the Naungsa lake, and it is very doubtful whether the 'Nmaikha receives any large volume of water from a lake source. It is, however, probable from the information received that a large stream does flow into the 'Nmaikha from the east, at a point several days journey up its course from the confluence. All information about the head-waters of the 'Nmaikha is terribly vague and hazy. The Kachins never seem to go up there, as the country is so wild and bleak. There does not appear to be any trade at all, and the 'Nmaikha, north of 'Nsentaru, probably rapidly degenerates into a furious mountain torrent, dashing through profound gorges, and quite impracticable even for any rafts of the lightest kind. This tract of country seems destined to remain for a long time unknown, as the obstacles to any movement through it to any distance north seem well nigh insuperable.

To ascend the 'Nmaikha, a force of at least 250 men would be required; a base would have to be opened at 'Nsentaru and all rations required north of 'Nsentaru would have to be carried by coolies. Under these circumstances it is not likely that a column would be able to push its way very far. The only practicable way of obtaining any information as to the head-waters of the 'Nmaikha seems to lie in a march across the hills to the east and north-east from the Kanti country. In MacGregor's narrative of Woodthorpe's tour it is laid down that the good will and influence of the leading Kantis would be of the greatest assistance to a column working east, probably as far as the east branch of the Irrawaddy. He says that the natives of Kanti referred to two rivers east of Kanti, called the Nam Tisan and the Phungmai. The Nam Tisan is described as three days' journey from the Kanti country, being separated from the latter by the Tchetpum, and five days more marching to the east, is said to bring one to the Naikôn range (from which silver is extracted), and beyond which flows the Namdumai or Phungmai. There can be no question that this is the 'Nmaikha in its upper reaches. The Kanti Shans expressly called it the east branch of the Irrawaddy, and the great similarity of the names, which (stripped of words signifying stream or water) are Dumai Phungmai, and 'Nmai, tend to show the identity of the river with the unseen east branch of the Irrawaddy. The depth given by the Kanti Shans would also correspond with the probable depth of the 'Nmaikha in that latitude. They describe it as not deep, but not fordable, or somewhat deeper than the Malikha about the same latitude, which was ascertained to be 5 feet, and we know the 'Nmaikha is somewhat the larger river of the two. Besides this the distance from the Kanti country east to the Phungmai, say nine marches, or in a straight line east about 45 miles, would approximately correspond with where the 'Nmaikha valley must be, since the river cannot come further from the east, as the position of the Lukiang or Salween is known in the latitude of Bonga, and also lower down between Bhamo and Talifu, and if the 'Nmaikha falls further east, it will come within what is now regarded as the drainage of the Salween. The Kantis also said there were two more big rivers to be crossed before reaching China, and these would be the Lukiang or Salween and the Lan Ts'ang Kiang or Mèkong. Little doubt can remain now that the Lukiang is identical with the Salween. Colonel Yule in his introduction to "The river of golden sand," by Captain Gill, states that the chief ground for discrediting the length of the course of the Salween and its Thibetan origin was its comparatively small body of water, and adds that this may be due to its restricted basin and all the infomation we could collect tends to confirm the truth of this reasoning. As far as we know all the water up to within a few miles of the actual Salween falls into the Irrawaddy drainage. It is the vast drainage of the latter river, combining the Malikha, 'Nmaikha, and Chindwin areas that makes it develop so rapidly into a noble river, and the same reasoning will tend to make us look not very far for the sources of the river. It is doubtful if the 'Nmaikha or main stream of the Irrawaddy has any source higher than 28° 30'. Yule calls the east branch of the Irrawaddy in the introductory essay above referred to, the

Tchitom, Schètè, Kuts'kiang, and Khinshi Ho. These are the Thibetan and Chinese names; and as all our information was from purely Kachin sources, we were unable to identify the river under any of the above names."

406. From Lakapyang it was decided to move southwards, exploring the country along the Yunan frontier as far as the Taping river. A considerable area on the frontier was thus traversed and reconnoitred. Bhamo was finally reached on the 15th of April.

407. The area reconnoitred by Major Hobday amounts roughly to 4,300 square miles of previously unexplored country. The Political officer in charge of the expedition has reported as follows on Major Hobday's services therewith :—

"It may seem superfluous for me to remark on the admirable survey work done by Major Hobday of the Survey of India, as that officer has so distinguished himself by his surveys in Upper Burma during the past five years. Marching as we were through a country where the first consideration was the safety of the column, a number of obstacles were thrown in the way of a successful survey, which would have baffled many a man less proficient in his profession, but in spite of all these difficulties, Major Hobday has succeeded in bringing out an elaborate map of an enormous extent of country in the Upper Irrawaddy, of which nothing whatever was previously known."

The Surveyor General fully endorses the opinion expressed of Major Hobday's services in Upper Burma. He has conducted the survey operations therein from their initiation with marked energy and success, and as he has now been transferred therefrom, it is due to him to place on record this appreciation of the valuable services he has rendered during the past five years.

408. Major Hobday's detailed report on the above operations, together with a map, will be found in the appendix.

II.—The operations on the Eastern Frontier of the Northern Shan States.

409. The survey detachment left Mandalay on the 25th of November 1890, and reached Lashio, the head-quarters of the Superintendent of the Northern Shan States, on the 14th of December. Two expeditions were to start from Lashio; one under Lieutenant Daly to visit the chief villages of the outlying States to the eastward, which lay near the Burmo-Chinese frontier, and to ascertain the nature of the relations which existed between these States with Burma and China, whilst the second expedition under Mr. Saunders was to traverse the North Theinni State and visit the Kachins inhabiting the tracts to the north of this State, as well as to obtain information regarding the Taungbaing State lying directly to the west of North Theinni.

Personnel.

Captain T. F. B. Renny-Tailyour, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Bapu Jadu, sub-surveyor.
Ali Nawaz Khan, sub-surveyor.

410. It was arranged that Captain Renny-Tailyour and sub-surveyor Ali Nawaz should accompany Lieutenant Daly's party, whilst sub-surveyor Bapu Jadu joined Mr. Saunders. Owing to illness, however, Bapu Jadu was unable to start with Mr. Saunders, but joined the party later on in the Taungbaing State in the month of January. Lieutenant Daly's escort consisted of 56 Gurkhas of the Military Police with 50 followers and 30 mules, and, besides the survey detachment, Captain Burrows of the Intelligence Branch and Mr. Warry of the Chinese Consular Service, accompanied the expedition.

411. The party started from Lashio on the 21st of December and marching eastward, reached Meungyaw on the 23rd and Maumak on the 24th. Thence the track turned south-east to Nawngleng, the capital of the Loi-maw subdivision of the South Theinni State. Leaving Nawngleng on the 4th of January, the party reached and crossed the Salween river at Takwi-hpong on the 8th. The crossing here was difficult, the banks being steep and rocky, and the current extremely rapid. The width of the river at this point was some 90 to 100 yards, and its approximate height above sea level 1,300 feet. The Salween was recrossed on the 12th January, and again on the 20th at the Hsupket ferry, at the approximate height above sea level of 1,250 feet. Pangyang, the former capital of the East Mangleun State, was reached on the 26th of January, and during a halt here the Sawbwa paid the camp a visit, coming from his new capital

of Takeut, some 8 miles from Pangyang. Here Captain Renny-Tailyour and Ali Nawaz Khan made a trip of some 20 miles along the Pemeung range, from which a considerable amount of country was mapped.

412. On arriving on the 10th of February at Meung-nga in the Meunglem State, the party found fighting going on between the latter State and East Mangleun, and the villages around Meung-nga deserted. Peace, however, was restored and the villages re-inhabited within a few days of the arrival of the column. After halting two days at Meung-nga, the march eastwards was resumed, and Meunglem, the capital of the State of that name, reached on the 15th February. Leaving again on the 20th, the column passed through hilly and very scantily populated country to Meungse, which was reached on the 1st of March. Here also fighting was going on between the Meungse Myoza and the Sawbwa of Kenghung, a large State lying to the east, the centre of hostilities being some three miles from Meungse.

413. Marching thence, Meunghai was reached on the 6th, and here the main body of the Kyaington-Chiengmai mission, under Mr. Scott, was met. Leaving Mr. Scott's party at Meunghai, the column started again on the 10th of March, and on the 12th arrived at Kenghung, the capital of the State, a wretched town, considering the size of the State, situated on the right bank of the Cambodia (or Mekong) river.

414. The column left Kenghung on the 15th of March, and following a new route, on the return journey, reached Meungma in Kengtung State on the 22nd. From Meungma the track led north-west, until on the 28th the old route was met at Meungma in Meunglem State. From Meungma the column marched to Pang-hsang, a village on the right bank of the Namkha, not far from Meung-nga, where the fighting had been going on on the occasion of the first visit. From here a new route was followed due north to Panglong, passing partly through the Wa country; Pangkwawn, the capital of the Sumu State, was reached on the 15th of April, and Panglong on the 17th. Leaving this place on the 20th, the column camped at Namhu, five miles from the Kunlong ferry on the Salween on the 21st. From here a visit was made to Tunyeo, the capital of the Kokang sub-division of North Theinni State, where the column halted for two days. The Salween was crossed at an elevation of a little under 1,500 feet on the 27th of April, and after joining the Meungse-Theinni road at Yungmaw, the party arrived at Theinni on the 4th of May. Lashio was reached on the 7th, and Mandalay on the 22nd of May.

415. The geographical results of the expedition comprise an area of about 4,000 square miles of country mapped on the $\frac{1}{4}$-inch scale and based on triangulation. To this has to be added an area of 1,250 square miles, mapped on the same scale by sub-surveyor Bapu Jadu in Taungbaing State, whilst accompanying the expedition under Mr. Saunders. The whole of the tract thus surveyed was previously unknown, and much credit is due to Captain Renny-Tailyour and his subordinates for the large and satisfactory results obtained.

416. Captain Renny-Tailyour's report on the above operations will be found in the appendix.

III.—The operations with the Kyaington-Chiengmai Frontier Mission.

417. The survey party, attached to Mr. Archer's frontier mission, proceeded early in November 1890 from Meiktila Road Station to Fort Stedman, and thence, after a short halt to arrange for an escort, to Moné, the most eastern post of the Shan States. Mr. Archer joined the expedition at Mongtun from Zimmé. As a route traverse had been run the previous year by Captain Jackson from Mongtun, north-east to Maingthat, Mr. Kennedy struck eastwards to visit Loi-pakulin, the last of the trigonometrical stations visited by the Anglo-Siamese boundary party in the previous season. Having observed here he descended to Tongtun on the northern side of the hill, and after a long march rejoined the main body at Maingthat. Here one

Personnel.

Mr. J. M. Kennedy, Assistant Surveyor, 1st grade, in charge.
Mohamed Hussein, sub-surveyor.
Abdul Rahim, sub-surveyor.

sub-surveyor was sent southwards into the hills to sketch the country in that direction, while the other went south-eastward to Hongluk on the Me-huok, and thence south-west to Wiengkhé, a village at the north-east end of the Muang-fang valley. Meanwhile Mr. Kennedy worked in a north-easterly direction up the Mekôk valley, returning again to Maingthat before the main body had moved.

418. The Mekôk river was crossed on the 31st of December, and the party marched down the east bank through heavy jungle to Hweha, a day's march north of Wiengkhé. From Hweha Mr. Kennedy ascended Loi-paham-pup (7,500 feet), the highest of the hills west of the Mekôk. After observing here he descended to Muang-fang, marching thence to Wiengkhé, and so, with one sub-surveyor, across the hills to Hongluk. The other sub-surveyor worked down the river to Kainghai with the main body under Mr. Archer, and thence by an easy road rejoined Mr. Kennedy at Hongluk. From here he was sent to the westward to sketch carefully the course of the Mekham river, which he completed up to its source, returning subsequently to Hongluk.

419. The party then proceeded in a north-easterly direction to Meunglen and struck the Mekong again at Kyanglah. From this place Mahomed Hussein was sent back *viâ* Meunglen to Kyaington to work through the hills and await the arrival of the party at the latter place, whilst Abdul Rahim proceeded northward to Mongyu. From Mongyu he was to turn across the hills eastward to Mongsin, whilst Mr. Kennedy accompanied the main body to Mongsin by the Namma valley. From Mongsin Mr. Archer proceeded in a north-easterly direction with the other officers attached to the mission, and Mr. Kennedy, with sub-surveyor Abdul Rahim, went westward towards Kyaington. They followed different tracks as far as Mongyu, where they united after sketching in a large extent of country on both banks of the Mekong. Kyaington was reached some four or five days before the arrival of the main body, now in charge of Mr. Scott, as Mr. Archer had left the party some two days march from Mongsin and had proceeded by a different route. From Kyaington the party proceeded westward, the return march being commenced on the 29th of March. Mr. Kennedy reached Rangoon early in May 1891.

420. The total area reconnoitred on the $\frac{1}{4}$-inch scale amounts to 9,000 square miles, and is in continuation of the work executed in the previous season by the Anglo-Siamese Boundary Commission Survey. The mapping thereof has been prepared in two special sheets, and these with an additional sheet to the north embracing the more important of Captain Renny-Tailyour's survey which adjoins, form a connected series with those of the previous year's work along the entire length of the Upper Burma-Siam frontier. Mr. Kennedy has maintained his well-earned reputation as a surveyor and draftsman by the results of his labours with the Kyaington-Chengmai mission: the out-turn accomplished is a very large one. Furthur details will be found in an extract from Mr. Kennedy's re- port in the appendix.

Summary of the out-turn of work of the Field Parties during the year 1890-91.

Scale of Survey.	Number of Party.	Locale of Field Operations.		TRIANGULATION.														SPIRIT-LEVELLING OPERATIONS.				TRAVERSING.					TOPOGRAPHY.						Remarks.
				Instrument used.	Area triangulated in square miles.	Number of stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Secondary—in which each angle is usually observed on two zeros.				Tertiary—in which two angles of each triangle are observed.				Number of miles levelled over.	Number of permanent bench-mark stones embedded	Number of Trigonometrical stations connected with lines of levels.	Number of permanent points fixed as bench-marks.	Number of stations at which theodolite was set up.	Linear miles.	Average angular error per station in seconds.	Average linear error per *mille*.	Square miles of village survey.	Area in square miles.	Average number of plane-table fixings per square mile.	Number of linear miles of test lines.	Number of villages.	Number of fields.	Average size of field in acres.	
									Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	Number of intersected points fixed.	Number of triangles.	Error per mile in feet.	Number of heights.															
32 inches=1 mile	5	Rampur City	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
		Garhwal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
16 inches=1 mile	2	Chittagong	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,189	...	...	...	...	2·6	...	...	...	...	...	
		Tipperah (Serail)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17,658	4,366	...	...	845	189	...	1,226	1,054	770,804	0·11	
	3	Mandalay	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	27,644	2,479	3	·4	806	469(*b*)	...	902	505	1650,875	0·13(*a*)	(*a*) Calculated on the cultivated portion only.
		Meiktila		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	62	20	...	...	...	23	...	23	16	20,351	0·72	
		Sagaing		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7,765	2,007			389	584	...	792	183	424,247	0·89	
	4	Jalpaiguri	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10,035	1,744	10	·5	575	563	...	851	642	376,925	0·95	(*b*) Includes 120 square miles of skeleton survey of jungle lands.
	5	Rampur State	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10,512	1,370			714	...	...	...	...	...	...	
	6	Nowgong	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,013	307	4	·4	67	234	...	429	...	158,718	0·94	
		Kamrup		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8,959	1,250	3	·4	213	721	...	3,135	992	527,249	0·88	
		Darrang		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4,877	898	4	·6	270	414	...	1,342	501	73,752	3·58	(*c*) Inclusive of 9 River blocks.
		Sylhet		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5,526	1,138	4	·3	394	365	...	1,541	451	88,644	2·63	
	7	Thongwa	15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,299	752	3	·4	236	2	...	2	2	336	4·66	
		Amherst		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4,085	392	4	·6	116	47	...	101	46	18,398	1·63	
	8	Pooree		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16,208	2,995	4	·4	13	320	...	635	175	133,000	0·95(*a*)	(*d*) Inclusive of 3 Forest and 7 River blocks.
		Cuttack		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					814	408	...	977	308	370,632	0·48(*a*)	
	9	Mandla		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12,516	2,049	1	·4	481	366	...	1,224	823	667,487	0·35	(*e*) Inclusive of 5 Forest blocks.
	12	Hanthawaddy	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13,039	2,203	...	·5	501	321	...	1,543	863	485,691	0·42	
		Tharrawaddy		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	45,521	8,269	6	·3	3,229	...	...	...	1,214	...	...	
		Henzada		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	779	229	...	...	74	...	...	...	52	...	...	
		Prome		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,365	365	5	·2	114	...	...	...	125(*c*)	...	...	
	17	Bombay (Forest)		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9,138	964	5	·3	510	...	...	...	210(*d*)	...	...	
	Detachment	Burdwan		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14,655	1,372	6	·5	656	...	...	...	366(*e*)	...	...	
		Beerbhoom	25	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	22	315	37	...	...	...	
																					...	...	...	...	...	4	...	...	89	7,091	0·35	
8 inches=1 mile	17	Bombay (Forest)	...	7″ & 6″	340	49	7·9	7·9	35	57	9	0·5	35	12	18	1·5	11	25	...	...	...	...	...	...	...	0·4	...	...	10	934	0·28	(*f*) Determined by clinometer.
4 inches=1 mile	Detacht.	Indus Riverain	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6,732	870	8	·8	...	393	177	196	...	...	...	
	4	Jalpaiguri (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,826	893	4	·3	743	552	13	52	74	...	...	(*g*) Tested *in situ*.
		,, (Waste Land)	...	6″	19	26	...	...	26	53	19	0·8	...	...	54	80	0·9	...	...	...	2,012	226	1	·4	182	174	89	59	...	...	...	
	5	Lansdowne (Forest)	30	7″	35	10	...	...	42	56	...	...	41	...	...	...	769(*f*)	...	...	...	2,131	340	1	·4	172	56	44	13	...	...	...	
	7	Thongwa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30	...	...	...	...	...	...	...	35	...	...	...	...	...	
	14	Hoshangabad (Forest)	...	7″ & 6″	499	87	0·7	0·7	47	133	14	0·5	71	618	1,096	0·8	618	...	...	...	...	...	...	...	94	164	...	5	71	...	...	
	17	Bombay (Forest)	...	7″	170	95	1·6	1·6	58	128	11	0·5	58	121	236	0·7	121	...	...	...	4,535	600	7	·2	...	461	119	249	...	...	...	
	18	Himalayas	...	12″ & 7″	476	125	0·7	0·7	93	200	11	0·5	93	534	753	1·0	394	...	...	...	134	26	12	0·9	...	124	113	22	...	...	...	
	19	Madras (Forest)	35	6″ & 5″	950	175	2·2	2·2	164	386	17	0·4	161	350	741	0·9	347	...	...	...	...	...	...	...	...	272	49	(*g*)	...	...	...	
	20	Lower Burma (Forest)	...	6″	220	5	44·0	44·0	3	3	13	...	5	...	...	...	...	35	...	...	5,208	266	24	3·5	...	465	28	(*g*)	...	...	...	
																					7,387	340	5	6·6	...	167	181	56	...	...	...	
2 inches=1 mile	2	Chittagong	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	82	...	...	...	...	...	
	10	Gujarat	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1,083	18	209	...	...	...	
		South Maratha country	...	7″	1,440	45	...	...	45	59	12	0·4	45	14	341	0·4	141	...	...	...	3,477	1,226	8	·7	...	1,659	12	200	...	...	...	
	15	Baluchistan	40	5″	60	7	1·5	1·7	8	18	14	0·4	8	31	52	1·8	27	40	...	...	...	...	...	...	...	77	8	...	...	...	...	
	18	Himalayas	...	12″ & 7″	970	101	1·3	1·3	79	241	14	0·4	73	653	581	0·7	410	...	...	...	...	...	...	...	...	458	22	(*g*)	...	...	...	
	20	Lower Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	204	45	59	...	...	...	
	Detacht.	Black Mountain country	...	6″	...	12	...	...	10	24	10	1·1	10	31	60	...	30	...	...	...	...	...	...	...	...	184	...	(*g*)	...	...	...	
1 inch = 1 mile	10	Gujarat and Rajputana	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	896	6	93	...	..	...	
	13	Mergui	45	...	...	...	...	...	...	...	...	...	...	...	...	...	...	45	...	...	...	...	...	...	...	930	4	...	47	...	...	
	18	Himalayas	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	254	1·4	...	...	...	...	
	Detacht.	Miranzai border	...	5″	...	4	...	...	...	4	13	0·4	3	12	16	0·8	12	...	...	...	...	...	...	...	...	278	...	...	...	...	...	
½ inch = 1 mile	10	Gujarat and Rajputana	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	925	2	59	...	...	...	
	15	Baluchistan	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	50	...	...	...	...	...	...	...	380	0·7	...	...	...	...	
		Zhob Valley	50	...	...	...	...	...	...	...	...	...	...	...	...	...	...									1,359	0·3	...	...	...	...	
	Detacht.	Miranzai border	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	...	...	...	...	...	
	Do.	Black Mountain country	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	360	...	...	...	...	...	
¼ inch = 1 mile	11	Upper Burma	...	6″	12,470	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11,964	...	...	...	...	...	
	15	Baluchistan	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	23,500	...	...	...	...	...	
		Zhob Valley	55	...	...	...	...	...	...	...	...	...	...	...	...	...	...	55	...	...	...	...	...	...	...	5,004	...	...	...	...	...	
	21	Upper Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11,330	...	...	...	...	...	
	Detacht.	Upper Irrawaddy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4,300	...	...	...	...	...	
	Do.	Eastern Frontier, Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5,250	...	...	...	...	...	
	Do.	Kyaington-Chiengmai frontier	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9,000	...	...	...	...	...	
¼ inch = 1 mile	15	Persia	60	...	...	...	...	...	...	...	...	...	...	...	...	...	...	60	...	...	...	...	...	...	...	30,500	...	...	...	...	...	
	15	Baluchistan	...	14″	960	9	107	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Trigonometrical operations only.
	18	Bhutan snow peaks	...	7″	...	...	...	...	...	...	...	...	...	150	176	0·7	150	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	24	Upper Burma	...	12″ (new)	900	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	25	Bombay and Central Provinces	64	...	...	...	...	...	...	...	...	...	...	...	...	...	...	64	425	55(*h*)	3	392(*h*)	...	...	...	...	...	...	...	...	...	
		Totals	...	...	19,503	759	...	...	612	1,362	...	...	603	2,583	4,150	...	3,030		425	55	3	392	253,287	39,956	...	...	12,218	1,17,915	...	16,032	8,819	5,775,134	...	

Statement showing the cost rates of work executed by the several Field Parties during the year 1890-91.

Number of Party.	Nature and *locale* of Field Operations.	Cost-rate per square mile in Rupees.									Rate in annas for traversing, detail survey, and preparation of maps.		Cost-rates.					Total cost exclusive of charges for Instruments.	Remarks.
		Triangulation.	Traversing.	Detail Survey on Scales of							Scale 16″=1 mile.		Stone embedding.	Records (*Khanapuri*).		Compilation of Vernacular records, Assessment statistics, etc.			
				1″	1″	2″	4″	8″	16″	32″	Per acre.	Per field.	Per square mile.	Per square mile.	Per field.	Per square mile.	Per field.		
											a. p.	*a. p.*	₹	₹	*a. p*	₹	*a. p.*	₹	
	Topographical Surveys.																		
2	Chittagong	...	...	...	...	22·3	...	...	54·8(*a*)	...	...	...	...	...	...	...	...	8,406	(*a*) Skeleton survey of jungle lands.
4	Jalpaiguri	...	49·2	...	...	...	33·4	...	...	...	...	...	...	...	...	...	...	10,835	(*b*) Includes ₹1,457 expended in bringing up arrears and General Reports; and ₹13,183 on 1 and 2-inch mapping.
10	Southern Maratha country	5·0	2·1	...	...	10·4	...	...	...	...	...	...	...	...	...	...	...	73,477(*b*)	(*c*) Includes ₹20,994, cost of steam-launch.
	Gujarat and Rajputana	2·9	...	3·6		21·0	...	...	...	...	...	...	...	...	...	...	...		(*d*) Includes ₹12,838 expended on the first class triangulation.
13	Mergui	...	...	...	140·7	...	...	...	...	...	...	...	...	...	...	...	...	1,30,790(*c*)	(*e*) Includes ₹2,539, expended on Trans-frontier survey; ₹1,770 on plots of traverses for settlement survey; ₹1,894 on instruction of soldier surveyors; ₹4,328 on survey schools; and ₹797, on revisionary boundary survey.
15	Baluchistan	2·2	...	10·1	...	113·8	...	...	...	...	...	...	...	...	...	...	...	97,224(*d*)	
18	Himalayas	7·0	...	...	15·0	...	...	...	...	...	...	...	...	...	...	...	...	79,887(*e*)	
		13·7	...	...	...	39·3	...	...	...	...	...	...	...	...	...	...	...		(*f*) Includes ₹164 expended on the Rewari Municipality; ₹395 on atlas reduction; ₹1,908 on completion of previous season's records; and ₹762, on 2-inch mapping.
		14·6	...	...	...	...	71·6	...	...	...	...	...	...	...	...	...	...		
Det.	Indus riverain	...	11·1	...	...	...	12·4	...	...	...	...	...	...	...	...	...	...	17,765(*f*)	(*g*) Includes ₹4,609 expended in classification of forests and soils of 461 square miles; and ₹1,567, in the survey of 150 linear miles of boundary.
	Forest Surveys.																		(*h*) Includes charges on account of instruments.
4	Jalpaiguri	...	49·2	...	...	...	83·2	...	...	...	...	...	5·8	...	...	...	...	21,962	(*i*) Includes cost of demarcation.
5	Lansdowne (Garhwal)	...	...	...	...	...	86·7	...	...	...	...	...	...	...	...	...	...	3,007	(*j*) Includes ₹722 and ₹2,168 expended on completion of cadastral maps and records of Wards and Government estate, respectively, in *pargana* Shabazpore, district Backergunge.
14	Hoshangabad	28·7	15·4	...	...	...	125·5	...	...	...	...	...	...	...	...	...	...	84,733(*g*)	
17	Bombay { Northern Circle	2·1	23·0	...	...	...	87·2	...	...	...	...	...	...	...	...	...	...	66,274	(*k*) Includes ₹1,016 for connecting Lambhusara G. T. S. with main circuit No. 1 of office work.
	Bombay { Northern Circle	...	24·2	...	...	...	...	143·4	...	...	...	...	...	...	...	...	...		(*l*) Includes ₹11,972 expended on demarcation, and ₹858 on 2-inch mapping.
	Bombay { Southern Circle	...	...	...	...	...	...	...	193·3	...	...	...	...	...	...	...	...		
	Bombay { Southern Circle	10·7	13·0	...	...	...	...	88·2	...	...	...	...	...	...	...	...	...		
19	Madras	30·9		...	...	...	81·3	...	...	...	...	...	...	...	...	...	...	75,492(*h*)	(*m*) Includes ₹5,685 expended on completion of records of previous years; ₹17,501 on statistics; ₹1,790 on revision work; ₹116 instruction in surveying; ₹3,339 on 2-inch mapping; ₹6,886 on Bhutan boundary; ₹233 on Kuch Behar and Jalpaiguri boundary.
20	Lower Burma	58·2	160·6	...	...	71·5	178·0	...	...	...	...	...	...	...	...	...	...	97,284	
	Cadastral Surveys.																		(*n*) Includes ₹1,013 expended on repairing stations in the Gursari estates and on revision work in Lalitpur; ₹1,516 in giving instruction to junior civilians; ₹8,747 on 2 and 4-inch mapping; and ₹9,101 Lieutenant Crichton's pay, etc., while under training.
2	Chittagong	...	50·6	...	...	...	...	...	130·6	...	6 6	0 10	7·3(*i*)	...	...	...	...	1,27,024(*j*)	(*o*) Includes cost of Rampur city survey on 32-inch scale.
	Tipperah (Serail)	...	...	...	...	...	...	...	151·5	...	5 5	3 10	...	71·6	1 3	...	...	27,409(*k*)	
3	Mandalay	...	43·5	...	...	...	...	...	120·7	...	4 5	3 11	...	...	...	10·2	0 3	2,51,457(*l*)	(*p*) Includes ₹1,780 revision work in Sibsagar; ₹5,445 completion of cadastral maps and records; ₹1,264 instruction to *mandals* in surveying; and ₹2,854 on 2-inch mapping.
	Meiktila	...		...	...	...	...	...	123·9	...	4 6	4 3	...	...	...	10·6	0 4		
4	Jalpaiguri	...	49·2	...	...	...	...	...	176·1	...	8 3	7 9	5·8	39·8	0 7	...	...	1,19,737(*m*)	(*q*) The low rate is due to the employment of local agency in lieu of imported *amins* for the field survey.
5	Garhwal	...	32·8	...	...	...	...	...	...	282·6	7 11	0 10	...	...	...	...	...	1,01,553(*n*)	
	Rampur State	...	26·9	...	...	...	...	...	70·1(*q*)	...	2 5	2 1	...	(*r*)	...	...	...	56,510(*o*)	(*r*) The cost rate ₹70·1 under the head of detail survey, includes both the cost of Cadastral Survey and *Khanapuri*.
6	Kamrup, Nowgong, Darrang	...	29·8	...	...	...	...	...	38·8(*q*)	...	1 11	5 11	...	...	...	22·0	1 8	85,696(*p*)	
	Sylhet	...	44·5	...	...	...	...	...	39·0(*q*)	...	2 1	3 5	...	...	...	22·7	0 11	10,003	
7	Thongwa	...	46·8	...	...	...	21·7	...	120·2	...	4 2	6 5	...	...	...	...	...	51,215(*s*)	(*s*) Includes ₹1,389 expended on revision work; ₹2,838 on 2-inch mapping; ₹5,508 on demarcation in district Amherst.
	Amherst	...	55·8	...	...	...	...	...	142·6	...	4 11	3 5	...	...	...	...	...	1,09,197(*s*)	
8	Pooree	...	34·1	...	...	...	...	...	68·5(*q*)	...	4 0	1 4	6·8	26·4	0 3	2·0	...	79,082(*t*)	(*t*) Includes ₹789 expended on revision work; ₹2,955 in giving instruction in surveying; ₹1,023 on demarcation work in Cuttack; ₹2,447 on 2-inch mapping; ₹4,910 on completion of Killa Kanika; and ₹1,540 on Killa Kujang.
	Cuttack	...	34·4	...	...	...	...	...	76·6(*q*)	...	3 7	1 6	8·3	27·7	0 3	1·6	...	76,467(*t*)	
	Traverse Surveys.																		(*u*) Includes ₹3,484 expended on revision work in districts Betul and Hoshangabad.
9	Mandla	...	18·8	...	...	...	...	...	...	...	...	...	2·9	...	...	...	...	80,220(*u*)	(*w*) Includes ₹3,927 expended on revision work in districts Hanthawaddy and Prome.
12	Lower Burma	...	60·7	...	...	...	...	...	...	...	...	...	21·7	...	...	...	...	1,16,267(*w*)	

Particulars of Cadastral Surveys completed since 1889-90.

Districts and States.	Scale of survey.	Number of villages.	Number of fields.	Area surveyed in square miles.	Average size of fields in acres.	Cost exclusive of charge for instruments.	Rate per square mile.			By whom and when surveyed.	Remarks.
							Traverse survey.	Cadastral survey.	Cadastral survey with Record of Rights.		
						₹	₹ a. p.	₹ a. p.	₹ a. p.		
Burma.											
Thongwa . . .	16″=1 mile.	1,174	1,262,663	2,910	0·15	5,75,688	64 8 0	129 3 0	...	Col. H. S. Hutchinson and Messrs. F. W. Kelly and C. Wood during 1886-91.	
N.-W. Provinces.											
Rampur State . .	16″=1 mile.	1,093	576,965	790	0·87	75,530	23 1 0	...	72 5 0(*a*)	Col. J. E. Sandeman during 1889-91.	(*a*) Executed principally by *patwari* agency.

Particulars of Traverse Surveys executed for Settlement Department Surveys and completed between the years 1884-90.

Districts.	Number of villages.	Area traversed in square miles.	Cost exclusive of charge for instruments.	Rate per square mile.	By whom and when surveyed.	Remarks.
Central Provinces.			*R*	*R a. p.*		
Balaghat	699	1,300	31,037	23 14 0	Mr. G. H. Cooke during 1888-89.	
Betul	1,112	2,590	61,202	23 10 1	Messrs. A. D'Souza and G. H. Cooke during 1887-90.	
Bhandara	1,405	3,091	52,478	16 15 8	Mr. G. H. Cooke during 1888-90.	
Chanda	1,921	5,317	90,906	17 1 7	Mr. G. H. Cooke during 1888-90.	
Chhindwara	1,405	2,959	82,501	27 14 1	Col. D. C. Andrew and Mr. W. H. Patterson during 1886-89.	
Damoh	1,428	2,920	86,315	29 8 11	Mr. G. H. Cooke during 1885-87.	
Hoshangabad	1,629	2,998	73,012	24 5 8	Mr. A. D'Souza during 1887-89.	
Jubbulpore	2,534	3,881	1,03,165	26 9 4	Mr. G. H. Cooke during 1885-88.	
Nagpur	2,241	3,838	98,046	25 8 9	Col. W. H. Wilkins during 1887-89.	
Narsinghpur	1,092	1,916	64,830	33 13 4	Mr. E. J. Jackson during 1886-88.	
Nimar	705	1,736	48,250	27 12 8	Mr. W. H. Patterson during 1888-89.	
Raipur	3,451	6,880	2,18,007	31 11 0	Cols. W. H. Wilkins, E. H. Steel and Mr. G. B. Scott during 1885-88.	
Sambalpur	1,158	2,353	98,850	42 0 2	Messrs. P. A. G. Cowley and A. D'Souza during 1884-87.	
Saugor	2,068	4,013	1,14,238	28 7 5	Mr. E. J. Jackson during 1886-89.	
Seoni	1,680	3,261	87,165	26 11 8	Col. D. C. Andrew and Mr. G. H. Cooke during 1886-88.	
Wardha	1,381	2,420	61,750	25 8 3	Col. W. H. Wilkins during 1887-89.	
N.-W. Provinces.						
Lalitpur	756	1,939	34,022	17 8 9	Col. J. E. Sandeman during 1888-90.	

PART III.

THE OPERATIONS AT THE HEAD-QUARTERS OFFICES.

421. These offices comprise—

(1) The Head-quarters offices at Calcutta.
(2) The Trigonometrical Branch office at Dehra Dun.
(3) The Drawing office at Simla.

A detailed description of the work carried on in each office is given below:—

I.—HEAD-QUARTERS OFFICES, CALCUTTA.

SUPERINTENDENCE, CORRESPONDENCE, AND ACCOUNTS.

Personnel.

Colonel H. R. Thuillier, R.E., Surveyor-General of India.
Lieutenant-Colonel C. Strahan, R.E., Deputy Surveyor-General, in charge Revenue Branch.
Lieutenant-Colonel M. W. Rogers, R.E., Assistant Surveyor-General.
Mr. T. Archdale Pope, Deputy Superintendent, 4th grade, Personal Assistant to the Surveyor-General.
„ T. W. Babonau, Registrar.

Correspondence.

Mr. M. Francis, Head Clerk.
„ C. B. Heysham, Head Clerk, from 1st December 1890 to 30th June 1891.
„ J. F. Burbridge, Head Clerk, from 1st July 1891.
„ J. A. Vallis, Clerk.
„ T. E. Ware, „
Babu Kali Podo Banerji, Clerk, Officiating Head Clerk, to 30th November 1890.
Babu Bani Madhub Banerji, Clerk.
„ Durga Narain Ghose, „
„ Ram Kristo Chunder, „
„ Chuni Lal Dey, „
„ Bheekum Singh, Clerk, to 20th May 1891.
„ Gopal Chunder Dass, Clerk.
„ Raj Kumar Dutt, Clerk, to 1st July 1891.
Mr. E. Bonnaud.
Babu Kali Kristo Chunder,
and 9 others.

Accounts.

Mr. H. H. Fenwick, Head Accountant, to 31st December 1890.
„ C. O. Gray, ditto from 1st January 1891.
Babu Bama Churn Chuckerbutty, Accountant.
„ Raj Krishna Mukerji, „
„ Hem Nath Dutt, „
and five others.

422. The general direction of these offices has remained in the hands of Colonel H. R. Thuillier, R.E., Surveyor-General, throughout the year. The Revenue Branch section was under the superintendence of Lieutenant-Colonel C. Strahan, R.E., and the General and Topographical Branch sections under that of Lieutenant-Colonel M. W. Rogers, R.E.*

* The Assistant Surveyor-General reports as follows:—
Mr. T. W. Babonau, the Registrar, has carried on the general superintendence of the office very satisfactorily. Messrs. Francis, Gray, and J. A. Vallis have also done good work. The clerks have in general given satisfaction and the following are deserving of special mention:—Babus Bani Madhub Banerji, Chuni Lal Dey, Raj Krishna Mukerji, and Kanti Churn Sen.
The Deputy Surveyor-General reports that in the Revenue Branch office, Mr. J. F. Burbridge, who has lately taken over the duties of Head Clerk, is hardworking and painstaking, and promises to become a really efficient clerk. Babus Kali Podo Banerji, and Ram Kristo Chunder have continued to do good work, while Mr. E. Bonnaud and Babu Narendra Nath Mukerji have worked hard and satisfactorily.

DRAWING OFFICE.

423. On the transfer of Major Gore, R.E., to the Himalayan field party early in October 1890, Colonel W. H. Wilkins, S.C., was placed in charge of the Drawing Office, and has retained it during the year. The principal work of the three sections into which the office is divided is reported on separately, and a detailed statement of the work executed in each section will be found in the appendix.

Personnel.

Colonel W. H. Wilkins, S.C., Officiating Assistant Surveyor-General, from 10th October 1890.
Mr. G. A. McGill, Chief Draftsman.
„ S. M. Smylie, Head Draftsman.
„ G. D. Cusson, Draftsman.
„ W. Green, „
„ A. J. Musgrove, „
„ J. R. Adels, „
„ R. C. Sinclair, „
„ A. S. Bateman, „
„ A. J. J. Rodrigues, „
„ E. Dowling, „
„ E. Andrews „

Native Draftsmen.

Babu Harihur Sen,
„ Mohesh Chandra Sen,
Munshi Muttiullah,
Babu Purna Chandra Sen,
„ Gopal Chandra Roy,
„ Tincowry Sen,
and 39 others.

Additional Establishment.

Mr. A. J. James, Draftsman, and 7 native draftsmen.

Surveyors and Assistant Surveyors on duty.

Mr. H. Keelan, Surveyor, 1st grade, from 17th December 1890.
„ F. Adams, Surveyor, 2nd grade, to 25th April 1891.
„ A. G. Wyatt, Surveyor, 2nd grade.
„ W. C. Price, Surveyor, 3rd grade.
„ E. J. Martin, Assistant Surveyor, 1st grade.
„ C. W. F. Seyers, Assistant Surveyor, 1st grade.
„ W. H. Penrose, Assistant Surveyor, 1st grade, to 10th June 1891.
„ W. Warwick, Assistant Surveyor, 1st grade, from 4th May 1891.
„ W. H. D. Ewing, Assistant Surveyor, 1st grade, from June 9th to September 1891.

SECTION I.—GEOGRAPHICAL DRAWING, AND COMPILATION.

424. This section of the office has been engaged principally on the preparation and publication of the maps of Burma on various scales. Three sheets, Nos. 1, 3, and 6 of the South-East Frontier series, on the scale of 1 inch = 8 miles, have been completed from the latest editions of $\frac{1}{4}$-inch maps supplied by field parties, while sheets Nos. 4 and 5 are in progress. The maps of the expedition to the Upper Irrawaddy in 1889-90 by Major Hobday, of the reconnaissance of the districts on the eastern frontier of the Shan states by Captain Renny-Tailyour, of Mr. Kennedy's survey while accompanying the Kyaington-Chiengmai Frontier mission, and of the survey made with the Anglo-Siamese Boundary Commission in 1888-89, have given considerable and valuable additions to the geographical knowledge of the northern and eastern frontiers. As was the case during the two previous years, the preparation of these maps of Burma has thrown an enormous amount of work on the Drawing Office, for when any fresh information is obtained a new edition is at once put in hand.

425. A second edition of the map of Burma and adjacent countries, on the scale of 1 inch = 32 miles, has been prepared and completed with the latest information available. The hills have been printed in grey, which renders the map clear and legible. The compilation of a new map of Upper Burma, on the scale of 1 inch=16 miles, has been commenced during the year and is well in progress: it is hoped that the map will be published during the present year. It was found more convenient to re-draw the map entirely than to make additions and corrections to the old one which had already gone through five editions, and the original would no longer bear drawing on its surface. It embraces, moreover, a far larger tract of country than the existing map, as it will extend from the Koladyne river on the west to the Mekong (Cambodia) river on the east.

426. It was mentioned in last year's report that a third edition of the 32-mile map of India was in preparation with extensions to the east and west, so as to include the whole of Burma and Baluchistan. The publication of this map has been delayed, in order that all the new material available in the additional areas might be inserted, and it is expected that it will be published during the first half of 1892.

427. A railway map was prepared for the Director-General of Railways for reduction to half scale or 1 inch = 64 miles, by photozincography. The map contains all the railways completed or in progress up to date, as well as all the

names of stations throughout India and Burma, and will probably be found a useful map for others besides the Railway authorities.

428. A set of maps for a new edition of Aitchison's Treaties required by the Foreign Department was commenced in July. There are twenty in all to be prepared, and of these, four or five, are maps of foreign and little known countries which require to be re-compiled from better and later materials to replace the very meagre and obsolete maps which illustrated the older edition of the work. The progress of these maps is slow, as they have to give way to more urgent work at times.

429. The 8-inch divisional maps of the Province of Bengal have been completed, with the exception of two, *viz.*, Chota Nagpur and Orissa. These maps are being drawn on an enlarged scale for reduction by photozincography, and by this method expedition and neat work are assured.

430. The completion to margin of the various maps of the Central India Agency and of the Central Provinces has involved a large amount of work in this section; during the past year eleven maps of the former and one of the latter have been published, while twenty of the former and one of the latter are in various stages of progress. It was found desirable that, as the various maps along the boundary of one province contained only a small portion of that province, these maps should be drawn to margin and published as a series of complete maps; but this has entailed a considerable amount of labour.

431. The preparation of maps for other departments during the year under review has not decreased, and continues to suspend to a great extent the progress of the regular departmental publications. The demand for maps for every conceivable purpose has increased enormously amongst officials throughout India, and the work of the Drawing Office is now more than can be carried out with the existing staff of draftsmen, which was fixed at its present strength many years ago. The increasing pressure demands a larger staff to cope with the present day requirements, and it is intended to represent the matter to the Government of India with a view of a larger establishment being sanctioned.

SECTION II.—REVENUE.

432. The ordinary routine work of this section consists in examining and preparing for photozincography the fair maps received from the field parties of the Revenue Branch, in bringing up to date and republishing old maps, and in supplying data. Besides this regular work the fair topographical sheets, on the 2-inch scale, of districts Ferozepore, Umballa, and Hissar in the Punjab, were completed up to margin. The additions were obtained from the 4-inch and 2-inch surveys of the late district of Sirsa, district Karnal, and Sikh States, as well as from the adjoining district of Saharanpore in the North-West Provinces.

433. A map of the Punjab, on the scale of 8 miles to the inch, for reproduction to scale, showing the *reh* (alkaline earth) affected localities, was drawn for the Revenue and Agricultural Department and sent to press, and proofs are now under correction. A skeleton map, on the scale of 4 miles = 1 inch, of districts Garhwal and Kumaun was prepared for His Excellency the Viceroy. The old map of the city of Calcutta, on the scale of 6 inches = 1 mile, was, as far as practicable, brought up to date, and information regarding new postal and police stations was inserted. The new docks at Kidderpore have also been added, as well as fresh topography in the suburb of Ballygunj.

434. The district map of Raipur, Central Provinces, on the scale of 2 miles = 1 inch, has been passed through the press, and the proof is now under correction. In the North-West Provinces the ½-inch district map of Ghazipur has been published; that of Benares is under publication, and the map of district Basti will shortly be sent to press; the maps of districts Gorakhpur and Mirzapur are in progress.

435. The computing establishment attached to this section has as usual been engaged on a great amount of miscellaneous work for other departments, and the arrears in the examination of the records of the field parties have in consequence not lessened. The assistance expected from the field parties, as reported last year, has been of little avail at present, as spare computers could not be obtained therefrom, but it is hoped that help may be obtained in this way

in future. The demands made by other departments for the supply of data have been very great, involving much labour and time; for instance, demands for the areas of the different Native States in Central India and Rajputana, as well as those of the several districts in Assam, were received, which necessitated the calculation by the planimeter of different areas in about 900 sheets. The field records of district Saugor, extending over three years, have only been examined during the year under review. The very large amount of traverse surveys that have been done during the past few years, to furnish a basis for settlement surveys in the Central Provinces, is the main reason for arrears having accumulated. As there were ten field parties employed entirely on this class of work this last year, and as the records of one party for three years could only be examined, it follows that the records of seven parties for one year have been added to the arrears that existed last year.

SECTION III.—CADASTRAL.

436. This section is employed in preparing the original maps of all the cadastral surveys for zincography and photozincography. The method is to examine the numbering of the fields and to observe if all holdings and divisions of land are correctly tabulated in the area statements. The total number of maps passed for publication during the year was 4,710, of which 1,215 were for zincography and 3,495 for photozincography, showing an increase of 303 on the return of the previous year; but of these only 4,449 were actually printed, 3,216 being coloured, examined, and sent for record with the Settlement Officers of the districts to which the maps belonged.

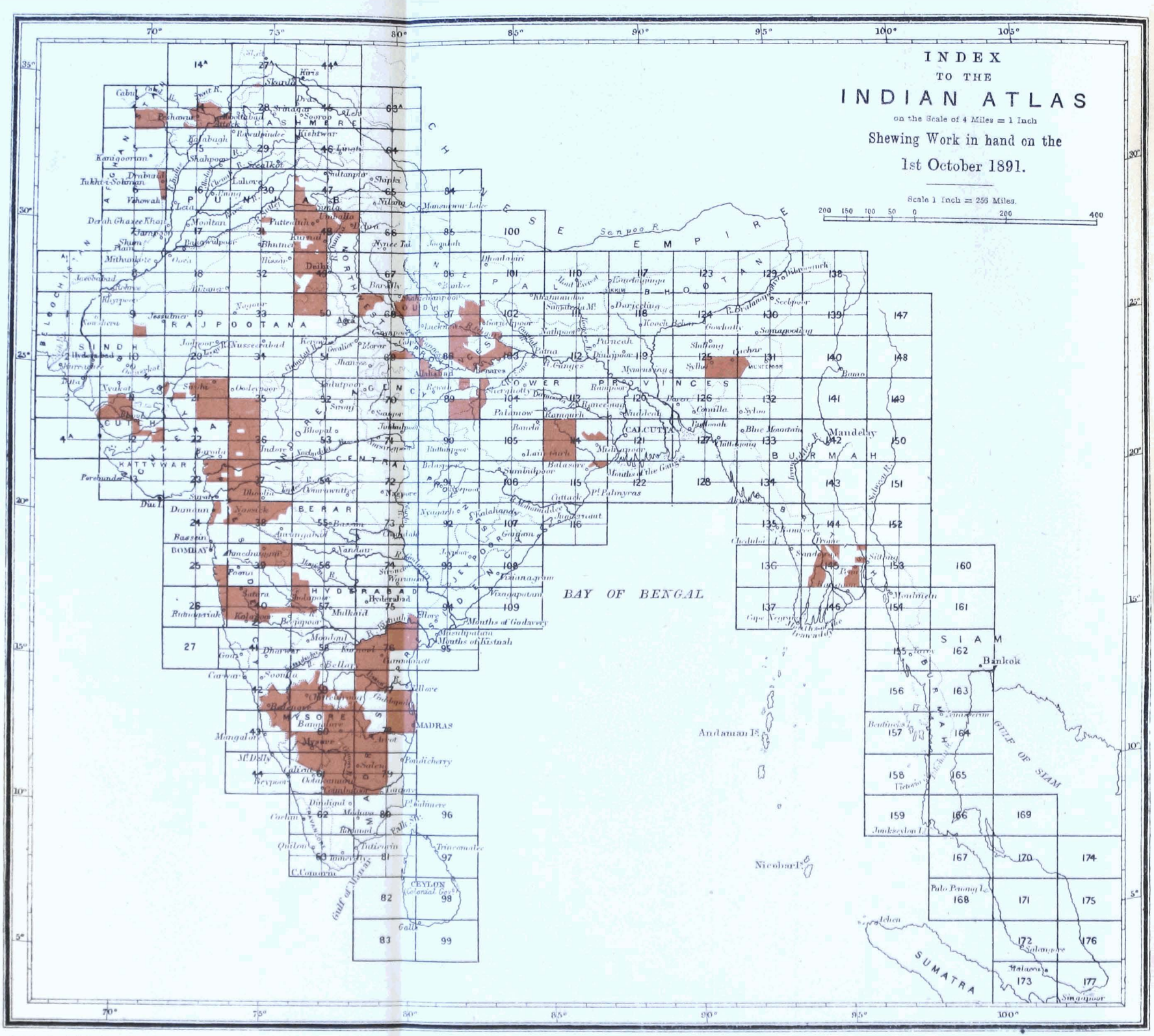
437. The maps completed and published have been arranged and bound into 53 volumes for record in this office, and 44 volumes of printed cadastral maps of district Thongwa, Lower Burma, have been arranged in circles and townships, indexed, examined, and bound, and forwarded to the Chief Commissioner of Burma.

438. In consequence of the urgent demands made for the publication of the cadastral maps of districts Basti and Gorakhpur which have not yet been printed, all reprints of former published maps were stopped from February 1891. The maps of district Basti were completed in May, and it is hoped that the publication of the maps of the Gorakhpur district will be completed by May 1892.

439. The work of examination and preparation of the maps of the current cadastral surveys is greater than can be accomplished with the existing establishment, and it has not been possible to diminish the arrears that have accumulated as reported in the last Annual report. If the printing of cadastral maps is to be continued, it will be necessary to increase the staff of this section. At present the Burma and Assam Governments continue their demands for printed maps.*

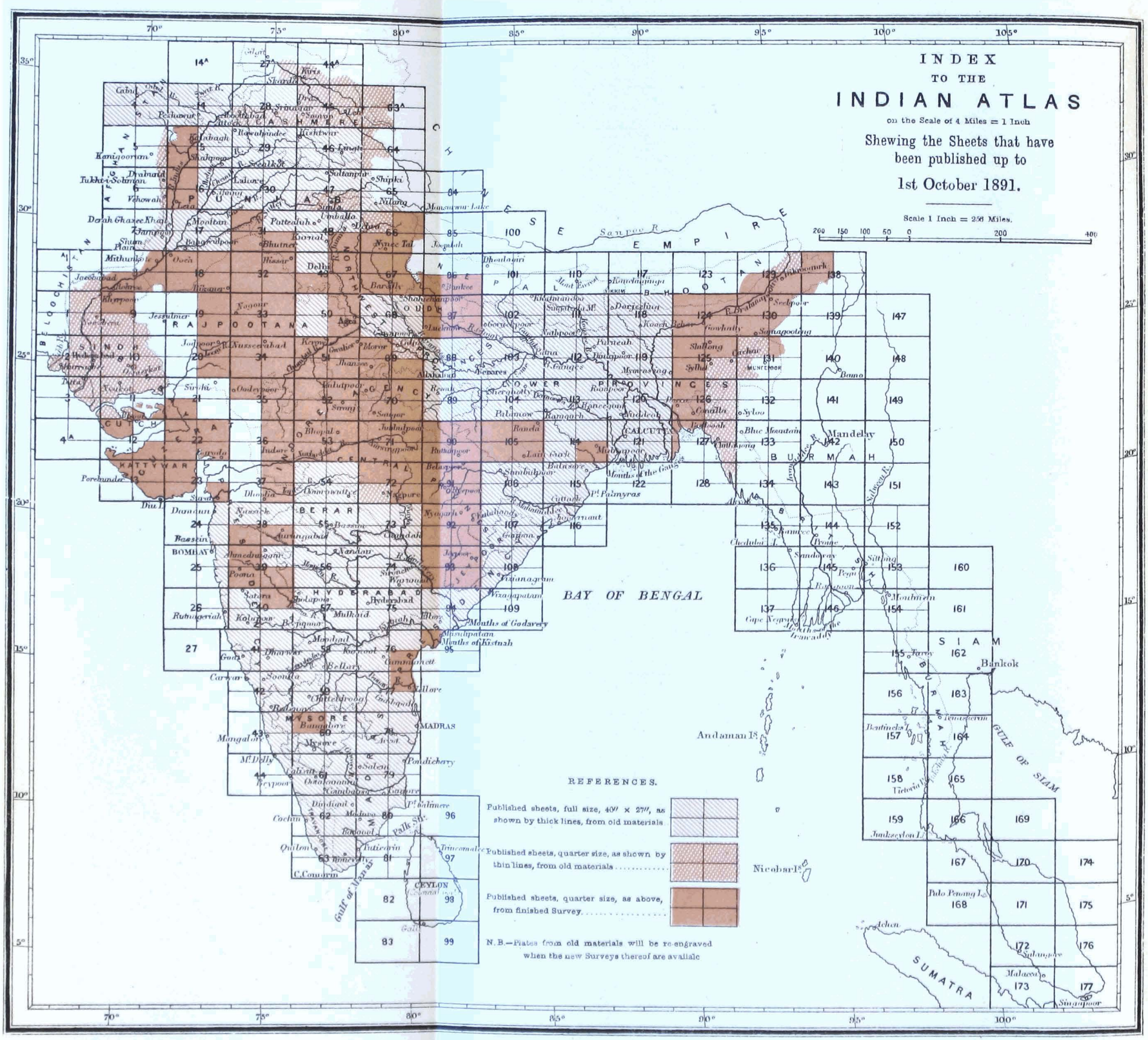
* The Assistant Surveyor General reports as follows regarding the assistants in charge of the three sections:—Mr. McGill, the Chief Draftsman in charge of No. 1 Section, was in indifferent health for the greater part of the year; but he has discharged his duties well. Mr. Smylie, the Head Draftsman in charge of No. II Section, has again given the greatest satisfaction in the discharge of his duties. Mr. James, in charge of No. III Section, has also done well. Mr. Price was in charge of the Examining Section, which is attached to No. 1 Section, and rendered efficient service. Of the European and native draftsmen the following are commended:—Messrs. Green, Musgrove, Cusson, Martin, and Penrose, and Babus Mohesh Chandra Sen, Gopal Chandra Roy, Harihur Sen, and Munshi Mutiulla.

Special mention is made of Mr. Sinclair's services, as he is thoroughly acquainted with every detail of the work of No. 1 Section.



Reg. No. 619. S. I. D.—Nov. 91.—550.

Litho S. I. O., Calcutta.



Reg. No. 619, S. I. D.—Nov. 91.—550.

Litho. S. I. O., Calcutta.

ENGRAVING OFFICE.

440. The superintendence of this office is in the hands of the Assistant Surveyor General in charge of the Drawing Office. Mr. G. G. Palmer was Head Engraver till the 23rd April 1891, when he retired on superannuation pension after 18 years of highly approved service and was succeeded by Mr. J. Fulford.

Personnel.

Colonel W. H. Wilkins, S.C., Officiating Assistant Surveyor-General in charge, from 10th October 1890.
Mr. G. G. Palmer, Head Engraver, up to 22nd April 1891.
Mr. J. Fulford, Head Engraver, from 23rd April 1891.
Mr. W. Donaldson, Engraver.
„ S. M. Coard, „
„ T. B. Rodger, „
„ A. W. N. James, „
„ A. R. Coard, „
„ E. C. Ollenbach, „
„ E. Earle, „
„ L. H. Musgrove, „
„ F. R. C. Scallan, „
„ W. M. Wells, „
„ A. T. Vieux, „
22 native engravers.
3 apprentices.

Copper-plate Printing Section.

Mr. W. T. Collins, Copper-plate Printer.
„ A. E. Pilley, Assistant Copper-plate Printer and Store-keeper.

441. The out-turn of work, a summary of which will be found in the appendix, is much the same as last year, the smaller return in outline being fully compensated for by a larger number of letters cut over last year's return; the hill etching is also in excess.

442. The 32-mile map of India, in six plates, is still unfinished; the plates have to be enlarged on the east and west margins to allow of the insertion of additional areas in Burma up to the borders of China and Siam and in Baluchistan, and they are in various stages of advancement. The 64-mile map of India, in 4 sheets, is being corrected as regards orthography, and brought up to date in respect to railways, &c. The 96-mile Railway map in one plate is almost completed. The compilation of this map, which is being engraved especially for the Railway Department as a standard map for their Administration Reports, has been greatly delayed owing to the alterations required by that Department being so heavy as to necessitate a matrix, and a duplicate being made of the original plate. Another map of India, on the scale of 128 miles to the inch, has been projected to replace the original plate thereof, and the new 256-mile map has made fair progress, being about half completed in writing.

443. Heavy corrections and additions have been carried out on the various provincial maps on the scale of 1 inch = 16 miles. The map of the Punjab in four sheets and the map of Mysore have been well advanced, both being nearly completed in lettering, while that of the North-Western Provinces and Oudh is having all the additional material added as far as possible.

444. A map of Darjeeling, on the scale of 1 inch = 4 miles, has been completed in outline, and the lettering is about to be commenced. Of the Administration Report maps, those of Bengal and the Punjab, on the 80-mile scale, have been completed with hills; Assam on the 48-mile scale has been nearly completed, while 43 district maps on various scales are in progress in different stages. The index map to the standard sheets of the Central Provinces has been completed, while many miscellaneous maps, amounting altogether to 240 plates, have been worked upon during the year.

445. The Copper-plate Printing Section pulled 21,000 impressions and the Steel-facing Section dealt with 122 plates.*

CALCUTTA CITY SURVEY OFFICE.

446. This detachment has remained throughout the year under the charge of the Assistant Surveyor General, Drawing Office, Calcutta.

Personnel.

Colonel W. H. Wilkins, S.C., Deputy Superintendent, 1st grade, in charge.
Mr. D. Atkinson, Surveyor, 1st grade.
Mr. A. B. Smart, Assistant Surveyor, 2nd grade.
17 draftsmen.
3 field surveyors.

447. Last year's report recorded the following work as still remaining to be completed:—

(1) The house-to-house enquiry as to names and addresses of proprietors, and the investigations of the boundaries of holdings, of which

* Mr. Palmer supervised the office very efficiently, and on his retirement Mr. Fulford has carried on the duties to the satisfaction of the Assistant Surveyor-General. The European and native engravers are on the whole very favorably reported on.

there are probably 200 remaining in the collectorate and about 2,500 in the Sutanoti *taluk* of Calcutta.

(2) The completion of the original field sheets in colour, which involves many references on the spot, and in some cases re-surveys in consequence of additions or alterations since the original survey was made.

(3) The survey and adjustment of the boundaries of about 1,500 holdings, of which the proprietors were not present at the time of survey.

(4) The completion and publication of 235 fair sheets, all of which are in various stages of completion and are only waiting for the demarcation and insertion of all the boundaries.

(5) The completion of the register of proprietors.

448. The following progress has been made in the above during the year under report :—

(1) In the house-to-house enquiry the estimate of holdings which remained to be completed in Sutanoti *taluk*, was found to be exceeded by 552. It may be mentioned that it was impossible to find out the exact number until a survey was made, as there was no register of any kind available. During the year the demarcation of 2,752 holdings of this *taluk* was completed, leaving about 300 to be dealt with ; these could not be done in consequence of the non-attendance of the proprietors.

(2) As regards the completion of the 459 original field sheets in colour, the sheets, 228 in number, of the south division have been nearly finished, and the 231 sheets of the north division will not require much labour, as the field sheets were to a great extent coloured before the demarcation of the boundaries was taken up.

(3) In the survey and adjustment of boundaries, 245 holdings have been completed. Since the house-to-house enquiry as to names and addresses of proprietors was originally made, some of the holdings have changed hands, necessitating the issue of fresh notices which prevented more being accomplished. In the holdings demarcated there were 36 disputed cases. The total number of holdings demarcated since the commencement of the survey is as follows :—

Up to September 30th 1890 . . .	17,401
During 1890-91	2,997
TOTAL .	20,398

It is probable that 1,550 holdings still remain for final demarcation.

(4) Some progress has been made in the completion and publication of the 235 fair sheets, and those containing blocks XI and XII of the south division will be soon forwarded to the Photo. Office for reproduction.

(5) The register of proprietors has been progressed with, and about three-fourths has now been completed.

449. During the year there were 230 disputed boundaries, of which claims were entered for 191 cases which were sent to the Court of the Assistant Superintendent of Survey under the Calcutta Survey Act, Rai Kally Churn Ghose Bahadur. Of these cases 139 were decided and 52 are in course of investigation. The Municipality was involved in 50 cases, of which 29 were decided against it.

450. During the year it was decided to publish the map of Calcutta by the process of heliogravure on the scale of 16-inches to the mile. This map will consist of 15 sheets, and each of these sheets will contain 25 of those on the scale of survey, or 1 inch=50 feet. Two of these sheets are now in hand and will be soon ready for photography.

SPECIMEN OF DIRECT REDUCTION OF TWO SHEETS OF THE NEW SURVEY OF THE CITY OF CALCUTTA.

FROM THE SCALE OF 1 INCH=50 FEET TO 1 INCH=330 FEET, OR 16 INCHES=1 MILE.

Photo-etching.

Survey of India Offices, Calcutta, February 1892.

451. The causes of delay in the completion of the City Survey were explained in para. 468 of last year's report. During the year, prosecutions for non-attendance to point out boundaries, and for evading the summonses to appear before the Assistant Superintendent's Court have been made whenever the defaulters have not shewn sufficient cause for their neglect. Only eleven prosecutions were instituted, and of these ten were successful, fines from ₹10 to 20 being inflicted. It does not appear that more stringent measures can be enforced to secure better attendance.*

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE.

Personnel.

Colonel J. Waterhouse, S.C., Assistant Surveyor-General, in charge up to 7th May 1891.
Mr. T. A. Pope, Deputy Superintendent, 4th grade, in charge from 8th May.

NEGATIVE SECTION.

Normal Establishment.

Mr. H. Haward, Head Assistant, up to 7th July 1891.
Mr. J. Harrold, Officiating Head Assistant, from 8th July 1891.
Munshi Ismail Khan, Assistant Photographer.
Mr. G. W. Mackie, Assistant Photographer.
Mr. E. Savedra, apprentice.
One assistant photographer and two negative retouchers.

Cadastral Establishment.

Mr. L. Lagnier, Photographer.
„ T. Lloyd, Offg. ditto.
„ C. D'Cruze, Assistant Photographer.
Three native assistant photographers and three negative retouchers.

PHOTO-TRANSFER PRINTING SECTION.

Normal Establishment.

Mr. J. Harrold, Photographer, up to 7th July 1891.
Munshi Habeebul Hossain, Assistant Photographer.
Mr. P. C. Michael, Apprentice.

Cadastral Establishment.

Mr. R. George, Photographer, and two assistant photographers.

SILVER-PRINTING SECTION.

Mr. C. J. Meade, Apprentice, and one assistant photographer.

HELIOGRAVURE AND COLLOTYPE SECTION.

Mr. A. W. Turner, Photo-Engraver.
„ P. Mackenzie, Apprentice, up to 31st May, one assistant photographer, two engravers and three copper-plate printers.
Mr. J. T. Meade, Collotype Printer.

LITHOGRAPHIC DRAWING SECTION.

Mr. H. L. Lepage, Head Assistant.
Babu Umbica Churn Mookerjee, Examiner.
Munshi Sobhan Baksh and 24 other draftsmen.

ZINC-PRINTING SECTION.

Normal Establishment.

Mr. B. Mackenzie, Zincographer.
„ F. R. Vandyke, ditto.
„ J. B. Mackenzie, Assistant Zincographer, one writer and four zinc correctors.

Cadastral Establishment.

Mr. E. A. LeFranc, Zincographer.
„ G. A. LeFranc, Apprentice, one writer and nine zinc correctors.

LITHO-PRINTING SECTION.

Mr. D. Deas, Head Lithographic Printer.
Mr. S. U. Ravenscroft, Assistant Lithographic Printer.

TYPE PRINTING SECTION.

Mr. E. DePyvah, Head Printer.

CORRESPONDENCE AND ACCOUNTS SECTION.

Normal Establishment.

Mr. W. Moore, Store-keeper.
Babu Kanny Lall Sen, Head Clerk and Accountant.
Babu Gopal Chunder Mookerjee, Clerk, and one other.

Cadastral Establishment.

One Clerk.

LITHOGRAPHIC ESTABLISHMENT.

Babu Russick Lall Shaw, Clerk, up to 6th April 1891.
Babu Nogendra Nath Mookerjee, Clerk, offg. from 7th April 1891.
Babu Rajani Kanto Chatterjee, Clerk, and three others.

452. The office was under the charge of Colonel J. Waterhouse from the commencement of the year under report till the 7th May 1891, when he proceeded to Europe on furlough for six months, and Mr. T. A. Pope took charge and officiated for the remainder of the year. There have been but few changes in the personnel of the establishment during the year, and no casualties among the European assistants.

453. The machinery has continued to work without difficulty during the year, and has been most valuable in getting through the increasing amount of printing work. The hand-presses have also been fully engaged.

454 The general abstract of work turned out, given in the tabular statement below, again shows a very large increase in all sections over last year's out-turn. The few items in defect, *viz.*, the number of stones transferred and the number of type items set up, and of blue prints, are more than counter-balanced by large increases in the number of zinc plates transferred, in additional pulls from type and a large number of silver prints.

* Mr. D. Atkinson, who was in immediate charge of the detachment, has performed his duties to the entire satisfaction of his superintending officer, and Mr. A. B. Smart is also well reported on. Mr. Atkinson reports very favourably of Rahim Bux, draftsman.

General Abstract of work done during 1890-91.

Classification.	Photo-zincographic and Lithographic Printing.										Type Printing.			Silver and other Printing.		Heliogravure and Electrotyping.				Photo-collotype.		Value.
	Sheets or Subjects.	Negatives and transparencies.	Photo-transfer prints.	Zinc plates transferred.	Zinc plates printed.	Stones.	Pulls.	Number of Copies. Coloured.	Uncoloured.	Total.	Pages or items.	Pulls.	Copies.	Silver prints.	Blue prints.	Heliogravure plates.	Heliogravure prints.	Photo. Blocks.	Electrotypes.	Plates.	Prints.	R a. p.
Departmental maps and plans	1,145	1,320	1,276	481	667	108	173,878	16,320	156,612	172,932	9,098	1,074,280	581,690	9	2,403	12	2,134	...	26	...	...	80,987 4 9
Cadastral maps	4,376	3,211	3,257	4,484	4,484	...	151,557	...	142,519	142,519	...	...	...	...	...	...	...	...	...	...	...	65,722 5
Extra Departmental maps and plans	1,546	1,163	1,046	476	460	465	386,543	94,480	350,437	444,917	...	...	...	1,096	288	58	31,881	35	...	...	...	61,944 3 0
Totals	7,067	5,694	5,579	5,441	5,611	573	711,978	110,800	649,568	760,368	9,098	1,074,280	581,690	1,105	2,691	70	34,015	35	26	...	...	2,08,653 12 9
Totals of 1889-90	7,021	5,600	5,148	5,377	5,540	585	598,997	99,053	563,650	662,703	9,918	1,061,577	573,885	179	2,823	56	30,589	6	17	12	3,432	2,00,374 12
Differences	+ 48	+ 94	+ 431	+ 64	+ 71	− 12	+ 112,981	+ 11,747	+ 85,918	+ 97,665	− 820	+ 12,703	+ 7,805	+ 926	− 132	+ 14	+ 3,426	+ 29	+ 9	− 12	− 3,432	+ 8,279 0 3

455. The increase in the number of copies printed off zinc or stone has been general, and the colour printing again shows a very large increase of nearly 12,000 copies. The number of cadastral maps printed shows a falling off of fifteen, but on the other hand, the number of copies printed shows a large increase of 43,165. Of the surveys in the North-Western Provinces 2,308 sheets; of Burma 895 sheets; of Assam 1,173 sheets, were photozincographed or zincographed from tracings. Although there is some falling off in the number of items set up in the type-printing section this year, the number is still very far above the average, and there is an increase of 12,703 in pulls and of 7,805 in copies.

456. The preparation of the third and extended edition of the 32-mile map of India has progressed and the map was nearly completed for issue, but large additions of hill shading have still to be made on the stone of sheet 4, containing Burma, and as these will take some time to draw, the publication of the map will probably be delayed for some months. The conversion of the Military and Railway map of India, on the 32-mile scale into an ordinary departmental publication for general purposes, which was referred to in paragraph 478 of last year's report, has had to be stopped for the present owing to the pressure of more urgent work.

457. Among the statistical maps published may be noted:—Two railway maps of India with hills, on the scales of 48 and 64 miles to the inch; reprints of the railway map of India, on the 32-mile scale, and of India showing telegraphs, on the 96-mile scale, both corrected up to March 31st, 1891. Among the Provincial maps, new issues, with corrections and additions to railways, have been made of:—The Madras Presidency, North-Western Provinces and Oudh, and the Central Provinces, all on the scale of 1 inch = 32 miles; and also of the Presidency and Chittagong divisions, on the scale of 1 inch = 8 miles. Divisional maps of the North-Western Provinces and Oudh, Agra, Meerut, Rohilkhand, Fyzabad, and Lucknow, on the scale of 1 inch = 4 miles, were received for lithography, and some of them are in hand.

458. The following district maps, taken from the engraved plates of the Atlas of India, were lithographed during the year, *viz.*, Rungpore, Cachar, Darrang, Monghyr, Lakhimpur, Chittagong, Dacca, Jalpaiguri, and Singhbhoom; those of Bogra, Sylhet, Goalpara, Dinagepore, Shahabad, and the Naga Hills were transferred but not printed. Maps of district Darjeeling (skeleton), $\frac{1}{4}$-inch scale, and of districts Lahore, Bilaspur, and Ghazipur, on the $\frac{1}{2}$-inch scale, also a second edition of the map of the Garo Hills, on the same scale, were photo-

zincographed and printed off. A large number of standard sheets, amounting to 481, have been in hand, of which 239 have been published, exclusive of reprints. Among them may be noted 11 sheets of Bengal, districts Patna, Pubna, Monghyr, and Mymensingh; 11 sheets of Bombay, districts Ahmedabad, Belgaum, Dharwar, Mahi Kanta and Poona, all on the 1-inch scale: also 30 sheets of Lower Burma, districts Akyab, Hanthawaddy, Henzada, Pegu, Prome, and Tharrawaddy, on the 1-inch scale, and six quarter-sheets, on the 4-inch scale, districts Prome and Tounghoo; 13 sheets of the Central Provinces, districts Sambalpur, Betul, and Chhindwara; 33 sheets of the North Western-Provinces and Oudh, in districts Basti, Gorakhpur, Mirzapur, Agra, Gonda, Kheri and Bahraich, all on the 1-inch scale, and 3 sheets of Aligarh, Etah and Mainpuri, on the 2-inch scale. Of the North-East Frontier, 1 sheet on the 8-mile scale, and new editions of two sheets on the 4-mile scale. Of the South-East Frontier, 2 sheets on the 8-mile scale, and 15 sheets of new editions of maps already published, on the 4-mile scale; 5 sheets of the Punjab, districts Dera Ismail Khan, Jhang, Bikanir, and Bhakawali, Patiala, and Bhurtpur, on the 1-inch scale, besides, 11 sheets of districts Gurdaspur and Jummoo, on the 6-inch scale. Reprints with additions have been made of 59 sheets of the Madras survey, on the 1-inch scale, including new editions of several sheets of the Mysore survey with corrected boundaries; also of 21 sheets of the Central India and Rajputana surveys.

459. Among the city and cantonment plans published, may be noted a new edition of the plan of the city of Calcutta in two sheets, on the scale of 6 inches to the mile; a plan of the city and environs of Lahore, with the civil station and cantonment of Meean Meer, in six sheets, on the scale of 6 inches = 1 mile. Besides the above a large number of technical charts, index maps, and miscellaneous maps and items have been reproduced on account of the department.

460. A trial was made of reducing the original sheets of the new survey of the city of Calcutta from the scale of 1 inch = 50 feet to that of 16 inches = 1 mile with the object of preparing a map by heliogravure for general purposes. With considerable manipulation good results were obtained in this way, as will be seen from the specimen attached to the report of this survey at page 92. It was found, however, that the sheets were over-charged with many small details, which would have been superfluous and confusing on the smaller scale; and as the removal of these, and other necessary alterations and additions to details and names to render them suitable for the smaller scale, would have involved a large amount of labour on the photographic negatives and copper plates, it was considered desirable to have the sheets re-drawn specially for reduction, and this is now being carried out.

461. The amount of extra departmental work has again been very large. Among the principal items are a military map of India, on the scale of 32 miles to the inch; a forest map of the Punjab, lithographed in colours on the same scale, and a geological map of South Malabar in colours, on the 4-mile scale. A map of the communications in the Bengal Presidency in 17 sheets, on the 1-inch scale was printed off, and 61 sheets of the plan of the city of Mandalay, on the scale of 1 inch = 40 feet, with several maps of the Yenang Yaung and other oil-fields, have been photozincographed for the Chief Commissioner of British Burma. A very large number of maps and drawings have been lithographed and photozincographed for the Director General of Railways. Besides the usual weather charts and diagrams executed for the Meteorological offices, India and Bengal, the illustrations of the new monthly weather report which was started in January last have been taken up; they consist of five full page diagrams, in two printings each, monthly, and their reproduction by lithography has entailed a good deal of work. It is, however, now proposed to reproduce them by photozincography. Fourteen maps of field-firing were drawn, printed, and coloured for the Adjutant General's Office. Maps of 32 districts and plans of 33 civil stations in the Punjab were received for lithography, and most of them have been drawn and printed. The value of the work executed for other departments was R61,944·3, or R7,994·5 less than last year.

462. The heliogravure section has made good progress during the year, and the out-turn is steadily increasing all round. By the photo-etching process 70 plates have been produced and 34,015 copies printed; 35 photo-blocks have been prepared and 26 plates have been electrotyped, either as matrices or duplicates. The preparation of the plates of the Technical Art series has been

continued during the year, and 21 plates have been reproduced and distributed. Besides these, 17 plates of moths, etc., illustrating the Indian Museum notes on Economic Entomology, were prepared and partly printed, besides 29 half-tone blocks for the same publication which were prepared here and printed with the type at the Government Printing Office. This new branch of work, which is more fully detailed in the appendix, is likely to be very useful, and it is hoped that better results may be obtained by means of some finely ruled gratings received by Colonel Waterhouse from America. Mention may also be made of an illustration for the "Scientific Memoirs by Medical Officers of the Army in India:" this was reproduced on an orthochromatic plate from an original drawing executed in delicate shades of violet, blue, and reddish orange. The copper plate was printed at *one* operation in these three colours as well as in black, as will be seen in the annexed specimen.

463. Owing to Colonel Waterhouse's absence on furlough no further improvements have been made in working out the process of producing reversed positives on dry plates in the camera by means of thio-carbamides in the developing solution, which was reported on last year. Some experiments have been made with other salts of the same kind, but further working is still required to bring the process to a practical issue. Colonel Waterhouse has continued his investigations of the electrical action observed in the development of these reversed images, and has obtained evidence of the existence of distinct and, in some cases, comparatively strong electrical currents generated during the development of ordinary photographic dry plates. It is hoped that further experiment in this direction may throw light on the general theory of development of the invisible photographic image, and also possibly lead to a completely practical reversing process with the thio-carbamides.

464. In the course of his furlough Colonel Waterhouse visited the Ordnance Survey Office, Southampton; the "Institut Cartographique Militaire" at Brussels; the Imperial State Printing Office, Berlin; the "Imprimerie Nationale" and the Photographic section of the Geographical Department of the Ministry of War at Paris, and private establishments at Munich, with a view to obtaining information regarding the printing of copper plates by machinery, the production of half-tone photo-blocks, and other points connected with his work. He found that the various automatic copper-plate printing machines hitherto brought out had universally been found unsatisfactory, but that some gain in speed of printing could be obtained, either by cold printing with a fluid ink and dry paper in a specially powerful press worked by steam as at Southampton, or by the use of D presses worked by steam, which, however, requires the plate to be inked in the usual way by hand. One of the latter presses has been ordered for the office. Beyond several useful hints on various points, no important information could be obtained regarding the block processes which do not appear to be regularly worked at present in any of the Government institutions visited. Further details of these visits and of other technical points connected with the working of the various new processes tried, are given in the appendix.*

* Colonel Waterhouse reports well of the conduct and satisfactory carrying on of their duties by his principal assistants: Mr. H. L. Lepage, Mr. B. Mackenzie, Mr. D. Deas, Mr. E. A. LeFranc, Sergeant Vandyke and Mr. E dePyvah in the Printing sections; Messrs. H. Haward, J. Harrold, R. George, L. Lagnier, and W. Moore in the Photographic sections. Among the assistants and apprentices are mentioned Messrs, S U Ravenscroft, G. A. LeFranc, J. T. Meade, and C. J. Meade, G. Mackie P. Michael, and J. Makenzie, who have all worked satisfactorily. In the Lithographic sections the draftsmen have all worked well. Babu Umbica Churn Mookerjee and Munshi Abdul Hamid are specially mentioned. Babu Kali Podo Dass, a very promising young draftsman, died in May last and his loss has been very much felt. The clerks are also well reported on, specially Babu Kanny Sen, Head Clerk and Accountant, Babus Gopal Chunder Mookerjee, Kedar Nath Ghose, Rajani Kanto Chatterjee and Surji Kumar Banerjee. Babu Rassik Lal Shaw died in April last after a service of 24 years in the Lithographic Office: he was a very steady, hardworking man, well up in his work, and his loss also will be much felt. Shama Churn Chukerbutty, paper-keeper, had to retire on invalid pension. In the Photographic section the native assistants have done good work, especially Mahomed Ismail, Habeebul Hossain, Abdul Rahman, Umbica Churn Bhattacherjee, and Preonath Chatterjee.

SPECIMEN OF ORTHO-CHROMATIC REPRODUCTION FROM A COLOURED DRAWING AND OF COLOUR-PRINTING IN 4 TINTS FROM ONE COPPER-PLATE.

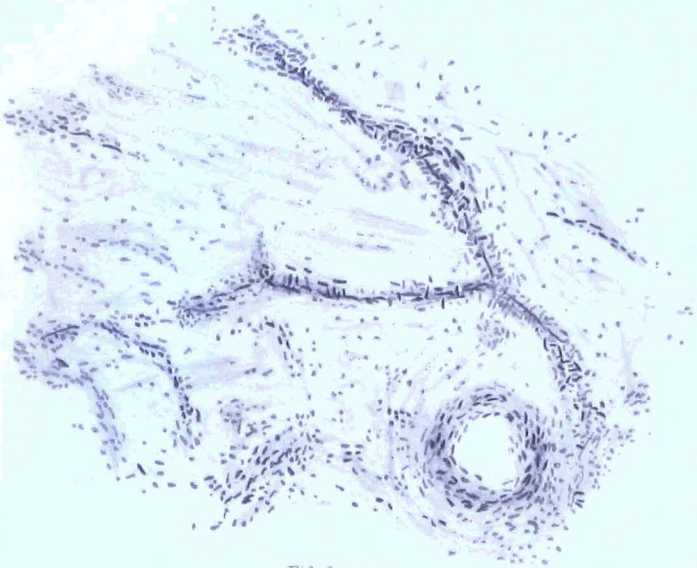


Fig 1. ×160.

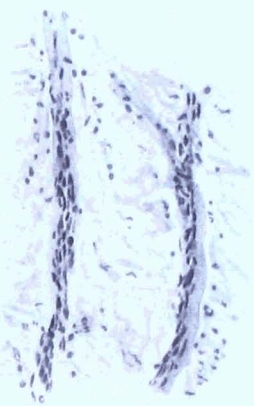


Fig 2. ×160.

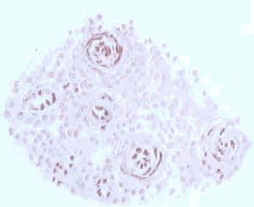


Fig 3. ×160.

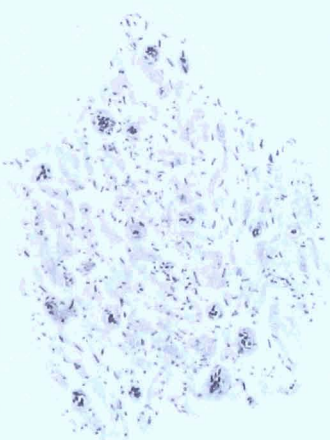


Fig 4. ×37.

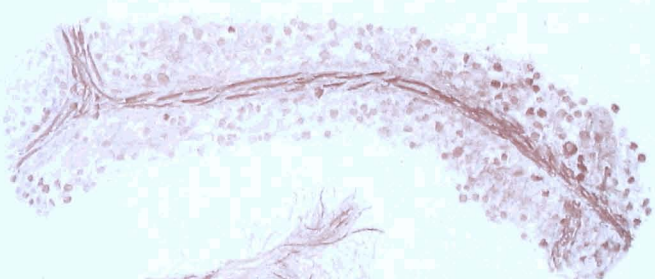


Fig 5. ×160.

Fig 7. ×160.

Fig 6. ×160.

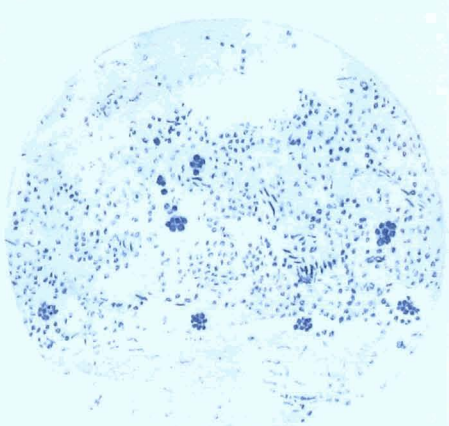


Fig 8. ×160.

MYCETOMA. CONDITION OF THE VESSELS IN THE INITIAL STAGES &c.

Photo-etching

Survey of India Offices, Calcutta. April 189

MAP RECORD AND ISSUE OFFICE.

Personnel.

Colonel W. H. Wilkins, S.C., officiating Assistant Surveyor-General, in charge.
Mr. A. E. Byrn, Head Assistant.
„ H. R. Vallis, Map Curator, and 13 clerks.
„ B. M. Wilson, Assistant Surveyor, 2nd grade, attached.

465. The general superintendence of this office has remained in the hands of Colonel W. H. Wilkins, S.C., throughout the year under report.

466. During the year, the number and value of maps issued were as follows :—

Maps issued.	Number.	Value.
		₹
General maps to Government officials	48,517	46,330
Ditto to India Office, London	7,088	10,774
Ditto to Agents	1,285	1,924
Ditto to private individuals	8,974	12,384
Total	65,864	71,412
Cadastral maps to Government officials	142,620	63,833
GRAND TOTAL	2,08,484	1,35,245

467. There has been a large increase in the number of maps issued and a corresponding increase in their value, as compared with last year's totals, which were 1,66,604 and 1,22,472, respectively.

468. During the year the actual cash sales amounted to ₹12,917, *viz.*, ₹12,384 realized from private individuals, and ₹533 from map sale agents showing an increase of ₹1,365 over the sales of the previous year. In the Revenue section, 754 applications were received for extracts from original records of the Revenue surveys and 4,177 certified copies of village plans, tracings and traverses were supplied at a cost of ₹8,901.

469. The details of work done are given in the following statement :—

Details.	Number.
Applications received for maps	5,445
Letters issued in reply	2,655
Cash and credit map sale bills	1,615
Invoices and receipts issued for published maps	2,154
Ditto ditto for cadastral maps	271
Ditto ditto for extracts from original records	315
Packets, parcels, and local despatches	3,412
Ditto received in the office	723
Packages despatched by rail and steamer	472
Ditto received by ditto	60
Maps, coloured, for sale and issue	29,727
Ditto for other departments	1,600

A list of the maps and charts published during the year is given at page 103.*

* Of the establishment in this office Mr. H. R. Vallis has discharged satisfactorily the arduous duties of map curator and salesman.

MATHEMATICAL INSTRUMENT OFFICE.

470. During the period under report the charge of this office has been held by Lieutenant-Colonel M. W. Rogers, R.E., Assistant Surveyor General, who also continued to hold the appointment of Patents Secretary.

Personnel.

Lieutenant-Colonel M. W. Rogers, R.E., Deputy Superintendent, 2nd grade, Assistant Surveyor-General in charge.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument Maker.
,, F. Marshall, Assistant Mathematical Instrument Maker.
197 artificers.

Store Branch.

Mr. W. Campagnac, Instrument storekeeper, up to January 1891.
,, M. C. Belletty, Ditto ditto, from January 1891.
Babu Woomesh Chunder Chowdhary, Material storekeeper.
1 packing sirkar and 2 packers.

Office Establishment.

Mr. C. O. Gray, Head Clerk, up to 31st December 1890.
,, W. Campagnac, Head Clerk, from 1st January 1891.
,, M. C. Belletty, 2nd Clerk, up to 31st December 1890.
,, W. R. Tulloch, Ditto, from 1st January 1891.
8 clerks.

471. The figures given in this report refer to the Financial year 1890-91, *i.e.*, from 1st April 1890 to 31st March 1891. During this period 63,196 serviceable instruments, valued at R2,59,909, were received into store, and 64,203 instruments, valued at R2,88,337, were issued; the number of serviceable instruments in store was therefore diminished by 1,007, whilst their value was diminished by R28,428.

472. The following tabular statement shows the principal sources from which the serviceable instruments were received:—

Sources of Receipt.	No.	Value.
		R
From England on indent	7,064	1,08,791
By purchase in the local market	21,062	32,550
Manufactured in workshop	19,069	26,581
Returned to store by public officers	887	23,345
From other manufacturing offices	3,250	89
,, repairable stock after repair	4,762	65,683
,, other services	7,102	2,870
TOTAL	63,196	2,59,909

473. The number and value of instruments obtained from England are considerably less than last year; but the value is much the same as that of the year 1888-89. It has been found necessary to increase the supply in the last indent submitted in order to meet to some extent the very large demands that are now being made for instruments. The purchases in the local market are a little in excess of last year in value, whilst the number of instruments manufactured in the workshop is smaller both in value and number, this decrease being balanced by a corresponding increase in the number and value of the repairs executed. Recourse to the local market for supplies is unavoidable owing to the impossibility of fore-seeing the demands of other departments for instruments and providing for them in the regular yearly indents on England. Sufficiently long notice is not generally given by Governments and departments of their probable requirements, and when their indents are sent in, the supplies are invariably required quickly.

474. The number of instruments taken from the repairable stock and rendered serviceable for issue is less both in number and value this year than last. This decrease is due to increased demands for current repairs to instruments sent in for that purpose, which, although the legitimate employment for the workshop, and one of the chief sources of the usefulness of the office, are of a kind which, whilst involving much care and expenditure of time, do not make a good show in the returns of the work of the office, as their money value is small. During the year the office received 3,668 repairable instruments (considerably less than the number received in either of the last two years) valued at R60,734. The total

issues from repairable stock were 4,785, valued at ₹43,801; these were repaired in the workshops at a cost of ₹21,882 and transferred at the enhanced value to the serviceable stock. The repairable stock has thus been diminished in number by 1,117 and increased in value by ₹16,933. This is satisfactory, as showing that there is no increasing accumulation of repairable instruments.

475. The conversion of old fashioned and obsolete theodolites and levels, alluded to in paragraph 494 of last year's report, has been continued, and in the financial year under report 16 theodolites and 25 levels were made into seviceable instruments, and all issued at a total value of ₹8,700, whilst in their original state they were useless for modern requirements. During the year 63,196 serviceable instruments have been received into store, making, with the 3,668 repairable instruments mentioned above, a total of 66,864 instruments.

476. During the year under report the resources of the Mathematical Instrument Office have been considerably strained by the requirements of the Meteorological Department, who have indented for the supply to almost the whole of India, of 5-inch rain gauges of an improved pattern furnished with spirit levels, testing gauges, and measuring glasses. The glasses have had to be obtained from England, but all the gauges have been made up in the workshops: their cost, however, does not enter into the accounts of this financial year.

477. Several large indents for cheap instruments have been received from the local Governments of the Central and North-Western Provinces, and these have been satisfactorily supplied; the Madras Revenue Survey has also indented largely on the office for measuring chains. A large amount of repairing work has been done for the Ordnance Department, chiefly in altering the service heliographs to agree with the new sealed pattern.

478. A considerable quantity of extra work has been thrown upon the office establishment by the new arrangement asked for by the Comptroller, India Treasuries, of demanding payments in cash for all charges under ₹50. This, and the general expansion of the work of the office, render advisable a small increase to the strength of the clerical establishment to prevent the work falling into arrears.

479. Table A (in the appendix) shows the amounts of debits against various offices and departments for instruments supplied and for work done. It also exhibits the credits for all instruments and materials returned to store. The value of the issues and repairs executed on book debit was ₹2,84,822, being ₹16,000 in excess of last year: this amount includes the value of instruments purchased with the extra-departmental grant of ₹36,000. The credits for instruments returned into store amounted to ₹84,666, which is slightly less than last year. The cash sales were ₹14,871 against ₹10,203 in last year.

480. During the previous year, 9,118 instruments valued at ₹29,505 were purchased in the local market. In the year under report the number was 20,013 and the value ₹32,551, the disproportion in the numbers and values being due to a larger number of items of very small value, such as pins for maps and chains, etc., being required. The actual number of instruments which have been manufactured in the workshop is about one-fourth less than last year, and their value is ₹4,000 less. This is due to a great extent to the larger number of repairs executed, and also to the fact that a large number of workshop manufactures were only partially completed at the date of closing the accounts, and therefore credit for them could not be taken. The figures for the last three years are given below:—

	Number.	Value. ₹
1888-89 . .	11,220	33,082
1889-90 . .	27,589	30,798
1890-91 . .	19,069	26,581

The class and value of these instruments will be found in Table C in the appendix.

481. The number of principal instruments repaired in the workshop is 2,473, which is almost the same as last year: the total number of instruments of all kinds repaired amounts to 3,565 compared with 3,104 in 1889-90.

482. The experience of the past year is the same as that of previous ones, and shows that the work of the Mathematical Instrument Office is steadily increasing, and that the demands for instruments and repairs become larger yearly, as is only to be expected from the large increase in survey, and other kinds of

work for which instruments are necessary. The Survey of India Department, although still the largest customer, took this year under one-fifth of the total instruments issued.

483. Stock taking has been carried on at intervals during the year whenever the services of one of the Mathematical Instrument Makers was available, but the ordinary business of the workshops now so fully employs their time that little progress has been made in it during the year under report. As it is desirable to complete the present stock-taking at an early date, arrangements will be made to depute an officer of the department specially for the duty.

484. The profit and loss account of the workshop will be found in the appendix; the result of the operations showing an apparent loss of ₹8,021 compared with an apparent loss of ₹1,213 on last year's work. This difference is due to there having been an unusually large amount of unfinished work in hand in the workshops on the 1st April when the balance was struck, which could not be brought to account. This will give an extra amount to be shown as gain in next year's accounts.*

II.—TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

485. The work of the office is divided into the following sections:—

(1) Correspondence, Accounts and Records.
(2) Computing.
(3) Type-printing.
(4) Drawing and compiling.
(5) Photozincography.
(6) Solar Photography.
(7) Miscellaneous.

486. The principal work is the final reduction and publication of the operations of the trigonometrical survey, and to the carrying out of this, each of the first five sections, mentioned above, contributes. The office has to deal with the principal chains of triangulation spread over the whole of India and the secondary triangulation executed in connection therewith; the astronomical observations for the determinations of azimuth and of latitude and electro-telegraphic determinations of differences of longitude; also with spirit-levelling operations and tidal observations.

Personnel.

Colonel G. Strahan, R.E., Deputy Surveyor-General, in charge Trigonometrical Branch.

Mr. W. H. Cole, M.A., Officiating Deputy Surveyor-General, from 27th October 1890 to 28th January 1891, and Deputy Superintendent, 2nd grade, in charge Computing Party, from 1st October 1890 to 26th October 1890, and 29th January to 1st April 1891.

Mr. J. Eccles, M.A., Deputy Superintendent, 4th grade, in charge Computing Party, from 27th October 1890 to 28th January 1891, and 2nd April to 30th September 1891.

Lieutenant J. M. Burn, R.E., Assistant Superintendent, 2nd grade, from 10th May to 30th September 1891.

(1) Correspondence, Accounts and Records.

Mr. F. A. D'Rozario, Head Clerk, and 4 other writers.

(2) Computing.

Mr. H. W. Peychers, Surveyor, 2nd grade.
Mr. L. J. Pocock, Surveyor, 2nd grade.
Mr. H. G. Shaw, Assistant Surveyor, 3rd grade.
Babu Cally Mohan Ghose, Senior Computer.
Babu Kally Coomar Chatterjee, Computer.
Babu Amba Prasad, Computer, and 27 other permanent and temporary Computers, Recorder, and Account keeper and Librarian.

(3) Type-printing.

Mr. B. V. Hughes, Printer, 18 compositors and temporary hands.

(4) Drawing and Compiling.

Mr. C. H. McA'Fee, Surveyor, 3rd grade, 5 Draftsmen, 1 Sub-surveyor, and 11 Assistant and Apprentice Draftsmen.

(5) Photozincography.

Mr T. S. Manuel, Assistant Zincographer, 2 Assistant Photographers, 2 Native draftsmen, and 1 Map-keeper.

(6) Solar Photography.

Mr. C. F. Guthrie, Assistant Solar Photographer.

487. The reduction of the tidal observations is however made in the field party office; it is only in the compilation and publication of the results that this office is concerned. The calculations of observations for latitude, longitude, azimuth, etc., taken by various explorers are also performed in this office, and of late years a good deal of work has been done in this respect, not only in connection with explorations carried out by the Survey Department, but also by officers of other departments.

* Colonel Rogers reports most favourably on the zeal and ability with which Messrs. Bolton and Marshall have carried out the work during the past year, and states that the office is very fortunate in having the services of two such capable officers.

The correspondence and store branches under Messrs. Gray, Campagnac, and Belletty have worked well and satisfactorily, and these officers report well of all their subordinates.

488. The drawing and compiling section and the photozincographic section, although existing as auxiliaries to the computing section, for the publication of maps, charts, etc., required to illustrate the operations of the trigonometrical survey, have besides been engaged with other work; the former with the compilation and publication of exploration maps, charts of levels determined by railway and canal officers, and other miscellaneous maps; and the latter with a very considerable amount of work for the Forest Department, and for the Quarter Master General's Department.

489. The solar photography has been continued as usual; the work was started in 1877 at the request of the Industry, Science and Art Department, conveyed through the Secretary of State. At first the pictures were 4 inches in diameter, but later on they were increased to 8 and 12 inches in diameter. The 12-inch pictures are only taken when special features show themselves on the sun's surface. In addition to the ordinary daily routine of photographing the sun, some photographs of the planet Mercury during its transit across the solar disc on the morning of the 10th of May were obtained.

490 The work of the miscellaneous section is chiefly in looking after the depôt of instruments and stores appertaining to the trigonometrical branch of the survey, and of a special equipment for mobilisation which has now to be maintained on a large scale. It also includes the training of officers and explorers both of this and other departments, and certain scientific investigations which have to be made from time to time.

491. During the year under report, the office has been engaged in passing through the press volume XIV of the Account of the operations of the Great Trigonometrical Survey, containing the final reduction of the principal triangulation of the South-West Quadrilateral: this has been bound and issued. The volume dealing with electro-telegraphic differences of longitude, which will be the fifteenth of the series of professional volumes, has also been going through the press; and a beginning has been made with the printing of the letter press of the volume on tidal operations.

492. The synoptical volumes of the several chains of principal triangles, which are required by local officials and detail surveyors, have made rapid progress. Six of the Southern Trigon and one of the North-East Quadrilateral were occupying special attention. Of these, two have been printed and are now in the hands of the binder, another is about half printed, while the compilation of three others is nearly completed, and there remains only one which is still in a backward state. Some progress has also been made with the synoptical volumes of the South-West Quadrilateral, six in number. Hand-books for the Trigonometrical and Topographical branches have been printed, and two pamphlets of spirit-levelled heights, *viz.*, No. 5, Bombay Presidency, and No. 6, Madras Presidency, were printed, bound and issued: reprints of two exploration reports were also completed, of which one has been bound and issued, and the other is in the hands of the binder.

493. In addition to the regular work of the office, assistance has been afforded to the field parties as follows:—Two computers were lent for three weeks to the Astronomical parties, two computers were engaged for one month in preparing data for the officer who accompanied the Hazara Field Force, and two computers were employed for one month in the reduction of certain calculations appertaining to the triangulation in Baluchistan. The work done by the drawing and compiling section and by the photozincographic section will be found detailed in the appendix.

494. Photographs of the sun have been taken throughout the year on all days that the sun was visible, and the negatives sent to England to the Solar Physics Committee at South Kensington. The results of these photographs are included in the yearly volumes of the Greenwich observations.

495. Meteorological observations, including the record of the deep sunk thermometers, have continued to be taken as heretofore; the sunshine record has also been maintained. The preservation and issue of instruments have been supervised as usual, and the special equipment referred to above kept in an efficient state. One officer of the senior division and 32 candidates for the junior division have been examined, and one officer has received special instruction in the use of instruments appertaining to the scientific work of this branch. Further details of the work done will be found in the appendix.

496. The Surveyor-General inspected the Head-Quarter offices of the trigonometrical branch at Mussooree and Dehra in October 1891. The work in the various sections was found to be in efficient order and gave evidence of skilful administration. With the increased means placed at the disposal of the computing section for expanding the staff of computers, with a view to expediting the completion of the final reduction and publication of the trigonometrical records of past years, considerable progress had been made, but not so great as might have been expected. This was due to the small material assistance obtained from the new hands owing to the necessity of their being trained in the work required, and to their utilising the office as a stepping-stone for other appointments, from the fact of their being aware that the employment in the computing office is only of a temporary nature. Every endeavour is being made to push on the work as rapidly as is possible in the circumstances.*

III.—DRAWING OFFICE, SIMLA.

497. Under the orders of the Government of India the general supervision of this office is carried on during the recess season by the officer in charge of the Baluchistan party in addition to his other duties. During the field season the general superintendence of the office remains in the hands of the Deputy Quarter Master General, Intelligence Branch. Thus Colonel Woodthorpe, C.B., R.E., of the Quarter Master General's Department, held charge of the office from the commencement of the year under report until the 15th of March 1891, and again from the 10th of April, when Colonel Holdich proceeded on furlough, until the 22nd of June, when Captain Mackenzie, R.E., then in charge of the Baluchistan party, returned from the Miranzai expedition. As, however, Captain Mackenzie's services were shortly afterwards required at Quetta to superintend the recess work of No. 15 party, the services of Captain Wahab, R.E., who was on special duty in Simla in connection with the final mapping of the work done on the Black Mountain and Miranzai border, were utilized for superintending the work of the office until the close of the year under report.

Personnel.

Lieutenant-Colonel T. H. Holdich, R.E., Deputy Superintendent, 1st grade, in charge.
Mr. G. W. E. Atkinson, Surveyor, 1st grade.
„ W. J. Cornelius, „ 4th „
„ A. Kitchen, Assistant Surveyor, 1st grade.
„ F. E. Warde „ „ 2nd „
„ F. Rozario, Sub-Surveyor.
„ H. Sindon, Draftsman.
Munshi Jafir Khan, Draftsman.
Mr. W. Manly, Assistant Draftsman, and four other draftsmen.

498. The principal work of the season has been the preparation of the sheets of the North-West Frontier Series and of the South-West Asia Series, on the scale of 1 inch=8 miles. In addition to these, several miscellaneous maps have been prepared, illustrating the expeditions to the Zhob and Gomal valleys, to the Miranzai and Hazara borders, and certain explorations in Persia.

499. A new edition of the Turkestan map, on the scale of 32 miles to the inch, has also been under preparation. This has involved the entire re-drawing of the map, owing to the large number of corrections and additions rendered necessary by recent surveys. The two southern quarter sheets are completed in outline, and the two northern ones will shortly be commenced. The final map will be printed in two colours.

500. A new general map of Baluchistan on the 16-mile scale has been commenced and is nearly completed: owing to the urgency of the demand for this map, the present issue is only a preliminary one, and to save time in its preparation typing has been used instead of hand-printing. A final edition in two colours will be taken up when the $\frac{1}{4}$-inch survey of Baluchistan is completed.†

* Mr. Eccles reports very highly of his assistants, making special mention of Messrs. Peychers Mc A'Fee. Hughes, Manuel and Guthrie, who stand at the head of their respective sections; and of Messrs. Pocock and Shaw. He also bears testimony to the good work of the computers and draftsmen.

The Deputy Surveyor General reports very favourably on the services rendered by Mr. D'Rozario, the head clerk, and Babu Hira Singh, 2nd clerk of his office.

† The officer in charge reports as follows:—Of the assistants, Mr. Atkinson has borne much of the responsibility for the conduct of the office during the necessarily long absences of the Deputy Superintendent in charge. I cannot speak too highly of the ability and discretion with which his duties have been carried out.

Mr. Cornelius has maintained his high reputation as a careful and trustworthy compiler, as well as a rapid, skilful draftsman.

Mr. Kitchen has also done excellent work throughout the year both as a compiler and draftsman.

Mr. Rozario, with the draftsmen Messrs. Sindon and Manly, as well as Jafir Khan and Abdul Aziz are also well reported on.

LIST OF MAPS AND CHARTS PUBLISHED DURING THE YEAR 1890-91.

Title.	Scale.	Number of Sheets.	Remarks.
	In. M.		
Atlas of India.			
Sheet No. 15	1=4	1	With additions to 1890.
Sheet No. 47	1=4	1	With additions to railways and corrections to boundaries to 1891.
Quarter sheets Nos. 35 N. W., 48 S. E., and 131 S. W.	1=4	3	With additions to 1889.
Quarter sheets Nos. 13 N. W., 21 S. W., and 60 N. W.	1=4	3	With additions to 1890.
Quarter sheet No. 39 S. W.	1=4	1	With additions to 1891.
Quarter sheet No. 131 N. E.	1=4	1	
General Maps.			
Afghanistan	1=24	4	
Provincial Maps.			
Bombay Presidency	1=32	1	With additions and corrections to 1890.
Central Provinces, 1886	1=32	1	With additions to railways to July 1891.
Madras Presidency	1=32	1	With additions to railways to August 1890.
N.-W. Provinces and Oudh	1=32	1	With corrections to 31st March 1891.
Divisional Maps.			
Chittagong (Bengal)	1=8	1	
Presidency Division (Bengal)	1=8	1	With additions and corrections to railways and boundaries to February 1890.
District Maps.			
Bilaspur (Central Provinces)	1=2	5	One map in 2 and the other in 3 sheets.
Ghazipur (N.-W. P.)	1=2	2	
Garo Hills (Assam)	1=2	4	2nd edition.
Cachar (do.)	1=4	1	With additions and corrections to May 1890.
Darrang (do.)	1=4	1	With additions and corrections to July 1890.
Lakhimpur (do.)	1=4	1	With additions and corrections to boundaries and roads to May 1890.
Chittagong (Bengal)	1=4	2	With corrections to July 1890.
Darjeeling (do.)	1=4	1	Skeleton.
Dacca (do.)	1=4	1	With additions to boundaries and corrections to railway to March 1891.
Jalpaiguri and Cooch Behar (do.)	1=4	1	With additions and corrections to roads and boundaries up to April 1890.
Monghyr (do.)	1=4	1	With additions and corrections to roads and boundaries up to September 1889.
Rungpur (do.)	1=4	1	With additions and corrections to June 1889.
Singhboom (do.)	1=4	1	With additions and corrections to April 1891.
Standard Maps.			
Assam.			
Sheet No. 25	1=1	1	Preliminary edition.

Title.	Scale.	Number of Sheets.	Remarks.
Standard Maps—*contd.*			
Bengal.	In. M.		
Sheets Nos. 3, 20, 22, 40, 41, 42, 96, 123, 156, 345, and 360. .	1=1	11	
Bombay.			
Sheets Nos. 278 N. E., N. W., S. E. and S. W. . .	2=1	4	
Sheets Nos. 145, 146, 179, 233, 244, 277, 331, 352, 353, and 353 A.	1=1	10	
Sheet No. 198.	1=1	1	With additions and corrections to railways to May 1891.
Burma (Lower).			
Sheets Nos. 225 N. E./3, N. W./4, S. E./1, S. E./4. . . .	4=1	4	
Sheets Nos. 226 N. E./2 and N. E./4.	4=1	2	
Sheets Nos. 7, 8, 9, 10, 24, 25, 26, 27, 28, 43, 44, 45, 46, 47, 180, 228, 229, 230, 235, 236, 276, 277, 282, 283, 322, 323, 324, 325, 327, and 328.	1=1	30	
Central India and Rajputana.			
Sheets Nos. 200, 254, 283, 284, 285, 312, 338, 339, 340, 341, 362, 368, 380, 389, 390, 391, 392, 393, 468, 477, and 479. .	1=1	21	
Central Provinces.			
Sheets Nos. 12 S. E./2, S. E./4, 13 N. E./2, 19 N. E./1, N. E./3, N. E./4, S. E./2, S. E./3, S. E./4, S. E./1 and 2, S. W./1, S. W./2, S. W./3, N. W./4, 20 N. W./1, N. W./3, (N. E./1 and 19 S. E./3) (19 S. E./3 and 20 N. E./1) in one, (19 S. W./4 and 20 N. W./2) in one, (26 S. W./3 and S. W./4) in one, 26 N. W./3 and 26 S. W./1 and 2	4=1	22	
Sheet No. 19 N. E./2.	4=1	1	2nd edition.
Sheets Nos. 32, 236, 237, 238, 239, 251, 252, 253, 254, 262, 263, 264, and 265.	1=1	13	
Madras.			
Sheets Nos. 1, 2, 3, 9, 10, 11, 12, 13, 14, 15, 23, 24, 25, 26, 27, 28, 29, 30, 31, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 68, 69, 70, 71, 72, 73, 74, 76, 77, 78, 79, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 135, 136, 137, 138, 139, 140, 171, and 203.	1=1	59	With corrections to roads and boundaries, 1890.
N-W. Provinces and Oudh.			
Sheets Nos. 12A, 26, 99, 113, 115, 145, 158, 159, 163, 167, 168, 172, 173, 174, 175, 176. 181, 188, 189, 190, 191, 192, 197, 199, 203, 204, 205, 206, 213, 214, and 215. . .	1=1	31	
Sheet No. 43.	1=1	1	With additions to railways to July 1891.
Sheets Nos. 53 N. W., S. W., and 185 S. E. . . .	2=1	3	
Punjab.			
Sheets Nos. 231 N. E./9, S. E./2, S. E./3, S. E./5, S. E./6, S. E./9 232 N. E./3, 246 S. W./1, S. W./4, S. W./7 and 247 N. W./1. .	6=1	11	
Sheets Nos. 246 N. E./1, N. E./2, N. E./3, N. E./4, N. W./4, 285 N. W./1, N. W./2, N. W./3, 310 N. E./1 and 2, 310 N. E./4. . .	4=1	10	
Sheet No. 90.	1=1	1	2nd edition.
Sheets Nos. 144, 262, 280, and 325.	1=1	4	
North-Eastern Frontier Series.			
Sheet No. 15.	1=8	1	
Sheet No. 23 N. W.	1=4	1	4th edition.
Sheet No. 23 S. W.	1=4	1	3rd edition.

Title.	Scale.	Number of Sheets.	Remarks.
Standard Maps—*contd.*			
South Eastern Frontier Sereis.	In. M.		
Sheets Nos. 3A and 7	1=8	2	Preliminary editions.
Sheet No. 1 S. E.	1=4	1	4th edition.
Sheet No. 1 S. W.	1=4	1	
Sheet No. 2 N. E.	1=4	1	6th edition.
Sheet No. 2 S. E.	1=4	1	3rd edition.
Sheet No. 4 N. E.	1=4	1	2nd edition.
Sheet No. 4 N. W.	1=4	1	3rd edition.
Sheet No. 4 S. E.	1=4	1	2nd edition.
Sheet No. 4 S. W.	1=4	1	4th edition.
Sheet No. 5 N. E.	1=4	1	2nd edition.
Sheet No. 5 N. W.	1=4	1	4th edition.
Sheet No. 5 S. E.	1=4	1	2nd edition.
Sheet No. 5 S. W.	1=4	1	4th edition.
Sheet No. 6 N. W.	1=4	1	5th edition.
Plans of Cities and Cantonments.			
City of Calcutta	6=1	2	2nd edition.
City and environs of Lahore, with Civil Station and Cantonment of Mean Meer 1889-90	6=1	6	
Ferozepore Cantonment	6=1	1	
Rawalpindi Civil Station Cantonment, Town and environs, 1865-66	6=1	2	Partially corrected to 1890.
Town of Calcutta, showing boundaries of Wards	2=1	1	
Index Maps.			
Standard sheets of the North-Western Provinces and Oudh	1=48	1	
Standard sheets of Madras	1=48	2	
Index Chart of Triangulation of the Great Trigonometrical Survey of India	1=96	1	Corrected to 31st October 1890.
Statistical Maps.			
India, showing feeders to Railways, 1889-90	1=32	6	
Railway Map of India	1=32	6	Corrected to March 1891.
India, showing Railways	1=96	1	Corrected up to 31st March 1891.
India, illustrating the gauges of Railways	1=96	1	Corrected to 30th June 1890.
India, showing Telegraphs	1=96	1	Corrected to 31st March 1891.
Miscellaneous Maps.			
Kuttalam reserved forests, etc., Tenkasi taluk, Tinnevelly district, Madras	4=1	1	
Krishnapuram reserved forests, etc., Tenkasi taluk, Tinnevelly district, Madras	4=1	1	
Reserved forest, Block II, Shingalvariyar, Periyakulam taluk, Madura district, Madras	4=1	1	
Vasudevanallur reserved forests, Sankaranainarkoil taluk, Tinnevelly district, Madras	4=1	2	
Srivilliputur reserved forests, Srivilliputur taluk, Tinnevelly district, Madras	4=1	6	
Katankulam reserved lands, Srivilliputur taluk, Tinnevelly district, Madras	4=1	1	
Sirumalai reserved forests (Blocks I Serumalai, II Kachaikati), Dindigul and Madura taluks	4=1	2	
Reserved lands, Srivilliputur taluk, Tinnevelly district, Madras	4=1	2	
Ayyalur reserved forests, Dindigul taluk, Madura district, Madras	4=1	1	
Kadaiyanallur reserved forest and Reserved Lands Tenkasi taluk, Tinnevelly district, Madras	4=1	1	
Kapura Vallikutu and Akkamakardu reserved forests, Dindigul taluk, Madura district, Madras	4=1	1	
Tenkal reserved forest, Dindigul taluk, Madura district, Madras	4=1	1	
Parumalmulai reserved forest, Periyakulam taluk, Madura district, Madras	4=1	1	
Hazara Expedition, 1891	2=1	1	Preliminary issue.
Khanki valley (Miranzai border)	1=1	1	Do.
Ditto ditto	1=1	1	Do. (with additions.)
Part of Hazara and adjacent Independent Territory	1=2	1	
Preliminary Map of Chin hills	1=4	1	

Title.	Scale.	Number of Sheets.	Remarks.
Miscellaneous Maps—*contd.*	In. M.		
Reconnaissance of country traversed by the Anglo-Siamese Boundary Commission, 1889-90	1=4	2	
Preliminary Map of the Anglo-Siamese Boundary Commission, 1889-90	1=12	1	
Road Map of Punjab showing ferries, dâk-bungalows, etc., 1879	1=16	2	With additions to railways to May 1891.
Skeleton Map of the Baluchistan and Sind Frontier	1=32	1	With additions to railways up to 1891.
Skeleton Map of the Afghanistan and Punjab Frontier	1=32	1	With additions to railways up to 1891.
Skeleton Map of Burma and Assam Frontier	1=32	1	With additions to railways up to 1891.
Triangulation Charts.			
Gujarat Survey, triangulation and traversing, quarter degree sheet XV, season 1885-86	1=2	1	
Nos. 56, 57 and 58 of Burma coast (between Kutubdia Light-house and Akyab) showing the positions of beacons, etc., 1889-90	1=2	3	
Mandalay series, season 1889-90 (Preliminary)	1=4	1	
Mandalay series, seasons 1889-90-91 (Preliminary)	1=4	1	
Gujarat Survey, triangulation and traversing, seasons 1873-85, quarter degree sheet II	1=4	1	
Gujarat Survey, triangulation and traversing, quarter degree sheet XV, season 1885-86	1=2	1	

APPENDIX.

EXTRACTS

FROM

REPORTS BY EXECUTIVE OFFICERS.

UPPER BURMA TRIANGULATION.

Statement of the out-turn of work executed by No. 24 Party during Season 1890-91.

Description of details.	
Number of principal stations newly fixed	5
„ „ „ triangles completed	8
Length of principal series in miles completed	44
„ „ approximate series in miles in advance	175
Area of principal triangulation, in square miles	900
Average triangular error, in seconds	0″·36
„ probable error of angles, in seconds	0″·15
Astronomical azimuths of verification	2
Number of principal stations selected in advance	13
„ „ platforms constructed for principal stations	18
„ „ principal stations placed under official protection and protected	13
„ „ principal stations, the elements of which have been computed	5
Area embraced by the triangulation to points exterior to principal triangulation, in square miles	120
Number of points fixed by intersection, but not visited	2
„ „ stations and points, the heights of which have been determined	7
„ „ miles of rays and pathways cleared	50
„ „ preliminary charts of triangulation	1
„ „ hill-tops cleared of forest or jungle	12

GUJARAT, BOMBAY PRESIDENCY.

Extract from a Report by MR. W. STOTESBURY, *Surveyor, 3rd grade, attached to No. 10 Party,—Season 1890-91.*

The eastern portion of sheet 183 came under survey this season, and embraced a small part of the petty State of Narukot (now under British administration) and a large tract of the Chota Udeypur State.

One long range of hills enters the sheet at the extreme north-east corner and abruptly ends at Kudval; another range starts a little to the east of this place, and runs parallel to the former range and a few miles south of it. It may be said to begin in the remarkable block locally known as Ráyapura. From Ráyapura hill the range runs westwards, its northern face being very precipitous, while the southern face slopes gently for a few hundred feet, and then breaks up into a most intricate mass of low flat mounds of reddish clay with outcrops of granite and quartz, the whole cut up by a net work of ravines dense-

ly clothed with bamboo and thorny jungle. This mass of hills is about 4 miles wide, and some of the drainage breaking through the main ridge flows northwards through tremendous gorges, the precipices being on either side 600 to 700 feet in depth. The villagers cultivate a great part of the lower flat hills and slopes, felling and burning the forest and scattering the seed broadcast on the ashes when cool. There are a few isolated hills lying towards the south and east, some of them being very high and of a conical shape, forming conspicuous landmarks; of these the most prominent is called Masabar, lying 2½ miles north of the railway station of Bodeli, the terminus, for the present, of the Gaekwar's State Railway system on this side; another conical hill is Monju, 3 miles east of Jambughoda.

The only stronghold of any importance in this sheet is Páwagad. This remarkable hill forms a conspicuous landmark on the eastern horizon, as the traveller journeys by the Bombay, Baroda and Central India Railway after passing Baroda, from which place it is about 25 miles distant. It is an isolated block, the highest point in the country for miles around, and from its geological formation it is quite apparent that it belongs to the same group as the western ghâts, though separated from those mountains by about 50 miles of hill and plain, along which not a single feature is met with which bears any resemblance geologically to either Páwagad or the main chain of the ghâts. The height of Páwagad above mean sea-level is 2, 811 feet, and that of the plains at its base barely 400 feet.

A good road from Hálol, 5 miles westwards, leads to the old, historical, but now deserted city of Champáner, lying at the foot of Páwagad towards the north. From Champáner a well-made path ascends towards the fort along a gently sloping spur; the road winds up by easy gradients through the old Attock gate into a walled space, enclosing the ruins of an extensive city now lying desolate and overgrown with thick jungle. The old streets and houses are still distinctly traceable, but all is desolation and ruin; not a human being lives here; the only occupants of these old ruins now being large quantities of peafowl, jungle fowl, wild pigs, and a few deer. A little way up a deep tank with stone-faced sides is met with. This is called the 'Mendhi tank,' and along its banks lie carved pillars and sculptured blocks, with here and there an old temple or stately mansion more or less in ruin. Leaving this tank the road begins to rise more steeply, and after climbing up about a quarter of a mile, another walled enclosure is entered by a splendid arched gateway; the wall here is built up of immense stones, beautifully squared and dressed, and is 15 to 20 feet high, and the same in thickness, with another crenelated wall and platform on the top closely loopholed for musketry, with here and there strong bastions provided with gun embrasures. A ditch exists in places, but at present most of it has been filled up with the *debris* from the ruined wall itself and from the adjacent houses. From this gateway the road has been cleverly led through intricate gullies, flanked and enfiladed by high loopholed walls, and a little higher up, after passing through the remains of old gardens with ruined reservoirs for water, another enclosure is entered, containing a few buildings of modern date, one of which is used as a guard-house to accommodate the small guard of police quartered here to keep order among the thousands of pilgrims who visit this spot, in order to pay their devotions at the shrines on the summit of the hill. Another large double-storied building is now used as a *dharmsála* or rest-house. There are two tanks up here filled with water, called the Telia and Vasvel tanks, which are frightfully foul and used by the pilgrims for ablutions, cooking, washing clothes and by cattle indiscriminately. On passing out of this enclosure an old building, with three magnificent domes, is met with, and below are large reservoirs of water which are reached through holes in the floor: a little higher up the road bifurcates, one branch going off to the left along a flat spur to a temple dedicated to *Bhadar Káli Mátá*. This stands on the top of a flat knoll, surrounded on three sides by tremendous precipices 600 to 800 feet deep. At the point where the two paths meet the precipice from Bhadar Káli is joined on to the main block of the hill, and in the angle thus formed is a terrific chasm, 600 feet deep and only 150 yards wide. A hundred feet or so higher up from this point the road rises to the brink of a yawning gulf, 50 feet deep and 20 feet wide, across which a light wooden bridge is carried. In former days a draw bridge was dropped over this gulf from the gateway opposite, and this must have been a very strong obstacle in the way of an enemy, for there is no other way except through the gate; on the left being the escarped rock crowned by a loopholed wall 20 feet above the road, in front the yawning gulf commanded by the tower through which is carried the road, and on the right the steep slope of the hill which offers no foothold for hundreds of feet. On crossing the bridge and passing through the gateway the road narrows to about 6 feet and is cut through the solid rock, a parapet 6 to 8 feet only being left on the right, while the rock rises sheer on the left to a height of 50 feet. The path is carried upward in this way across the face of the precipice, the last gateway is entered and the citadel is reached. The top of the precipice is crowned by a strong wall with bastions and gun platforms at every commanding turn and point of vantage, and thus the whole of the lower fortifications and the road up are entirely enfiladed from the citadel. The interior of the citadel consists of a flat plateau and is some 2,000 feet above the level of the base of the hill. From the centre of this table-land another hump of rock rises to a height of 250 feet with precipitous sides; its summit is crowned by the temple of Káli Mátá, and near it lies the shrine of a Mahommedan saint, Sadan Pir, both being located under the same roof and separated from each other by only a thin wall. The path after leaving the gateway runs south-east at the base of the central bluff close by the Chhasia tank, generally dry, and past several beautifully sculptured old Jain temples rapidly falling into ruin.

On reaching the southern foot of the crag the path trends northwards and skirts another tank, which, from the whitish color of the water in it, is called the Dudhia tank. On its northern bank there is a fine Jain temple, with fluted dome dedicated to Bhadrinath; from this temple a flight of stone steps carries the path up the face of the precipice, and so to the summit of the central ridge or hump, the keep of the upper plateau and fort. Near the summit is the platform enclosing a station of the Great Trigonometrical Survey, and a few more stone steps lead up hence to the gateway into the enclosure, in which are the two shrines previously alluded to. A glorious view of the surrounding country is to be had from here: to the east, in the hazy distance, are visible the high peaks and ranges of the Vindhya mountains which may be said to end here; southwards and westwards stretch the black cotton-soil plains of Gujarat, dotted with hundreds of villages, and here and there sparkle the many small tanks met with all over this part of the country. About eight miles to the south-west, is seen the large sheet of water, some 4 square miles in extent of the Suriya lake, built by the Gaekwar's Government at a cost of several lakhs of rupees for the water-supply project of the town of Baroda.

The old city of Champáner which lies at the foot of Páwagad towards the north-east, is now a heap of ruins, containing a few shops, a temple or two, and a police station, with a population of hardly a hundred souls. Its magnificent ruins can be traced for miles around to the east and west, and cover an area of fully 8 square miles; several fine temples still standing testify to the grandeur and magnificence of this once populous and flourishing city. The grandest of these is the Jama Masjid, situated just outside the walls of the city towards the north-east angle, which must have been a beautiful building in its day. It is built of stone; the domes are most cleverly raised on square bases and both the interior and exterior of the domes and of the whole building are faced with well-dressed stone slabs of very large size. The minarets rise gracefully at either end, and are elaborately ornamented with sculpture. Several other smaller masjids are met with lying desolate in the midst of dense thorn jungle; some of them rapidly falling into decay; among these are the Wandra, the Kamina, and the Nagina Masjids lying north of the city, and the Panch Mahuda on the west. A mile further west is a single minaret called the "E al Minar," and within the old city walls opposite the Attock gate of the Páwagad fort is a large masjid now used as a traveller's bungalow. On the top of the hill is another five-domed building, called Makái Kothar, said to have been used as a granary in the old days; this building is also used as a rest-house for Europeans visiting the hill. The Jama Masjid has just been repaired by the British Government.

BELUCHISTAN.

Extract from a report by MR. E. GRAHAM, *Assistant Surveyor, 1st grade, on his Survey operations in Makran, Season 1890-91.*

The detachment assembled at Karachi on the 23rd of October, and after arranging for transport supplies, left for Bela on the 7th of November. The programme was to continue the Makran series from the most western base laid down last year west of Las Bela, following as nearly as possible the parallel of 26°, so as to connect with the triangulation executed in South West Baluchistan the previous season, and having effected this junction, to lay down as many points as possible over the remaining untriangulated area.

In starting work, I decided to lay out a degree in longitude at a time, and then complete the observations in this degree. I was just completing those of the first degree, when Sir Robert Sandeman's camp arrived, and I applied to the Political Agent, South-West Baluchistan, who was with Sir Roberts' camp at the time, for an escort, to enable me to carry on the work in the next degree. This was refused on political grounds, and I therefore determined to march to Kej and work down towards Pasni and Gwádar.

On arrival at Kej I started the triangulation in the direction of Pasni. I found that the country offered every facility for a very perfect series of quadrilaterals. It would follow the Kolwah and Kej valleys, which are practically one and the same, there being no *kotal* between the two worthy of that name. On either side of the valley was a range of hills running parallel to it, the distance between the two ranges varying between 18 and 20 miles. The weather was very hazy, the heat unbearable, and the haze made me quite despair of carrying the series down to Pasni that season. When I had got half through, I was warned by the Sirdar of Pidark that the country was in an unsettled state, and so I decided to march for Gwádar, working along the coast as I proceeded.

The total out-turn of triangulation for the season is 7,900 square miles. The results obtained from the series are very satisfactory; the work about Kej and Pasni is also good, though all the observations are not complete.

The country over which the series passed may be described as a succession of hills and valleys. First comes the Hada range overlooking the Bela plain on its east, and the Arrah and Jhao plains on its west. Then, west of the Jhao plain is another mass of sandstone ridges overlooking the Kolwah valley, and west of the Kolwah valley is a very high range known as the Kholwah-band.

The Hada range is a mass of sandstone and hard clay, resembling very much the hills about Bostan Railway station near Quetta, and consists of two ridges, the eastern one of which passes along, with a strike almost due north and south, down to the coast. The western ridge is very precipitous, and its strike is slightly east of north. This range

appears to be the eastern limit of a system of hills which form a complete semicircle, the centre of which lies about the Mashkel Hamun.

The Arrah plain is a perfectly barren piece of ground, interrupted by several large streams and ravines, with a few low sandstone ridges lying between it and the Jhao valley. The plain is used only by shepherds, who graze their cattle over it. There is plenty of water in the Arrah river.

The Jhao valley is long, fertile, and fairly well wooded. The Nali river which takes its rise about 20 miles south of Kalat flows through it. The valley lies north and south, its greatest length being about 45 miles and breadth 20 miles, and very large portion of it, in fact all the available ground, is under cultivation. Several hamlets are scattered about on both sides of the river, and the population of the valley is probably 4,000. The water-supply is from wells. Jhao is a settlement belonging to the Bizanjo section of the Brahuis. The Bizanjos are a very powerful and numerous section; the total number of the section is over 10,000 men.

Kolwah is an enclosed valley resembling the dry bed of a lake. There are several large villages and forts scattered about the valley, the principal of which are Hor, Sher, and Nag belonging to the Naosherwani Chief, Biloch Khan; Chambor, Bazdad, and Awara belonging to the Bizanjos; and Gushanak, Mattar, and Bedi belonging to the Mirivaris, a small section of Brahuis, numbering about 1,000 fighting men in all. The Kolwah valley is hemmed in on the north and south by two ranges of hills, and to the east and west are two very easy *kotals*, one connecting it with the Jhao, and the other with the Kej valley. To the north, between the villages of Awara and Bedi, the Durashi and Mashkai streams run through the valley, in a south-easterly direction, into the Nali river. The latter, after its junction with the Mashkai and Arrah streams, and after passing through a very narrow defile through the Goran hills (also called Taloband), is known as the Hingoli. This defile is known as Hingoli Dhat, and is impracticable for man or beast. The drainage from the eastern, western and southern portions of the Kolwah valley collects in the valley itself, and after heavy rain two lakes are formed, one of which is called Kap (meaning a salt swamp), and is about 20 miles in circumference, lying between the forts of Chambor and Hor, the other lake is about one-fifth the size of that abovementioned, and is known as Marav, which means a sweet water lake. Cultivation is carried on very largely in Kolwah; the soil is good, and with peace and order restored in the valley, the area under cultivation could be increased threefold.

The different tribes met with are Bizanjos, Mirivaris, Naosherwanis, and Kaodais. The first two are Brahuis and the others Baluchis; with the exception of the Naosherwanis, they are all peaceable and well disposed people, but the Naosherwanis are a very dissatisfied and untrustworthy lot. They are continually quarrelling with, and looting their neighbours, and are the dread of the whole of South-West Baluchistan.

Report by AHMAD ALI KHAN, *Sub-Surveyor, on his exploration of Sarhad (Persian Baluchistan) and Sistan (Eastern Persia) during season 1890-91, with a brief description of the country.*

I was directed by the officer in charge of the Baluchistan Survey to join the Agent to the Governor-General, Baluchistan, at Panjgur, who would instruct me as to the scope and extent of my exploration in Sarhad of Persian Baluchistan, and Sistan of Persia. I accordingly left Quetta on the 27th December 1890, and reached Panjgur 20th January 1891. Here I reported my arrival to Sir Robert Sandeman, who then made arrangements for me to proceed northwards.

On the 27th January a large Durbar was held for the Baluch Chiefs, and the Agent to the Governor-General was gracious enough to present me with a *khilat* in recognition of my previous work. On the following day I left Panjgur for Jalk *viâ* Kuhak, Isfandak, and Kallagan. From Jalk I started plane-tabling *en route* to Ladis, leaving the road now and then, and reached the latter place on the 24th February. Continuing my work northwards *viâ* Duzdap and Malik Siah Koh, I reached Sekoha on the 9th March. Here different arrangements had to be made, as I was not permitted to proceed to Nasirabad until permission was obtained from the Sarhang in command there. After a delay of nine days the welcome permission arrived.

On the 19th March I started, leaving my camp equipment behind and most of my escort. My following consisted of four mounted men and one *khalási*. The latter was utilised for pacing to check my timing on horseback, for I could take nothing in the shape of surveying instruments. Thus the position of Nasirabad and also of the eleven villages north of Sekoha should be considered approximate, as I had even to judge my direction to the best of my ability. After a stay of two days at Nasirabad, during which time I collected as much information as possible, I retraced my steps to Sekoha. Here I was again detained, as the inhabitants refused to sell me supplies, and it was only after much difficulty and persuasion that I obtained what was wanted at three times the local rates. From Sekoha I struck across country, taking the direction of the Taráku fort. Then, marching and working along the northern edge of the Hamun-i-Zirreh, I traversed its whole length and caught up the Nasirabad-Khárán route at the Orak springs. This route I now adhered to, and crossing the Amir Chah Kotal I made my way to Khárán *viâ* Panihám and Kondi. On the 14th May I reached Khárán, after having completed the ¼-inch recon-

naissance of nearly 22,000 square miles of ground, and compiling route reports, not only from authentic information, but from personal observations also, of nearly 1,000 miles in length.

I should not omit to note that the whole of the reconnaissance, with the exception of the bit north of Sekoha, is based on trigonometrically fixed points furnished by the Afghan Boundary Commission, and also by Mr. G. P. Tate, Assistant Surveyor.

Sarhad comprises an area, roughly speaking, of about 11,000 square miles, and is confined between the parallels of 28° and 30° North Latitude, and 60° 45′ to about 62° 45′ East Longitude. The average height of ground level is about 4,500 feet. Continuous chains of hills traverse the country in a N. W. and S. E. direction, with broad intervening valleys along which pass the principal routes. The whole of Sarhad is considered Persian Baluchistan, and is supposed to be directly under the authority of the Governor of Kirmán, the present incumbent being Mirza Abdul Majid Khan, Farman Farma-i-Daulat. The authority, however, is almost nominal, for the inhabitants are a wild, turbulent race, and lead a very independent life. Not a *tahsil* or *thana* exists throughout the land, and no man who has any vested powers from Persia resides in Sarhad.

The most important place is Ladis, which comprises seven villages and a fort, situated close together, the population of which at present may be estimated at about 1,200. The fort is built on the right bank of the Ladis river and is 150 feet above the bed: its dimensions are approximately 600 feet square, and it is surrounded by a wall 20 feet high, with bastions at the corners. Altogether the fort is a very inferior one. In the interior there are 100 houses, which are inhabited during the summer months only by Rekis. Surrounding Ladis there are about 1,400 acres of cultivated land, the cereals grown being wheat and barley. The produce suffices simply for home consumption, and *ghi* is the only commodity exported. There is a perennial flow of water in the Ladis river and numerous springs, all of which are utilised to a great extent in irrigating the land. I was informed that the Governor of Kirmán intends shortly to build a fort at Ladis capable of accommodating 200 sowars, and has levied a tax on the inhabitants of one-sixth of the annual crop: this they have refused to pay, and have signified their intention of bodily migrating to Khárán if any attempt is made to enforce the tax. The total number of houses in Ladis is about 300. South and west of the volcanic mountain of Koh-i-Taftán there are numerous villages.

The cultivated land, both in Persian and Afghan Sistan, amounts to about 3,000 square miles, which large tract is irrigated chiefly by canals fed from the Helmand river. The soil is so fertile that the sowing of one season is sufficient to yield crops for the following two. Afghan Sistan possesses 70 villages: the Persian side 100. During the period of Timur's (Tamarlane's) invasion of the country, nearly 800 years ago, numerous strong forts were erected between Puzai Margo and the Helmand. These are still in a state of preservation, though never looked after or occupied. The name of the tract where these forts stand is Sar-u-tar, signifying deserted.

The great Hamun or Gaud-i-Zirreh is 85 miles long, about 30 miles broad, and has an average depth of 10 feet. In dry seasons, however, this is greatly reduced and *khafilas* easily cross. The water is utterly undrinkable, and animals even refuse to touch it. On the north, running the whole length of the Hamun, is a bank 40 feet high, forming the southern limit of the Dasht-i-Taráku. Herds of wild asses abound in the neighbourhood. The soil all round the Hamun is covered with a white efflorescence. The tamarisk is found in small clumps scattered about, and grazing for camels is very plentiful. When the Helmand river receives an unusual supply of water, either from the melting of the snows or an abnormal rainfall, the reservoirs which receive its waters, such as the Hamun-i-Sistan and the Hamun i-Sowaran, overflow; the volume of water takes a southerly course, and after inundating a tract of land 130 miles long, with an average width of 30 miles, empties itself into the Hamun or Gaud-i-Zirreh.

The place second in importance to Nasirabad in Sistan is Sekoha; it is 23 miles south of it. A rectangular wall, 1,200 feet × 900 feet and 20 feet high, encloses all the buildings. In the centre, on a knoll 200 feet high, a small pucka fort is built, which contains a company of infantry. The population of Sekoha is equal to that of Nasirabad. The present Sirdar is Pasánd Khan, who has friendly feelings towards the British. The water-supply from a canal is very good. Supplies, such as wheat, barley, *bhusa*, etc., can be procured in large quantities. No pasturage for animals exists nearer than 15 miles from the town, and wood is almost as scarce. The camping ground is on the west side of Sekoha. Every European travelling northwards is stopped here until permission is received from Brijand for a safe conduct. In the case of Native foreigners travelling in the same direction, permission or otherwise from Nasirabad is sufficient. In ancient times Sekoha was the capital or chief town of Sistan, but on account of the constant depredations of the tribes from Sarhad, Nasirabad was brought into existence and gradually took the first place.

There are other forts of minor importance about 30 miles south, such as Hauzdár, Machi, Kundar, Ramród, etc. There are traces still visible that the whole tract of ground where these forts stand, was once well populated, and that in fact it was in a flourishing condition. Twenty-five miles east of Ramród, on a hillock 200 feet above ground level, there stands a very strongly fortified post, called Taráku, which, although unoccupied, is in perfect order. Inside of the surrounding wall there are very good specimens of architecture, the walls of which are all ornamented with paintings. The tradition is that 1,500

years ago this was the birthplace of Rustam Pailwán, the Persian Palladin, whose life is shrouded with romance and mystery. The fort is called Taráku, derived from Tarkiden, which signifies 'bursting,' as the mother of Rustam Pailwán had to undergo the operation called the Cæsarean section before she could give birth to her son. Taráku was then the most important town in Sistan.

There are two canals worthy of note. The first and longest is that called Nair-i-Sistan; it is 60 miles long, with an average width of 30 feet and depth of 10 feet. The main branch with its numerous outlets irrigates about 3,000 square miles of land. The second largest is called the Nair-i-Taráku, which passes the fort of Taráku half a mile to the south. It is about 50 miles in length and of variable breadth, and used, in times gone by, to irrigate about 1,000 square miles. At present it is not worked on account of the deserted state of the land. Both these canals are fed from the Helmand. In 1885, when the river overflowed, a large volume of water found its way into the Nair-i-Taráku, burst its banks and inundated the country westwards for miles.

About 22 miles due west of Nasirabad there is a flat hill called Koh-i-Khwaja. It is about 500 feet above ground level. A fort stands at the southern base. The remains of numerous houses are still visible, all more or less fortified, on the summit, and huge caves exist on the slopes. The area of the level ground on top would be about one square mile.

The men of Sistan are on the whole a pacific lot. Very few are to be seen armed, and then only with the antique matchlock.

Koh-i-Taftán is the most remarkable mountain in Sarhad. There are two peaks a mile apart on the crest lying north-west and south-east, which are about equally high. To the north-west peak an approximate height was obtained giving a result of 14,000 feet above sea-level. The south-east peak is volcanic; there are two distinct craters on it which, when witnessed from any distance, appear to be only one. The whole of the higher crest of this range is covered with snow throughout the year, and the volcano lies dormant during the winter months. The streams which take their source from the range have a continual supply of good drinkable water. Skirting the bases on both sides there are numerous villages possessing large orchards and vineyards. Pomegranates, apples, apricots and peaches are to be had in abundance, the first two especially being of excellent quality.

The physical features of Sarhad present no difficulty whatever to any enterprise that may be undertaken either in the construction of railways or roads. The valleys are all broad and fairly level, with an average height of about 4,500 feet above sea-level. The *kotals* or saddles over which the principal routes pass are all accessible even in their present state for laden animals and mountain batteries. The main ranges which take a north-westerly direction are all more or less continuous and skirted on both sides by rather rugged ground, sparsely covered over with stunted trees. There is, however, an abundance of pasturage in the valleys during the summer months. Sarhad is actually the hot-weather resort for the inhabitants of Sistan and the Helmand valley.

The soil is unfit for cultivation, even when irrigated, as there is an admixture of sand combined with stones: this is particularly the case in the valleys. The ranges are all of sandstone formation totally devoid of any vegetation. The majority of the watercourses have always a good supply of running water. The best springs are to be found at the base of the Koh-i-Taftán range.

As a very small proportion of the inhabitants are agriculturists, large quantities of wheat and barley are imported into the country from Sistan, which are bartered for ghi in the proportion of 7 maunds of wheat for one of *ghi*. The maund is equivalent to about 6½ seers Indian weight. With the exception of woollen *numdahs* nothing whatever is manufactured in the country, and all muzzle-loading guns, matchlocks and swords are imported from parts of Persia.

Sistan comprises an area of about 20,000 square miles. The Helmand river from Chahar Burjak takes a northerly course and flows through it, dividing it into two parts. From the east or right bank of the Helmand up to the great Dasht-i-Margo plain is Afghan Sistan; that on the left bank up to the lofty Palang Koh range is Persian Sistan. From north to south it extends from Lash Juwain down to the Lar Koh and Kach Koh hills.

The tri-junction boundary pillar of Persia, Afghanistan, and Baluchistan stands on the summit of Malik Siah Koh, and was erected by General Sir F. Goldschmid in 1872, south of Sistan; the pillar was found destroyed. A fresh pile of stones 8 feet high and 5 feet broad at the base was erected. Afghan Sistan, comprising Chakansur, Kali-Kang, Kalifat, etc., is subject to the authority of the Governor of Farrah: Western Sistan, comprising the important town of Nasirabad, and others of less importance, such as Sekoha, Dowlatabad, etc., is under the direct authority of the Governor of Birjand in Persia.

The town of Nasirabad is about half a mile long and a quarter broad. Before the Husseinabad fort came into existence, twenty years ago, the fort of Nasirabad was attacked and destroyed by the Baluchis under Sher Muhammad Khan, Sanjaram of the Helmand valley. The population of the town now is about 4,000, inhabiting 700 houses. The majority of the people are agriculturists. Woollen *numdahs* and carpets of inferior quality are manufactured. There are no bazaars or shops, and even the ubiquitous *bania* does not find an abode here. The reason of this is that the religious teaching of the Persians, who are *Shiahs*, precludes them from buying or receiving anything for consumption from a Hindu. *Atta*, *dhal*, *ghi*, fowls, eggs, sheep, and *bhusa* are to be obtained

in large quantities and very cheap. The imports are sugar, tea, indigo, and ingredients for cooking. The following are the rates obtainable :—

Wheat	6 maunds	for 1	karan.
Barley	10 maunds	„ 1	„
Ghi	1 maund	„ 7	„
Fowls	4 or 5	„ 1	„
Eggs	120	„ 1	„
Wood	1 maund	„ 2	„

The maund is equivalent to about 7 seers Indian weight. The karan equals 6½ annas. The exports are sheep's wool, goats' hair, and *ghi*. One-third of all the produce of the country is taken as revenue by Government. The Persian Sistanis are not migratory, while the Baluchi Sistanis on the other hand are never stationary. The latter being a pastoral race move about with their cattle wherever grazing grounds are most favourable. The animals are taxed at the rate of 1 karan for every bullock or cow, and 1 karan per annum for every seven heads of sheep or goats. The whole amount of taxes thus imposed amounted during the past year to 40,000 karans.

HIMALAYAS, PUNJAB.

BARA BANGAHAL, KANGRA DISTRICT.

Extract from the Narrative Report of MAJOR ST. G. C. GORE, R.E., *in charge of No. 18 Party (Himalaya), Season 1890-91.*

The survey of Bara Bangahal had been added to the programme by request of the local authorities. Fortunately it had been triangulated previously, so I was enabled to have the topography taken in hand. For this purpose Mr. Senior, who had been recessing in Kulu after his triangulation in Láhul during the previous summer, was sent into Bara Bangahal as soon as the weather permitted.

This remote and outlying portion of the Kángra District comprises the head waters of the Ravi river, and embraces an area of about 250 square miles. It is without doubt one of the most isolated and inaccessible portions of the Himalayas. Cut off on the north-east and south from the neighbouring districts of Láhul, Kulu, and Kángra by watersheds ranging in height from 16,000 to 19,000 feet, it is even more inaccessible from the west, along the Rávi, as the great spurs from the watersheds drop precipitously into the river. There is a track leading up to the river from Chamba, but it is only just practicable for human beings. The best road into it is over the Thamsir Pass, 15,546 feet above sea-level, leading from Palampur in Kángra. There is but one village, Bangahal, situated low down near the Rávi, at a height of 8,340 feet, and there is a small amount of cultivated land near it. There are eleven Government Forests in Bara Bangahal, but their boundaries are undemarcated, and from the nature of the country it is difficult to see in what way the timber can be utilized.

The physical conformation of the country consists of lofty spurs converging from the surrounding watershed towards the west centre of the district to about the point where the village is situated, the heads of the intermediate valleys being filled with glaciers. The lower limit of the glaciers may be taken at approximately 13,000 feet.

The principal passes are as follows :—

(i) Those leading into Láhul—		
Over the Sha Glacier to Gushal 16,829 feet, by the Laluni Nal to Muling	17,841	feet.
(ii) Leading to Kulu—		
The Tainta Pass to Beas Kund	16,391	„
The Thanaod Pass, height not ascertained.		
The Kaliheyni Pass	15,284	„
(iii) Leading to Kangra—		
The Makori Pass	14,774	„
The Barla Pass	15,500	„
The Thamsir Pass	15,546	„
(iv) Leading to Chamba—		
The Nikora Pass	15,694	„

The greater number of the inhabitants are nomads, crossing over in the winter into Kángra with their flocks, and returning in summer when the passes are open. A few people stop in the village through the winter, cut off of course entirely from the outside world.

Mr. Senior finding that the Thamsir Pass was not likely to be opened till late in May, determined on crossing over by the Surai Pass into Chamba, and thence up the Rávi valley. After one or two ineffectual attempts he succeeded in crossing the pass on the 22nd April, though he had to leave a good deal of his baggage in the snow, sending back for it subsequently. He prosecuted his work under great difficulties owing to bad weather, but succeeded in completing the plane tabling of the district on the 1-inch scale early in July, having mapped an area of 254 square miles.

The heavy snowfall of the previous winter which in many way was so detrimental to the prosecution of the work proved in one way to be a considerable aid, for Mr. Senior was enabled to make his way up otherwise impassable *nalas* over the snow, with which they were so thickly filled.

LATITUDE OPERATIONS.

Extract from the Narrative Report of LIEUTENANT G. P. LENOX-CONYNGHAM, R.E., *in charge Nos. 22 and 23 Parties (Astronomical), Season 1890-91.*

The new zenith telescope having been received from Messrs. Troughton and Simms, I was ordered to undertake the determination of latitudes with it by Talcott's method.

I tested the levels which were mounted on it and found that the larger one, on which the accuracy of the method in great measure depends, was very sluggish and not as sensitive as it should be. I therefore tested six levels by Holmes which were in store: these I found to be very much better, being sensitive and at the same time settling very rapidly. I selected the two I considered best, and had one of them mounted on the instrument, keeping the other as a spare level.

I also took observations to determine the value of a revolution of the micrometer head, and the intervals between the vertical wires in the telescope.

The stations at which latitudes were to be observed are on the Madras meridional series between Dhulipalla, where observations were taken in 1888-89, and Saint Thomas' Mount, Madras, and are seven in number, *viz.*:—

1. Saint Thomas' Mount, Azimuth Station	13°	0′
2. Madras Observatory	13	4
3. Gudali Hill Station	14	1
4. Kistama Hill Station, Azimuth Station	14	27
5. Darutippa Station	15	1
6. Ongole Hill Station	15	30
7. Danapa Hill Station, Azimuth Station	15	56

all being approximately on the meridian of 80° East longitude.

I had received instructions only to take the latitude of Madras Observatory if it seemed to be required, and that the advice of the Government Astronomer should be taken on the subject. Mr. Pogson was in favour of having it taken, as there was apparently some doubt about its correctness, values differing by 1″ having been used by former astronomers. With the approval of the Deputy Surveyor General it was decided to adopt Madras Observatory as one of my stations.

Observations were commenced at Saint Thomas' Mount on 19th December. Though I had put off the commencement of work till so late in the hopes of fine weather, still I was a good deal interrupted by clouds which came up in greater or less quantity almost every night, though the days were perfectly fine. I completed my observations there on the 30th, having observed 15 pairs four times each, 15 three times, 8 twice, and 2 once. I moved to Madras the next day, and there I also had cloudy weather, so that I did not complete the observations till the 11th of January. Mr. Pogson was most kind in every way, taking great interest in the work and affording me every facility for carrying it on.

I erected my instrument on a small granite pillar which had been built some time before on the meridian of the longitude station used by this department: the centre of my instrument was 41 feet 7½ inches north of the longitude station. I had had a floor prepared, so as to minimise all chances of disturbing the instrument when moving about in the observatory. It was not ready for Saint Thomas' Mount observations, and unfortunately it would not fit round this pillar, as it had been made for my tripod. I attribute the larger probable error of the first two stations to the want of this floor. At the Madras observatory I observed 21 pairs four times each, 15 three times, 3 twice, and 1 once.

I left Madras on the evening of the 14th and reached Gudali on the 16th. The station is at the top of a hill about 300 feet above the surrounding country, and is entirely covered with cactus and scrub jungle. The Great Trigonometrical station is situated at the north-west quarter of the hill. Some deviation of the plumb-line towards the south may perhaps be discovered, but it cannot be very great. No more central position could have been made use of, as the form of the hill would have shut out all view to the north. I had a meridian mark built in the plain to the north, about ¾ mile off, so as to be able to correct my azimuth without waiting for transit of a circumpolar star.

I set up the instrument and began work the night I arrived. Clouds prevented work on two nights, otherwise all went well. I completed my work on the 25th, having observed 37 pairs four times and 8 three times.

I had written from Madras to the Deputy Surveyor General to propose a method of procedure different from what had been laid down for my guidance. Up to this I had used two programmes of 20 pairs each, each of which was observed on four nights. It seemed to me that I should obtain better results by using three programmes of 20 pairs each, observing each twice, as I should then have 60 values from independent stars whence to deduce my latitude, instead of 40. I heard now that I might employ this method at three of my seven stations, retaining that originally decided on for the other four.

As a matter of fact I only employed this method once (at Darutippa station), owing to the impossibility of obtaining a sufficient number of pairs of stars, but a scrutiny of the probable errors of the different latitudes will show that I was correct in my idea that it is of more importance to increase the number of pairs observed, rather than the number of observations of each pair. With so light an instrument as the zenith telescope it seemed improbable that changes of instrumental position would produce much effect, and the results bear this out.

Leaving Gudali on the 27th I reached Kistama on the 30th, and camped at the bottom of the hill that day. The hill is about 350 feet high, covered with dense jungle, through which a road had been cut by the sub-surveyor. The platform of the Great Trigonometrical station was rather out of repair, but this had also been made right. It would be advantageous if in future all platforms were made square with two of their sides lying approximately in the meridian: if this is not the case, it is difficult to erect the observatory tent. The station here is well placed, so that no deviation of the plumb-line is to be expected.

I noticed a very great unsteadiness in the instrument at this station. The vertical axis did not retain its verticality however carefully adjusted, for more than a short time. I tried every expedient I could think of to correct this, tightened up all screws both of stand and instrument, tested the counterpoising, and finding it not good, improved it by means of a piece of lead tied on. Still the unsteadiness was apparent, not always, but about every second night. On examining the notes I had made on the subject, I discovered that the unsteadiness was always apparent during the early programmes, 7 P. M. to midnight, and not during the late programmes, midnight to 5 A.M. This pointed to expansion and contraction as the cause, for the temperature falls rapidly from sunset to midnight, but is fairly steady after that. Further experience has placed it beyond a doubt that this is really the cause, and it is only necessary for the observer to watch his instrument carefully and keep on adjusting, so that the amount of dislevelment may never be so great as appreciably to affect his observations. I would suggest that before being used again, the instrument should be provided with a better transit-axis level, the one at present in use being a particularly bad one.

I completed my work on the 7th of February, having observed 35 pairs four times each, 8 three times and 2 twice, and moved down the hill the next day. My march to Darutippa took me through Nellore. I had heard that there might be difficulty in crossing the Pennair: however, the anicut proved to be quite clear of water and in good repair.

I heard from the sub-surveyor that he would not be able to have a pillar ready for me till the 20th, owing to difficulties in procuring bricks lime, etc., so I halted at Nellore for three days, and reached Darutippa on the 18th, where I found that he had selected a point on the prime vertical of the Great Trigonometrical station. The platform of the latter would have required very extensive repairs, as it is about 12 feet high, and a large part of it had fallen down. Moreover, the station is in the middle of an extensive jungle with no water near, nor any space for tents. The new pillar was 6½ furlongs to the west of the old one, and I found that the prime vertical had been very correctly laid down. It was at this station that I was successful in getting enough pairs to make three programmes.

I had to wait till the 21st before commencing work, as the pillar was not dry enough until that date. I had many interruptions from clouds here, but managed to complete work on the 27th by beginning early, or staying on late after each night's proper programme, so as to pick up stars missed the night before. Sixty pairs of stars were observed on two separate nights and one pair on one night only. The Great Trigonometrical station is slightly higher than the place where my pillar was built, and for a long way round there is not a hill visible; no deviation is therefore to be expected.

I left Darutippa on the 28th and reached Ongole, my penultimate station, on the 4th of March. The Great Trigonometrical station is on a hill some 350 feet high to the north-west of the town. The distance from the sea is only about 10 miles, and every night a very strong wind from the south-east got up and blew till early morning; there was some difficulty in making the observatory secure, but I do not think that the work suffered in any way.

I marched from Ongole on the 19th and reached Danapa, my last station, on the 22nd. The Great Trigonometrical station there is on the top of a rocky hill about 700 feet high. There was no water nearer than about 2 miles from the base, and as there seemed to be no particular object in observing from the top of the hill, I decided to have a new station built in the plain to the east: the distance between the old and new station is 82 chains (1 mile 44 yards). The prime vertical had been very correctly laid down by the sub-surveyor; I was unable to discover any error when I checked it with my instrument,—that is to say, the error must have been less than 10″, which would subtend 3 inches at the distance of 1 mile. The weather at this station was all that could be desired, and I finished my observations on the 30th, having obtained 41 quadruple observations and 4 double ones. The heat by this time was getting very great, and I was very glad to be able to say good-bye to my tents.

The baggage was to be stored in Poona, so I decided to take my final observations for the determination of instrumental constants there. I arrived there on the 12th and took a large number of observations for wire intervals by transits of circumpolar stars; value of micrometer by circumpolar stars at elongation; relative values of micrometer and level by means of a collimator; and for what I have called the "horizontality of the micrometer wire" also by means of a collimator. The necessity for determining this last quantity occurred to me during work. I had adjusted the horizontality of the wire at the beginning of the season, but as I became more accustomed to the instrument, I noticed that the adjustment was by no means perfect, and discovered that I could not further improve it, as I had already exhausted the play allowed to the adjusting block.

So long as the same wire, whether the central one or not, is used for the intersection of both stars of a pair, it will make no difference whether the micrometer wire is truly horizontal or not, but if one star is bisected on the centre wire and the other at any other

point of the field, then, unless the wire is truly horizontal, the micrometer readings will not be truly comparable; my object was therefore to determine what correction should be applied to reduce the micrometer reading of a star bisected at a point other than the centre to what it would have been if bisected at the centre, not for the present considering the small correction on account of the star's extra-meridian position.

The method I adopted was as follows:—I set up a collimator and moved my telescope until the collimator cross appeared on wire I, and intersected with the moveable wire, repeating the operation several times so as to obtain a good value. I then revolved my instrument in azimuth by means of the tangent screw until the collimator cross appeared on wire V, and again intersected with the moveable wire. Had this wire been truly horizontal the readings would have been identical, and the difference observed was a measure of its actual inclination. Knowing the intervals between the wires and the differences in the readings of the micrometer according as the star was on wire I or V, it was easy to discover the correction applicable to a reading taken at any part of the field to reduce it to a reading on central wire.

The weak part of the above process was the turning in azimuth by the tangent screw, and the values deduced after return to recess-quarters did not prove very accordant. To make the values of these corrections more certain, some observations were taken by Mr. McA'Fee in Dehra by a different method. He observed zenith distances of stars of about N. P. D. 25° to 30° at upper transit. The instrument being carefully adjusted in the meridian, it follows that wires I and V would be very nearly equidistant therefrom, so that the zenith distances of a star at the instant of transit over them would be equal, and that the micrometer readings would be equal if the moveable wire was horizontal. This method proved more successful, and the values found by it were used in all cases where one or both stars had been intersected when at a distance from the centre wire.

As the zenith telescope was used for the first time this season, it may be well to give some account of the method of observing adopted. The great difficulty of Talcott's method consists in finding a sufficient number of well-determined stars which form pairs. It was for this reason impossible to get as many determinations of the latitude as used to be obtained with the zenith sector.

With the zenith sector about 100 stars were observed twice each, it being considered that two observations of Z. D. with this instrument gave a value, the precision of which was equal to that of the star's place. With the zenith telescope it was thought advisable to increase this number to four, so that it was decided to observe two programmes on four nights each, making a total of eight nights per station.

Assuming four hours as a fair average night's work, it was found that about 20 pairs could be obtained in that time, and 40 pairs was finally decided on as the minimum number for a station. At some places I was able to obtain a few more, but the number was never greatly in excess of this.

In order to introduce every possible variety of instrumental position, it was decided to proceed as follows:—

1st night, Foot screw A, North.
First star, Telescope East.
Second star, ,, West.
2nd night, Foot screw A, North.
First star, Telescope West.
Second star, ,, East.
3rd night, Foot screw A, South.
First star, Telescope East.
Second star, ,, West.
4th night, Foot screw A, South.
First star, Telescope West.
Second star, ,, East.

Foot screw A was one of the screws of the instrument which I had marked A in order to distinguish it.

When I had become familiar with the instrument, it seemed to me unlikely that with so light an instrument these changes would produce much effect on the result and moreover, I had great hope that the results by each pair of stars would not prove very discordant *inter se* so that to multiply the observation of each pair would not tend to diminish the probable error, and I therefore applied for permission, as already related, to alter the procedure, and, when possible, to observe three programmes on two nights, thus saving time and increasing the number of values obtained.

In order to test the propriety of this change, I have calculated the probable error of observation in a single determination of the difference of Z. D. of a pair, and that of half the sum of the declinations of two stars forming a pair as taken from the catalogue, and find that, at Saint Thomas' Mount my first station, the former is 0″477, and the latter 0″502. This shows that it is futile to multiply observations of the same stars, so that the plan of observing each pair only twice, and of increasing the number of pairs observed, is justified. It will often, however, be found impossible to obtain more than about 45 pairs, and with this number it will be best to adhere to the old procedure. Unless about 60 pairs can be obtained, it would probably be injudicious to reduce the number of observations of each.

With the zenith sector, great differences have been observed in the results obtained sometimes by north and south stars respectively, and sometimes according as the stars were observed east—west, or west—east. With the zenith telescope, as each result involves an observation of a north star and also of a south one, no north—south equation was to be expected. It seemed possible, however, that some difference would appear depending on the direction in which the instrument was turned between the observations of the stars of a pair, whether from east to west or from west to east. However, a very careful scrutiny of the results has not brought to light any evidence of the existence of such a law. The mean of all east—west values always agrees closely with that of all west—east values, the differences between them, if any, being irregular in sign and amount, showing that they are entirely accidental.

The results were arranged in several ways in order to test whether there was any discoverable law governing the discrepancies. They were first arranged in descending order of zenith distances, then according to the interval which had to elapse between the two observations forming a pair; thirdly, according to the weight of the star's places as deduced from the number of observations recorded in the catalogue, but no evidence of a system among the discrepancies was discovered. It lastly occurred to me that if the value adopted for a division of the micrometer head were incorrect, a differencwou d appear according as a large $+^{ve}$ or $-^{ve}$ micrometer correction had been applied.

To test this I collected all the results in which $+^{ve}$ corrections had been applied in one column, and all with $-^{ve}$ corrections in another and took means. It at once became apparent that there was an error of this sort. The mean, by positively corrected results, was always considerably smaller than that by negatively corrected ones.

I now added up the amounts of the $+^{ve}$ and $-^{ve}$ corrections and took the mean of each, adding these two means together. It was evident that whatever difference there was between the means of the positively and negatively corrected results, was due to the error in a micrometer division multiplied by the sum so obtained. Thus if :—

Mean +ve correction.	Mean of +vely corrected results.	Mean − ve correction.	Mean of −vely corrected results.
2,000	20·2	2,500	21·0

then the accumulated error of 4,500 micrometer divisions or of 45 revolutions $= 0''.8$.

Therefore the error of 1 revolution $= -\frac{0''.8}{45} = -0''.018$ nearly. The real error in the value of a revolution is twice this amount, for only half the difference of Z. D., as determined by the micrometer, enters into the latitude.

The following table shows the actual results obtained from the different latitudes observed :—

Station.	Error in ½ micrometer revolution.
Saint Thomas' Mount	0″·0191
Madras Observatory	·0252
Gudali Hill Station	·0183
Kistna Hill Station	·0273
Darutippa	·0230
Ongole Hill Station	·0207
Dânapa Hill Station	·0236
Mean	0″·0225
Error of 1 revolution =	−·0450

The excellent accordance of these results proves beyond doubt that the adopted value of the micrometer revolution is too small, and it has been assumed that the mean of them, *viz.*,—·0450, is the actual error. On looking at the value and its determination it seems strange that it should be so largely in error, for it is the mean of two values with a probable error of ·005 and ·05 respectively, so that its own probable error is only $\pm 0''.0251$. However, there is very good reason to believe that the cause lies in the refraction applied : the value of this was 0″·19, and an alteration in the constants of barometric pressure and temperature, which were not applied, could easily produce a difference of 0″·05. I have attempted to estimate the probable barometer and thermometer heights, and find that the refraction correction was too great by ·040, leaving only ·005 as the correction now to be applied, a quantity well within the probable error. Or, taking only that determination of which the probable error is 0″·025, the value of one revolution of the micrometer head with the mean refraction correction error is 69″·309. The value which the present investigation points to as the correct one is 69″·345. Applying the refraction correction as now determined by assuming heights of barometer and thermometer (27·5 inches and 75° at Poona on April 16th—19th), the first value becomes 69″·349, which differs from the apparently correct value by 0″·004, a quantity less than the probable error. These considerations seemed to me to justify the adoption of the new value 69″·345, and this has consequently been used throughout.

It is worthy of note that had the sums of $+^{ve}$ and $-^{ve}$ micrometer corrections been equal, an error in the value of micrometer revolution would have disappeared in the mean, so that the latitude would not have been affected. This is a condition which it would be

very difficult, if not impossible, to comply with in arranging the programme, but it should not be lost sight of, and it might even be advisable occasionally to reject a few results, so as to bring those amounts into approximate agreement.

The following is a table of the final values, etc.:—

Stations.	Number of pairs observed.	Number of observations.	Astronomical Latitude and probable error $= \lambda_o$.	Geodetic Latitude $= \lambda_c$.	$\lambda_o - \lambda_c =$ apparent deviation of plumb line.
Saint Thomas' Mount . .	40	122	13°— 0′—20″·66±·077	13°— 0′—14″·79	+5″·87
Madras Observatory . .	40	136	13 — 4 — 9 ·88±·067	13 — 4 — 2 ·06	+7 ·82
Gudali	45	172	14 — 1 —10 ·65±·056	14 — 1 — 9 ·45	+1 ·20
Kistama	45	168	14 —27 —12 ·30±·050	14 —27 —14 ·56	—2 ·26
Darutippa	61	121	15 — 0 —33 ·52±·041	15 — 0 —36 ·47	—2 ·95
Ongole	47	171	15 —29 —52 ·90±·051	15 —29 —56 ·85	—3 ·95
Dànapa	45	172	15 —55 —59 ·70±·050	15 —56 — 0 ·14	—0 ·44

The mean probable error is ±·056.

It will be noticed that the smallest probable error [±·041] occurs at the station where the largest number of stars was observed, although the number of observations at that station was the smallest of all, owing to there having been six nights' work instead of eight. This points clearly to the advantage of increasing the number of stars observed as far as possible, and to the futility of observing the same stars repeatedly. As before remarked, it will probably be found most advantageous to observe each pair twice and not more often. The differences between the astronomical and geodetic values are on the whole less than those found in 1888-89, and the sign is not so constant.

TIDAL AND LEVELLING OPERATIONS.

Extract from the Narrative Report of Lieutenant-Colonel J. Hill, R.E., *in charge No. 25 Party,—Season 1890-91.*

Tidal Operations.

During the survey year under review tidal observations were carried on at seventeen stations, namely, *Aden*, *Kurrachee*, Bhávnagar, *Bombay* (*Apollo Bandar*), Bombay (Prince's Dock), Cochin, Minicoy, Tuticorin, Trincomalee, Madras, Cocanada, *Kidderpore*, Chittagong, Akyab, *Rangoon*, Mergui and *Port Blair*. The eleven tidal stations, whose names are not italicised, are minor stations, where observations, as a rule, are taken for five years only. The six whose names are italicised are *permanent* stations, where the minimum duration of observations is for 19 years, and where observations should be continued until the work at all the stations is completed.

At Madras the tidal observatory worked for only ten days during the year, as it was closed on the 10th October 1890 for reasons given at page 73 of the General Report for 1889-90, and at pages xvii and xviii of its appendix. At Cocanada the observatory was closed on the 18th April and at Chittagong on the 22nd July, five years' observations having been completed at these stations.

Two new tidal observatories were established during the year,—one at Trincomalee and the other at the island of Minicoy. Registrations commenced at the former on the 10th November 1890, and at the latter on the 12th January 1891. Particulars of their establishment will be found further on.

It will be seen from the foregoing, combined with the particulars given in previous annual reports, that since the resumption of tidal operations systematically in 1877, observations have been taken at 31 tidal observatories, of which 17 (including Madras) have been closed on the completion of their registrations and 14 are now in operation.

I shall now describe briefly the working of each observatory, commencing with Aden, and following the order of the stations round the coasts to Burma :—

Aden.—It is disappointing to have to report that the recent tidal observations at this important station have been of a very unsatisfactory nature. I left India on leave in May 1888, at which time the observatory was one of the most satisfactory in operation; but when I returned to India in November 1890 I found it the most unsatisfactory. This I am obliged to attribute not only to the carelessness of the observatory clerks, but to the lax supervision of the Port Officer. Aden is one of the permanent tidal stations which have all to be kept up as long as the general tidal operations continue, and at which it is important that there should be no break in the continuity of the registrations. During the eleven years extending from March 1879, when the station was permanently established, to March 1890, the registrations at Aden were continuous and satisfactory. Since the latter date, although the gauge has continued to work almost without interruption, its registrations have in many cases been rendered useless, owing chiefly to the diagrams having sometimes been wrongly adjusted, and to the driving clock having been damaged through too frequent tampering with it in order to regulate it; the result being that, except for making a few comparisons between actual and predicted tides, a whole year's tidal regis-

trations (from March 1890 to March 1891) were rendered useless, and have had to be rejected, thus causing a most serious break in what ought to have been a continuous series. The actual working of the auxiliary instruments at Aden was on the whole fairly satisfactory; but, for two periods of about a fortnight each, the readings of the barometers and thermometers were incorrectly taken by the observatory clerk. The error of the tide gauge clock was also incorrectly recorded by him on several occasions; and these faults, which ought to have been at once detected in Aden, were only discovered in my office when the daily reports arrived there. The attention of the Port Officer was drawn to these circumstances. The observatory was inspected towards the end of last March by Mr. Belcham, who put all the instruments into good order and adjustment, and since his inspection the work of the observatory has been proceeding satisfactorily.

Kurrachee.—At this station the record of the year's work is very satisfactory. The tide gauge worked practically without a break, only one short interruption worth mentioning having occurred on the 11th January, when the inlet holes of the cylinder were blocked for 15 hours. The auxiliary instruments also worked most satisfactorily; except when they were being cleaned their registrations were absolutely uninterrupted. For the continued efficiency of this observatory my thanks are due to Mr. Morris, the Port Engineer. He takes a great interest in the tidal observations, and continues the arrangements made by his predecessor who appointed Mr. Dharam Sing, Assistant Engineer, to make frequent visits to the observatory and take measurements for determination of zero, etc., when necessary, and provided for the ordinary cleaning and repairing of the instruments by a skilled mechanic. I inspected the observatory in December, and found all the instruments in perfect order, except that the rack and pinion moving the reading vernier of the standard mercurial barometer had to be repaired.

Bhávnagar.—The working of this observatory has been satisfactory on the whole. Apart from the usual interruptions caused by flushing the cylinder, and one special interruption of five days while a portion of the inlet pipe was being renewed and the cylinder cleaned and painted, the accidental interruptions of the registrations were few and trivial. One accident to the tide gauge, however, occurred during the year. While the cylinder was being flushed on the 22nd August the float band broke; but it was immediately repaired, and zero measurements at once taken by the Assistant State Engineer proved that the working zero of the instrument had not undergone any change. All the auxiliary instruments worked well, except the self-registering aneroid, which worked imperfecty throughout the whole year. The usual readings of the standard mercurial barometer have, however, been taken uninterruptedly, and supply the necessary barometric information. This observatory was not inspected during the year under report: it will therefore be expedient to make an inspection of it early in the survey year 1891-92.

I am indebted to Mr. Proctor Sims for his co-operation, to which the success of the tidal observations at Bhávnagar is entirely due.

Bombay (*Apollo Bandar*).—At this observatory the tide gauge has as usual worked extremely well, and no interruptions of the registrations occurred during the year. The driving clock was under repair for two days in October last; but the height of the tide was marked upon the drum every quarter of an hour during that time, thus avoiding a break in the observations. The observatory was inspected by me in December, when the gauge was found in very good order. The new graduated staff however was found not to work satisfactorily, and I recommended its removal and the substitution of another of a different construction.

Auxiliary instruments are not used or required at either of the Bombay tidal observatories, as the meteorological observations are taken at the Colaba observatory.

Bombay (*Prince's Dock*).—The tide gauge at Prince's Dock differs in construction from those in use at all the other Indian observatories, its drum for recording the tidal curves being vertical, and its mechanism not being so simple as that of the usual pattern. Its working on the whole has been satisfactory. There have been only three interruptions to its registrations during the year, none of which exceeded 17 hours in duration; the first was due to an accident to the cord of the clock weight, the second to an accident to the pencil wire, and the third, which occurred so lately as the 29th September, was caused by a rupture of the float band. The arrangement of the pencil markers in this pattern of gauge is not entirely satisfactory: it resulted on three occasions in the zero pencil sticking in the diagram and tearing it for a short distance. I inspected the observatory in August, when, although the gauge required cleaning, everything was found in good working order. My acknowledgments are due to the Engineer and the Assistant Engineer of the Port Trust for their continued interest in the tidal observations at both of the Bombay observatories, and for the assistance they are always so ready to give me, to which is due the fact that the tidal station of Bombay ranks first not only as regards continuity of the observations, but as regards the excellence of the results obtained therefrom.

Cochin.—The tidal registrations at this station were perfect throughout the year. The registrations of the aneroid barometer were nearly so, as only one short interruption lasting ten hours, due to the stoppage of the clock, occurred. The anemometer also worked very well, its registrations having experienced only three very short interruptions, none of them exceeding 5 hours in duration. The observatory was inspected in February by Mr. Belcham, who found it in order, and all the instruments working satisfactorily. The last 2 feet of the inlet pipe at its outer end had however become corroded and required renewal. This could not be done at the time owing to the height of the water

in the river, but during the time of lowest low water in May the corroded part of the pipe was removed, and replaced by new piping by Captain Winckler, the Port Officer, to whom our thanks are due for the great care he has exercised over the observatory ever since its establishment

Minicoy.—This new tidal station is situated in the island of the same name, which is a small coral island lying off the Malabar coast, between the Laccadive and Maldive islands, 270 miles west of, and in about the same latitude as Cape Comorin. It divides the 8 and 9 degree channels in 73° East longitude, and lies right in the track of steam vessels from Ceylon to Aden, for whose benefit a light-house has been erected at the south-westerly extremity of the island. The island which is well planted with cocoanut trees is a long, bent, narrow strip of low land, the southern and broadest portion (about 900 yards wide) extending from west to east for about two miles, then forming an elbow, from which a narrow portion trends in a north-easterly direction for about an equal distance, until a rather wider spot is reached, where the village of Minicoy has been built; from this spot the land tapers away for a further distance of 3 miles in a north-north-east direction, this part of the island being not more than 200 yards broad

An irregular coral reef, bare at low water and lying about three miles away to the westward of the village, bends eastwards at each of its ends and joins itself to the extremities of the island, forming with it a roughly pear-shaped lagoon (the wider part being to the south), at the south-west end of which is a small islet with trees, distant about half a mile from the lower extremity of the main island, where the light-house is situated. The continuity of the reef is broken at three places, *viz.*, at the northern extremity of the island, where there is a narrow and intricate passage, in no part deeper than 2 fathoms, through which boats and small vessels pass in and out of the lagoon, and at two spots opposite the village, and distant from each other nearly two miles, at each of which there is a gap just wide enough to allow fishing boats to pass through. The general position of the village has been mentioned: it is built on the margin of the lagoon, and is protected from any encroachment of the sea on its eastern side by an artificial embankment, in some places 20 feet high, which extends from it in each direction along the outer shore for a distance of about a mile. Minicoy is under the jurisdiction of the Collector of Malabar, whose head-quarters are at Calicut.

The tidal observatory is situated in the lagoon, 110 feet from the bank, and directly opposite the Kacheri, which is at the southern end of the village. The tidal instruments are contained in a small wooden house, 10 feet square, resting on a stout horizontal framework of cocoanut-wood beams, which also binds together the tops of 9 cocoanut piles which support the structure. These piles vary in length from 16 to 17 feet, and are driven well into the sand and coral and firmly braced together, and to make the whole structure as strong as possible, long iron bolts with nuts have been used to join the frame of the house to the framework surmounting the piles: a bridge of almond-wood, supported on cocoanut piles, connects the observatory with the shore. A very massive iron drainage pipe, purchased at Colombo, 12½ feet long and 20 inches in internal diameter, serves as a float cylinder: its bottom is plugged with a perforated wooden disc and rests on a large stone, 36″ × 30″ × 14″, the upper surface of which has a circular groove to receive the bottom rim of the cylinder. Under the centre of the cylinder the stone is hollowed out and connected by openings on each side with the external water, which has thus free communication with the float. A graduated staff, 8½ feet in length, divided into tenths of feet and set to the same zero as the tide gauge, is fixed to one of the piles of the observatory to act as an independent check on the registrations of the gauge. For regulating the tidal observatory clocks, one of the new pattern sun-dials, designed by Colonel G. Strahan and constructed at Dehra Dun, has been set up on the shore within a few feet of the communication bridge.

The instruments at work in the tidal observatory consist of a self-registering tide gauge of the new pattern (No. 23, by Adie), by which the tidal curves are reproduced on a scale equal to one-half the natural magnitude, a self-registering aneroid barometer by Légé & Co., and a mercurial barometer (No. 1308, by Casella): in addition to these a rain gauge has been fixed on a post near the sun-dial pillar, and a self-registering anemometer has been set up in a wooden house supported on piles, on an elevation formed of coral, about a mile to the north of the village, where the island is particularly free of tall trees. The site for the observatory was selected by Mr. Belcham early in 1890; and the greater part of the instrumental equipment and the timber house (formerly at Okha, Pamban and Colombo), which it was intended to set up, were taken to Minicoy from Colombo in October by Lieutenant Channer, R.N.: subsequently that officer landed Mr. Belcham on the island on the 14th December, together with the senior mechanic of the party, two tidal observatory clerks, and the remainder of the instruments.

Cocoanut piles which had been ordered through the Collector of Malabar were found ready, so Mr. Belcham experienced no delay in setting to work, and the instruments commenced their registrations on the following dates:—the tide gauge on the 12th, the aneroid on the 20th, and the anemometer on the 22nd January 1891. After satisfying himself that everything connected with the observatory was in thorough order, and that the clerks understood all their duties, Mr. Belcham left the island for Colombo with Lieutenant Channer on the 7th February. On the beach near the sun-dial pillar, a small thatched house, 10 feet square, was erected, in which a set of meteorological instruments were set up at the request of the Meteorological Reporter to the Government of India: these instruments are read daily

at specified times by the clerk in charge of the tidal observatory, and the records are sent to the Meteorological Reporter.

Lieutenant Channer, R.N., the Superintendent of Light-houses, visits the island every six weeks in fair weather and at longer intervals during the south-west monsoon. We are greatly indebted to him for his assistance and for his having very kindly undertaken to bring away the records and reports from the observatory and post them at Colombo.

During the year under report the tide gauge and all the auxiliary instruments have been working very satisfactorily, with the exception of the anemometer, which stopped six times, for about 12 hours at a time, up to the 4th March, from which date its record is continuous and satisfactory.

The tidal observatory is in charge of Mr. J. S. Francis, the senior observatory clerk, who had four years' experience in the tidal observatory at Cocanada, and who, having performed his duties there very carefully and well, was selected for employment at Minicoy. An assistant clerk is also attached to the observatory, as in such an isolated place it would be unwise to allow the registrations to depend on the health of a single clerk.

Tuticorin.—Here the tide gauge has worked very satisfactorily throughout the year, its record having been almost uninterrupted. On one day only two short interruptions took place, caused by the counterpoise chain of the float sticking at the bottom of the cylinder. The work done by the aneroid and anemometer has also been most satisfactory, no accidental interruption of any kind having occurred.

An inspection of the observatory was made from the 16th to the 22nd February by Mr. Belcham, who found the several instruments in good order, with the exception of the mercurial barometer, the cistern of which he noticed on the morning of the 17th February to contain about a tenth of an inch of water, which must have got in during a heavy downpour the night before ; the water was removed and the whole of the instruments were cleaned and left in good order. I am indebted to Captain Baker, the Port Officer, who continues to take a great interest in our work, for the kind supervision he exercises over the observatory. A circumstance worth mentioning is that during the spring tides of the 23rd, 24th and 25th June, which were accompanied by strong south-west winds, the water fell to a very low level. On the morning of the 24th the tidal curve reached a depth of one inch below the zero of the gauge, which is the first instance of the curve passing below the zero during the three years the gauge has been in operation at Tuticorin. The range of the tide was at the same time below the average, the immediately preceding and succeeding high waters being 2′ 11″ and 2′ 0″ respectively, above the zero of the gauge : while the mean value of the range at springs is 3·2 feet.

A peculiarity of the tides in the Gulf of Manar is that, contrary to what might be expected, the mean sea-level during the south-west monsoon is considerably lower than during the south-east monsoon. The yearly mean range of the tide in the Gulf is less than two feet ; but during August the monthly mean value of mean sea-level falls lower than during December by as much as 10·6 inches. It will thus be seen that tidal observations taken during one lunation only, may not, as it is sometimes assumed they do, supply a good working value of mean sea-level for spirit levelling purposes.

Trincomalee.—The position selected for this new tidal station on the north-east coast of Ceylon, is in the Naval Dockyard on the east side of Trincomalee Harbour. The tidal observatory is approximately in latitude 8° 33′ North, longitude 81° 13′ East. The arrangements for its establishment were made last year, and were mentioned in the General Report for 1889-90, and the observatory house, which was constructed under the superintendence of Mr. DeRidder, the Naval Store-keeper, was completed and made over, about the end of October, to Mr. Belcham, who started the work on the 10th November.

The observatory house, which is 12 feet square, with wooden walls and a tiled roof, is constructed on the pattern of the observatories at Tuticorin, Akyab and Mergui, and is situated on the small stone wharf at the south end of the Naval Dockyard, adjoining the Chief Clerk's house : it is very neatly and strongly put together ; half of the building rests on the wharf wall, to which it is secured by iron bolts, while the other half which projects beyond the wharf is supported by three iron struts thrown out from the wall. The float cylinder is a massive iron drainage pipe, similar to the one at Minicoy ; it is 12½ feet in length and 20 inches in internal diameter, one foot four inches of which is above and the remainder below the level of the observatory floor ; its bottom is closed with a plug of iron-wood, containing five perforations, each an inch in diameter, for the inlet and outlet of the water, and rests on three stout iron pegs, which project about nine inches above the bed of the harbour. A vertical graduated staff, six feet in length, divided to 10ths of a foot, was attached to the house and to the iron strut on the north side of the observatory, having its zero identical with that of the tide gauge to check the height of the water which should always be the same inside and outside the cylinder.

The self-registering tide gauge, aneroid barometer, anemometer and the mercurial barometer are placed in the tidal observatory, while the rain gauge is fixed on the north-west corner of the compound wall of the Chief Clerk's house. The observatory clocks are kept to correct mean time by comparisons made twice a week with telegraph time, which is signalled, as a rule, daily at 4 P.M. from Madras. The tide gauge by which the curves are reproduced on the natural scale has worked most satisfactorily up to date, no interruption of any kind having taken place.

The aneroid has worked continuously since it was started, and the barometric curve is correctly recorded. The registrations by the anemometer, however, have not been satisfactory; the instrument worked steadily for a month after being set up, *viz.*, to the 13th December, on which day the clock got out of order, and there were no less than 24 interruptions up to the 18th June, one of which lasted four days, and the remainder caused breaks in the record ranging from 4 to 15 hours, but since the latter date no further stoppages were reported until September, during which month two interruptions occurred, lasting respectively 14 and 16 hours.

Mr. W. D. Sarasinha, who formerly carried on the duties of observatory clerk at Galle, was appointed to this observatory, and remained in charge until the 22nd March, when he became ill and resigned and another Cingalese, named Arunasalem, who had been taught by him, was appointed in his place. Mr. DeRidder supervises the working of the observatory, and our thanks are due to him for the great trouble he is taking to ensure the success of the observations.

Madras.—As previously mentioned, this tidal observatory worked for only 10 days during the year under report, *viz.*, from the 1st to the 10th October. It will be unnecessary for me to report on the observations taken during this short period, as Mr. Wood brought his report on Madras, in last year's Annual Report, up to the latter date. It had been intended to continue the registration to the 4th November; but Mr. Wood remarked in the report just mentioned (*vide* appendix to General Report for 1889-90, p. xviii) :—

"I regret that a little undue haste on the part of the authorities responsible for the repairs to the pier head, induced the Presidency Port Officer to actually close the observatory on the 10th October, before apprising me of it."

The Madras Government have been led to abandon their intention of continuing tidal observations at Madras (although their costly new instruments for doing so are now lying there in store ready for erection), owing to the inconvenience that would be occasioned, by a tidal observatory of a needlessly elaborate and expensive design submitted to them being placed in the new harbour works in a position which they consider would interfere with and reduce the berthage inside the harbour. I see no reason why an observatory should not be constructed on the new harbour works which would not reduce the berthage at all or interfere with traffic of any kind, and which could be built at a very reasonable cost; and I shall ascertain whether the Madras Government would consent to re-open this question. It is desirable that with proper instruments suitably placed we should obtain good tidal registrations similar to those obtained at Bombay and other important ports, instead of the very inferior measurements altogether unworthy of the port of Madras, which were taken for a series of years with an inferior apparatus at an objectionable site, and which are now discontinued. I may add that in less than two years, unless the Madras Government consent to reconsider their decision, there will not be a single tidal observatory in operation along the whole eastern coast of India, which I think would be very regrettable.

Cocanada.—The usual five years' registrations having been completed at this minor station on the 18th April 1891, the observatory was then dismantled by sub-surveyor Dhondu Vinayek. The tide gauge worked satisfactorily during the year under report, not a single interruption having occurred; in fact from the commencement to the close of the observations there have been but four short interruptions on the record, all of them due to the float band slipping off the stud wheel: the tidal registrations may therefore be said to be continuous and most satisfactory throughout the whole period of the observations.

The aneroid barometer had been reported last year as being very insensitive; and as it continued so, it was not kept at work during the year under report: in fact the record of the aneroid from the beginning of the observations is worthless, owing to a defect in the instrument which prevented the diurnal variations of pressure from being correctly indicated; there is however a complete record of the readings of the standard mercurial barometer taken daily at 7 and 10 A.M. and at 4 and 6 P.M. throughout the five years of observation. The anemometer has worked satisfactorily throughout the observations, there having been only two short interruptions in its record for the present year, and only a few others in the previous four years. The tide gauge, anemometer and mercurial barometer have been left, carefully packed, in the Port Office at Cocanada ready for transmission to the station where they may be required, while the aneroid barometer was brought away to Poona to be repaired if possible.

During the time the observatory was being dismantled, a graduated staff, 8 feet in length, divided into feet and inches, and having its zero set to the datum of the tide tables, was attached to one of the piles of the Port Office jetty, for taking personal observations of the height of the water at one high and one low tide daily: these observations are being taken regularly under the direction of the Port Officer since the tide gauge was dismantled, and are sent by him monthly to my office for comparison with the values given in the Tide Tables. My thanks are due to Captain Wicks the Port Officer, for the deep interest he took in the regular observations while the tide gauge was at work, and for his courtesy in now having the graduated staff read daily.

Kidderpore.—During the year under report there have been sixteen interruptions in the record of the tide gauge, all caused by the stoppage of the driving clock from oscillation of the observatory; but as they in no instance exceeded 12 hours in duration they are unimportant; the wire attached to the counterpoise of the pencil traveller, also that

of the back lash weight, broke once ; but as they were instantly repaired, no loss of work was thus occasioned. The clock of the aneroid stopped twice between the 1st October and 18th November. The instrument was removed on the latter date to the Mathematical Instrument Office for examination and was replaced in position on the 22nd November, after which the clock stopped four times up to the 8th January, when it was cleaned and set in order during my inspection of the observatory, and since then no interruptions have been reported. The only failure in the working of the anemometer for the year occurred on the 11th August, when for three hours, owing to some fault in the spirals, the diagram was not marked.

A regular inspection of this observatory was made by me in January, when the several instruments were thoroughly cleaned and left in good order. In May Mr. Belcham, while passing through Calcutta, visited the observatory and laid down two new bench-marks at the entrance to the new dock in place of the old bench-mark of reference, which the Dock Engineer asked for permission to remove, and in August, Mr. Belcham again made a brief inspection of the observatory, and checked the relative levels of the bench-marks he laid down in May. The work carried on in this observatory is supervised by Lieutenant Petley, R. N., the Port Officer and Deputy Conservator of the Port of Calcutta, to whom my thanks are due for the efficient working of the observatory.

Chittagong.—At this minor station five years' observations were completed on the 13th June, but the observatory was not dismantled until the 22nd July. The tide gauge worked regularly during the year under report, with but two very short interruptions ; the driving clock however has not been keeping very good time, the error in sixteen instances being slightly in excess of that allowed. On the whole, however, the observations at this station throughout the five years the instrument has been at work have been very satisfactory. The registrations by the aneroid have been continuous, while those by the anemometer contain two short breaks of a few hours each, and from what has been said about the working of these instruments in former reports, it may be concluded that the record of each is also satisfactory for the five years they have been in operation.

The usual yearly inspection of this observatory was made in March by sub-surveyor Dhondu Vinayek, who found the several instruments working well, and after having them all cleaned by the assistant mechanic of the party, left them in adjustment. Another inspection was made in July by Mr. Belcham, who dismantled the observatory and fixed a graduated staff, 20 feet in length and divided into foot and 3-inch spaces against one of the piles of the iron jetty. The staff, which has its zero the same as the datum of the tide tables for Chittagong, is read twice daily at high and low water by one of the clerks in the Port Office, and the readings are compared in this office with the predicted values.

The aneroid barometer, anemometer and rain gauge were carefully packed and stored in the Port Office godown at Chittagong, but the mercurial barometer and tide gauge were taken to the Rangoon tidal observatory by Mr. Belcham, who set up the barometer and attached the driving 'regulator clock,' with English lever escapement, to the Rangoon tide gauge in lieu of its own pendulum clock which, together with the other portions of the Chittagong gauge, were packed and stored in the Rangoon Port Office godown, along with the set of instruments from the Elephant Point tidal observatory, to await transmission to other stations.

The observations taken in the tidal observatory have been supervised throughout the five years by Mr. Good, the Port Officer, and I am much obliged to him for the good results obtained from them, and for the interest he continues to take in having the graduated staff read daily.

Akyab.—No interruptions to the working of the tide gauge occurred, except two trivial ones, one lasting two and the other four hours ; and of the auxiliary instruments the registrations of the aneroid and the anemometer were equally perfect. The rain gauge however failed to register the proper amount of rainfall owing to its reservoir not being sufficiently capacious, but this is not of much importance as there is a meteorological observatory at the Government Telegraph Office, where the rainfall has been correctly measured.

The observatory was inspected by sub-surveyor Dhondu Vinayek in February, when he found all the instruments in good order. A subsequent brief inspection was made by Mr. Belcham while on his way from Chittagong to Rangoon. He found all the instruments in adjustment; but noted and reported the above mentioned defect in the rain gauge, which was brought to his attention by Captain Pryce, the Port Officer, to whom my thanks are due for the interest he takes in the observations and the supervision he exercises over the observatory.

Rangoon.—At this station the tidal observatory instruments had to be moved to new sites on two occasions during the year under report. From the 1st March 1880 the tidal observatory had occupied one position on Latter Street Wharf; but on the 14th of last April, as it interfered with the extension of the wharf, the observatory had to be temporarily moved a distance of 45 feet. The removal and re-adjustment of the gauge occupied three days, and it remained at work in its new position on the wharf from the 17th April to the 24th June. On the latter date, according to arrangements previously made with the Port Commissioners, the tidal instruments were finally removed from Latter Street Wharf, and on the 4th July they were set up in a new detached observatory which had been prepared for their reception by the Port Engineer between Brooking Street Wharf and Spark's Street Jetty, and which is very conveniently situated in the river opposite the Port Engineer's Office. The new observatory is a substantial, neatly made

wooden structure, 13 feet 9 inches long by 12 feet 6 inches wide by 11 feet high at the eaves, supported on 4 iron screw piles braced together by iron tie rods. It is connected with the bank by a strong wooden bridge 100 feet long and 4½ feet wide.

At present the observatory is not free from oscillation caused by the force of wind and water, because during its erection the height of the water rendered it impossible to complete the lower bracing of the piles; but when the river falls to its lowest level, about February, the work will be completed. After commencing work at the observatory the oscillations were frequently so severe as to endanger the pendulum clock, which had driven the gauge during the past 11 years at Latter Street Wharf. The pendulum had on such occasions to be removed, and the drum had to be turned by hand until the oscillations moderated. This inconvenient arrangement was only temporary. The Chittagong tidal observatory had recently been closed, and its clock, which was a 'regulator clock,' with English lever escapement, became available for use in Rangoon. The pendulum clock was removed and the Chittagong clock substituted for it on the 2nd August, since which date no further trouble has been experienced from the oscillations of the observatory. Owing to the precautions taken to avoid breaks in the observations while the gauge was unable to work, the registrations throughout the year are practically continuous.

With regard to the auxiliary instruments. The aneroid worked well as long as it remained at Latter Street Wharf; but since its removal to the new observatory, the oscillations already mentioned have hindered its registrations from being as satisfactory as could be desired. The anemometer still remains at Latter Street Wharf, and its registrations have been satsfactory. The mercurial barometer got out of order on the 25th June during its removal from Latter Street Wharf. On the 29th June an instrument was lent by Mr. Darlington, which was read daily until the 5th August, when the mercurial barometer brought away from the Chittagong tidal observatory was set up and the damaged instrument was taken to Calcutta for repair. A meteorological observatory is being constructed close to the new tidal observatory in the compound of the Port Engineer's Office, which will probably obviate the necessity of our continuing to use auxiliary instruments at the tidal observatory.

The observatory at Latter Street Wharf was inspected in January by sub-surveyor Dhondu Vinayek. It was again inspected and then dismantled by Mr. Belcham in June, and re-established by him in its new site in the following month. I am indebted to Mr. Darlington, the Vice-Chairman of the Port Commissioners, and to Mr. Reichenbach, the Port Engineer, for the interest they take in our operations, and for the trouble they have gone to in order to render them successful.

Mergui.—The registrations of the tide gauge may be pronounced satisfactory; for, although there were eight interruptions to them during the year, they were all trifling, the longest not exceeding eight hours. Six were due to the pencil traveller sticking between its directing bars, one to the breakage of the cord carrying the weight of the driving clock, and one to the breakage of the counterpoise chain of the float band. The registrations obtained from the auxiliary instruments have not been equally satisfactory. There were ten breaks in the aneroid observations, eight of which were caused by boats dashing against the observatory, and giving shocks to it strong enough to stop the aneroid clock, and two by the sticking of the hands of the clock. In order to save the observatory from damage by boats and from shocks of the kind just mentioned, it was decided to protect it by an outer barrier formed of four stout piles strongly braced together with horizontal beams. This protecting barrier was erected early in January, since which time no break in the observations due to shocks has occurred.

The anemometer may be said to have worked uninterruptedly; two very short stoppages of the clock having caused the only breaks throughout the year; but, owing to a part of the mechanism having worn away, the velocity of the wind was not marked from 15th June to 18th August, on the latter of which dates the instrument was repaired.

The observatory was inspected by sub-surveyor Dhondu Vinayek towards the end of January, after the protecting barrier had been erected. He found the observatory and instruments in good order. My acknowledgments are due to Mr. Batten, Deputy Commissioner of Mergui, for continuing the supervision of the observatory so well exercised by his predecessor, and to Mr. Darlington, the Vice-Chairman of the Port Commissioners of Rangoon, for his kindness in allowing one of his Customs clerks, who had formerly learnt the duties of a tidal observatory clerk at Rangoon, to perform the duties of tidal observatory clerk at Mergui.

Port Blair.—I am glad to be able to report that at this station the registrations by the tide gauge have been most satisfactory, not a single interruption having taken place during the year; moreover, the water communication with the float, which had been reported in the last annual report as being retarded to the extent of a foot in height and an hour in time, has been found on examination of the diagrams to have been perfectly free. The aneroid barometer has also worked most satisfactorily, and its record is quite complete.

The anemometer worked continuously from the 1st October to the 17th December, when it was damaged and rendered useless by a shot from a rifle fired by one of the soldiers in the barracks, on the tower of which the instrument had been at work since April 1880. On the 16th May a new instrument was set up, the record of which up to date has only two interruptions, one of 9 hours on the 9th July and one of 20 hours on the 11th July, both caused by the stoppage of the driving clock. The register of the wind for the five months during which the instrument was standing disabled was obtained from the record kept by the Medical Department of Port Blair.

Table showing the mean amplitudes (H) in feet and mean epochs (K) in degrees for each particular tide, which have been calculated from the values obtained by

STATION.	Year.	A_0 or Height in feet of Mean level of Sea above Zero.	S_1		S_2		S_4		S_6		S_8		M_1		M_2		M_3		M_4		M_6		M_8		O_1		K_1		K_2		P_1		J_1		Q_1		L_2		N_2		ν_2	
			H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K
Mormugão	1884-85	5'512	0'080	157°·27	0'638	336°·75	0'008	108°·91	0'003	119°·75	0'003	94°·57	0'045	97°·69	1'766	305°·20	0'018	307°·67	0'041	20°·58	0'010	260°·96	0'012	24°·42	0'516	53°·03	1'032	48°·07	0'182	324°·00	0'300	49°·40	0'061	42°·76	0'099	64°·02	0'030	306°·67	0'427	287°·03	0'153	278°·16
	1885-86	5'577	0'041	177°·47	0'641	332°·23	0'009	99°·97	0'005	109°·89	0'004	24°·44	0'055	98°·02	1'820	300°·10	0'015	299°·19	0'047	5°·62	0'013	245°·04	0'011	19 98	0'524	49°·59	1'033	45°·78	0'179	331°·45	0'305	42°·88	0'085	43°·16	0'119	51°·56	0'053	338°·19	0'438	282°·22	0'104	253°·59
	1886-87	5'573	0'047	171°·52	0'643	330°·54	0'008	89°·25	0'004	127°·48	0'003	30°·58	0'015	43°·12	1'835	299°·36	0'017	295 64	0'051	5°·60	0'012	254°·19	0'017	16 29	0'520	47°·85	1'026	44°·84	0'205	324°·14	0'289	41°·74	0'075	70°·57	0'111	41°·80	0'039	302°·74	0'427	281°·15	0'018	233°·27
	1887-88	5'486	0'046	181°·50	0'638	330°·05	0'009	86°·96	0'005	114°·34	0 001	45°·00	0'017	31°·94	1'820	299°·18	0'018	289°·25	0'049	2°·38	0'014	237°·94	0 013	29°·47	0'522	47°·66	1 027	44°·76	0'187	315°·57	0'300	44°·79	0'049	74°·65	0'099	45°·16	0'075	342°·98	0'434	279°·00	0'084	335°·21
	1888-89	5'451	0'050	184°·93	0'644	329°·36	0'010	76°·10	0'004	101°·04	0'004	43°·92	0'011	97°·64	1'809	297°·80	0'019	283°·85	0'049	357°·30	0'007	249°·18	0'012	22°·91	0'522	47°·03	1'021	44°·48	0'182	320°·87	0'305	43°·50	0'056	44°·50	0'112	56°·55	0'050	309°·09	0'439	278°·27	0'137	301°·00
	Means	5'520	0'053	174°·54	0'641	331°·79	0'009	92°·24	0'004	114°·50	0'003	47°·70	0'029	73°·68	1'810	300°·33	0'017	295°·12	0'047	6°·30	0'011	249°·46	0'013	22°·61	0'521	49°·03	1'025	45°·59	0'187	323°·21	0'300	44°·46	0'065	55°·13	0'108	51°·82	0'049	319°·93	0'433	281°·53	0'099	280°·43
Galle	1884-85	2'656	0'011	65°·77	0'357	96°·56	0'002	205°·20	0'001	264°·29	0'001	106°·70	0'010	225°·42	0'526	59°·80	0'014	166°·23	0'009	171°·06	0'004	1°·98	0'002	284°·91	0'044	78°·75	0'165	19°·87	0'093	91°·99	0'053	26°·58	0'010	68°·55	0'023	88°·84	0'036	67°·31	0'053	47°·26	0'048	66°·52
	1885-86	2'700	0'012	74°88	0'357	93°95	0'004	245°·56	0'000	135°·00	0'001	258°·69	0'008	245°·43	0'525	57'32	0'012	161°·03	0'011	164'32	0'003	335°·69	0'002	211°54	0'052	79°25	0'165	17°59	0'089	104°40	0'049	14°67	0'006	53°·28	0'024	95°68	0'028	6°·56	0'066	41°97	0'038	16°39
	1886-87	2'679	0'031	27°87	0'370	91°80	0'002	252°·65	0'004	106°·14	0'001	274°·09	0'004	332°·67	0'530	54'93	0'014	149°98	0'013	166°·44	0'003	24°·27	0'001	255°·33	0'046	78°·47	0'168	15°66	0'154	100°97	0'037	24°·19	0'012	355°·41	0'028	94°·72	0'042	79°98	0'054	44°·77	0'013	351°·33
	1887-88	2'606	0'011	34°·29	0'369	92°·94	0'003	241°·93	0'001	26'·57	0'001	296 57	0'007	349°·16	0'524	54'56	0'012	157°80	0'014	161°51	0'002	302°84	0'001	138°67	0'049	73°81	0'170	18°82	0'115	90°·42	0'043	20°·42	0'013	16°93	0'030	91°11	0'029	25°·77	0'060	44°·58	0'005	160°33
	1888-89	2'570	0'012	63°·02	0'358	93°51	0'004	213°·28	0'001	296°·57	0'003	322°·70	0'007	3'06	0'527	55'76	0'013	159°14	0'015	162°·32	0'002	270°·57	0'001	235°·43	0'049	70°·95	0'166	17°83	0'098	88°·95	0'053	19°87	0'008	57°87	0'024	104°·02	0'024	75°·28	0'072	46°·38	0'028	82°39
	1889-90	2'685	0'011	13°64	0'361	96°·40	0'003	248°·96	0'000	206°·57	0'001	261 87	0'003	64'08	0'531	58'93	0'010	174'32	0'012	159°44	0'002	31'23	0 002	31'38	0'041	72'20	0'166	19'61	0'108	94'72	0'046	23'91	0'010	22'11	0'025	104'13	0'020	3'·98	0'071	53'69	0'030	46'46
	Means	2'649	0'015	46°58	0'362	94°19	0'003	234°·60	0'001	172°·52	0'001	268°·44	0'007	323°30	0'527	56'89	0'013	161°42	0'012	164'18	0'003	341°10	0'002	252°88	0'047	75'57	0'167	18'23	0'110	95'24	0'047	21'61	0'010	35'69	0'026	96'42	0'030	47'98	0'063	46'44	0'027	60'57
Colombo	1884-85	2'208	0'018	61°·68	0'362	99°·60	0'004	211°·50	0'002	168°·53	0'001	236°·31	0'008	56°·56	0'546	52°·78	0'015	169°·49	0'015	176°·76	0'002	76°·27	0 000	54°·23	0'033	64°·30	0'237	35°·72	0'072	108°·98	0'082	34°·05	0'030	36°·95	0'029	80°·79	0'028	53°·79	0'063	28°·53	0'023	39°·47
	1885-86	2'261	0'030	59°87	0'389	101°25	0'004	248°46	0'002	214°38	0 001	105 95	0'013	192 29	0'563	54'04	0'015	166°04	0'014	174 19	0'003	62°83	0'001	228°21	0'101	67°36	0'231	35°·67	0'104	82°45	0'062	11°86	0'006	59°88	0'027	88°34	0'018	46°01	0'050	46°72	0'014	49°84
	1886-87	2'304	0'003	142°77	0'404	90°30	0'004	225°94	0'002	144°16	0'000	108°44	0'006	288°84	0'590	45°83	0'014	161°36	0'017	164°55	0'005	346°03	0'000	145°52	0'091	59°23	0'239	29°26	0'126	84°74	0'068	29°87	0'013	1°80	0'031	81°74	0'038	64°41	0'073	29°94	0'011	76°34
	1887-88	2'199	0'006	358°09	0'404	92°48	0'006	218°33	0'001	148°00	0'000	108°44	0'007	15'35	0'593	46°95	0'016	168°12	0'018	171'35	0'004	1°97	0'001	107'37	0'092	62°03	0'240	30'70	0'115	90°42	0'066	27'72	0'022	26'24	0'036	86'57	0'028	27'22	0'075	31'09	0'022	47'53
	1888-89	2'112	0'004	62°85	0'392	94°11	0'005	247°38	0'002	195°95	0'000	291°86	0'015	347°82	0'596	51'14	0'012	170°48	0'017	167°93	0'004	5'30	0'001	227'24	0'098	60°76	0 249	33'48	0'127	93'12	0'071	36°65	0'017	50'47	0'035	96°82	0'035	54'67	0'085	33'40	0'021	22'13
	1889-90	2'216	0'016	61°63	0'394	94°34	0'005	265°60	0'002	170°13	0'001	172°03	0'014	340°92	0'586	48'40	0'016	181 62	0'018	164'14	0'004	27'83	0'001	87'71	0'091	58'25	0'238	31'77	0'105	81'39	0'081	17'12	0'008	45'03	0'031	99'45	0'016	57'11	0'090	31'44	0'017	11'07
	Means	2'217	0'013	64°48	0'391	95°35	0'005	236°20	0'002	176°86	0'000	170°49	0'011	26°96	0'579	49°86	0'015	169°52	0'017	170°32	0'004	26°71	0'001	141°71	0'094	61°99	0'238	32'77	0'108	90°18	0'072	26°21	0'016	36°73	0'032	87°95	0'027	50°54	0'073	33°52	0'018	41°06
Negapatam	1881-82	1'996	0'048	116°·78	0'271	282°·72	0'006	136°·36	0'000	135°·00	0'001	225°·00	0'003	148°·92	0'712	251°·22	0'003	73°·46	0'023	76°·05	0'010	130°·33	0'005	297°·26	0'092	319°·82	0'222	345°·11	0'071	280°·50	0'083	342°·47	0'006	348°·09	0'007	143°·17	0'022	278°·33	0'164	242°·78	0'048	228°·46
	1882-83	2'048	0'044	99°59	0'277	285°·69	0'004	166°33	0'000	115°·96	0'001	228°37	0'006	72°88	0'727	252°05	0'003	133°35	0'018	77°16	0'013	126°07	0'004	308°82	0'089	323°24	0'227	345°32	0'082	290°52	0'085	350°18	0'016	307°30	0'007	218°60	0'031	278°85	0'152	245°55	0'047	206°21
	1885-86	1'811	0'040	95°91	0'284	280°91	0 006	106°61	0'001	146°31	0'001	240°95	0'017	303°16	0'739	249°31	0'004	85°49	0'017	71°18	0'011	124°49	0'004	252°11	0'087	318°05	0 224	346°55	0'078	285°04	0'080	339°72	0'019	356°72	0'007	284°01	0'039	264°92	0'168	237°00	0'030	209°02
	1886-87	2'048	0'021	97°36	0'261	281°07	0'006	125°88	0'001	251 57	0'001	218°66	0'016	289°39	0'706	250°99	0'002	72°57	0'021	75°58	0'010	135°14	0'003	334°54	0'087	325°84	0'216	348°58	0'097	286°09	0'075	347°52	0'014	34°82	0'001	310°17	0'047	219°13	0'151	231°62	0'015	273°36
	1887-88	2'047	0'055	120°32	0'249	285°44	0'004	139°69	0'002	97°60	0 000	153°44	0'008	3'75	0'654	252°74	0'004	78°35	0'031	96°36	0'006	133°53	0'001	149°21	0'088	321°25	0'210	349°04	0'091	281°93	0'074	344°40	0'008	355°74	0'003	34°46	0'030	272°14	0'157	239°46	0'020	279°22
	Means	1'990	0'042	105°99	0'268	283°17	0'005	134°97	0'001	159°29	0'001	213°28	0 010	307°62	0'708	251°26	0'003	88°64	0'022	79°27	0'011	129°91	0'003	268°39	0'089	321°64	0'220	346°92	0'084	284°82	0'079	344°86	0'013	352°53	0'005	270°08	0'034	262°67	0'158	239°28	0'034	239°25
Madras	1880-81	2'251	0'037	80°·49	0'437	277°·36	0'002	97°·77	0'002	60°·64	0'001	131°·19	0'019	3°·63	1'047	249°·43	0'004	65°·44	0'002	120°·65	0'010	160°·80	0'002	331°·11	0'094	326°·83	0'294	339°·58	0'121	277°·59	0'093	340°·64	0'029	336°·70	0'004	140°·43	0'037	277°·81	0'246	242°·97	0'053	208°·38
	1881-82	2'209	0'026	96°10	0'445	274°77	0'002	168°69	0'001	98°75	0'000	63°44	0'001	312°47	1'051	246°71	0'003	55°15	0'001	114°89	0'011	148°61	0'001	84°49	0'096	323°65	0'291	338°26	0'120	276°44	0'094	341°06	0'012	314°06	0'003	150°02	0'017	334°52	0'238	240°19	0'007	287°30
	1882-83	2'179	0'012	98°75	0'440	276°38	0'001	217°88	0'001	175°91	0'001	290°56	0'004	64°06	1'049	248°05	0'006	66°81	0'005	192°58	0'009	153°53	0'002	83°08	0'101	324°77	0'293	342°06	0'094	285°72	0'103	356°05	0'021	303°71	0'009	43°21	0'054	309°82	0'238	242°38	0'072	317°66
	1883-84	2'180	0'026	87°56	0'436	279°54	0'002	216°87	0'001	59°31	0'000	198°44	0'003	41°22	1'033	250°01	0'004	57°11	0'002	154°43	0'006	160°40	0'002	20°13	0'096	310°69	0'291	342°39	0'116	268°22	0'091	344°11	0'022	31'89	0'002	68°08	0'002	280°23	0'026	359°29	0'265	238°02	0'145	224°36
	1884-85	2'134	0'056	99°61	0'450	279°79	0'005	302°28	0'001	63°44	0'001	333°44	0'008	282°09	1'058	248°36	0'003	8°41	0'019	225°93	0'008	165°04	0'001	18°81	0'100	321°88	0'296	340°85	0'086	269°19	0'104	346°29	0'030	346°06	0'002	280°23	0'026	359°29	0'265	238°02	0'145	224°36
	1885-86	2'051	0'017	75°22	0'415	289°92	0'003	287°75	0'002	272°86	0'002	50°19	0'018	268°91	0'983	258°54	0'003	359°58	0'014	225°20	0'006	203°94	0'003	192°60	0'089	332°80	0'286	345°82	0'118	305°28	0'090	348°17	0'006	323°27	0'009	96°33	0'040	298°72	0'193	250°21	0'050	177°44
	1886-87	2'320	0'078	147°89	0'442	286°34	0'002	272°86	0'002	141°34	0'000	39°29	0'014	302°80	1'019	251°69	0'004	33°67	0'008	247°99	0'011	157°75	0'003	295°30	0'107	324°97	0'281	343°29	0'163	276°11	0'070	343°84	0'014	249°39	0'019	87°07	0'094	275°37	0'183	242°09	0'118	341°31
	1887-88	2'266	0'005	353°16	0'393	291°44	0'003	263°42	0'001	201°80	0'000	243°44	0'013	153°99	0'950	262°45	0'004	30'37	0'003	237°13	0'004	176°45	0'003	166°00	0'089	339°74	0'280	350°62	0'108	278°34	0'084	356°63	0'029	336°07	0'013	78°95	0'020	313°20	0'237	247°77	0'053	267°30
	1888-89	2'133	0'023	95°04	0'461	278°36	0'002	236°98	0'001	135°00	0'001	304°99	0'019	326°07	1'063	250°13	0'006	28°67	0'010	212°78	0'008	164°00	0'001	3°08	0'098	326°70	0'301	341°26	0'132	280°84	0'098	345°29	0'029	339°03	0'010	117°00	0'044	313°63	0'268	239°22	0'073	267°68
	1889-90	2'353	0'035	65°52	0'435	271°25	0'003	276°12	0'001	53°97	0'002	304°70	0'008	344°93	1'069	242°64	0'005	71°10	0'008	196°35	0'009	114°30	0'001	175°55	0'104	322°22	0'305	338°78	0'102	255°01	0'106	334°48	0'020	322°93	0'005	175°81	0'030	224°20	0'268	231°50	0'086	249°21
	Means	2'208	0'031	83°93	0'435	280°51	0'003	234°06	0'001	105°32	0'001	15°97	0'014	338°17	1'032	250°84	0'004	41°63	0'007	193°69	0'008	160°48	0'002	317°85	0'097	327°42	0'292	342°29	0'116	277°27	0'093	345°06	0'021	318°91	0'008	123°71	0'040	299°38	0'236	241°86	0'074	259°63
Cocanada	1886-87	5'488	0'036	92°·89	0'644	284°·85	0'003	125°·54	0'003	204°·78	0'003	220°·60	0'019	341°·40	1'486	252°·29	0'006	346°·15	0'026	108°·73	0'014	97°·59	0'002	66°·46	0'133	332°·93	0'347	340°·18	0'175	286°·38	0'099	344°·27	0'028	338°·46	0'017	35°·95	0'075	272°·21	0'308	243°·91	0'071	190°·83
	1887-88	5'324	0'037	77°05	0'628	285°83	0'007	146°54	0'004	159°62	0'003	83°09	0'023	341°58	1'545	252°43	0'009	19°88	0'027	105°95	0'016	100°84	0'002	294°65	0'137	332°37	0'352	338°20	0'169	283°50	0'089	343°11	0'036	336°26	0'008	20°99	0'082	235°22	0'326	242°06	0'018	302°68
	1888-89	5'154	0'034	82°47	0'642	287°43	0'008	131°58	0'003	185°19	0'003	81°12	0'018	345°08	1'525	253°74	0'006	18°01	0'032	105°10	0'017	98°22	0'001	318°20	0'138	332°65	0'347	339°03	0'161	282°07	0'100	343°00	0'035	11°20	0'002	113°10	0'066	255°89	0'316	247°39	0'105	289°52
	1889-90	5'413	0'034	61°55	0'632	287 58	0'006	143°70	0'001	146°31	0'002	114°23	0'022	62°48	1'493	253°41	0'007	28°32	0'030	106°96	0'016	92°89	0'003	270°92	0'144	333°81	0'346	339°56	0'161	290°30	0'096	344°09	0'019	329°05	0'002	93°11	0'061	232°42	0'325	245°38	0'115	252°51
	1890-91	5'308	0'038	81°31	0'648	284°73	0'007	121°66	0'002	142°43	0'002	24°23	0'010	56°66	1'517	251°86	0'009	16°10	0'034	103°35	0'018	95°24	0'003	57°01	0'135	331°70	0'344	339°03	0'180	279°41	0'091	341°72	0'023	299°98	0'001	325°01	0'046	266°69	0'322	247°37	0'092	208°57
	Means	5'337	0'036	79°05	0'639	286°08	0'006	133°80	0'003	167°67	0'003	104°65	0'018	13'44	1'513	252°75	0'007	13°69	0'030	106°02	0'016	96°96	0'002	345°45	0'137	332°69	0'347	339°20	0'169	284°33	0'095	343°24	0'028	334°99	0'006	45°63	0'066	252°49	0'319	245°22	0'080	248°82
Chittagong*	1886-87	8'251	0'060	120°·09	1'568	68°·45	0'049	54°·55	0'010	131°·08	0'002	217°·41	0'025	22°·82	4'428	34°·89	0'039	218°·15	0'421	341°·96	0'143	195°·45	0'035	127°·12	0'295	11°·55	0'582	22°·19	0'438	76°·88	0'192	26°·00	0'053	51°·47	0'016	327°·77	0'425	60°·30	0'869	23°·51	0'402	24°·23
	1887-88	7'945	0'056	126°75	1'553	68'18	0'053	62'52	0'010	125'19	0'002	146'98	0'022	46'83	4'440	35'29	0'044	198'34	0'395	343'52	0'149	187'69	0'034	111'64	0'289	16'13	0'576	20'30	0'397	65'93	0'195	31'21	0'027	98'88	0'025	358'65	0'399	39'17	0'841	24'78	0'295	1'67
	1888-89	7'923	0'072	116°28	1'534	68°46	0'056	57°51	0'006	135°00	0'004	154°89	0'048	85'37	4'424	35'12	0'040	205'35	0'403	341°10	0'124	190°55	0'029	122°48	0'287	10'79	0'599	21'87	0'389	68'30	0'188	31'32	0'018	17'75	0'021	55'02	0'345	39'71	0'847	24'48	0'117	19'39
	1889-90	8'086	0'077	105°21	1'584	70°86	0'061	64'95	0'007	159'25	0'004	146'31	0'043	106'76	4'485	34'61	0'031	176'88	0'391	341'89	0'143	182'79	0'027	120'31	0'289	9'00	0'576	22'95	0'471	65'69	0'185	34'19	0'038	33'91	0'019	355'91	0'181	65'96	0'823	28'77	0'314	50'28
	1890-91	7'977	0'067	106°70	1'571	69'88	0'054	66'66	0'010	150'83	0'004	215'91	0'006	110'16	4'445	36'49	0'012	161'03	0'418	346'29	0'143	196'04	0'029	130'80	0'293	11'72	0'613	21'14	0'458	65'57	0'219	32'52	0'059	59'94	0'034	359'00	0'342	70'35	0'824	22'81	0'368	38'03
	Means	8'036	0'066	115°01	1'572	69'16	0'055	61'24	0'009	140'27	0'003	176'30	0'029	74'39	4'444	35'28	0'033	191'95	0'406	342'95	0'140	190'50	0'031	123'67	0'290	11'84	0'593	21'69	0'431	67'27	0'196	31'05	0'039	52'39	0'023	3'27	0'338	55'10	0'841	24'87	0'299	26'72
Elephant Point*	1884	16'314	0'140	91°·02	2'384	139°·57	0'092	181°·37	0'013	294°·19	0'009	307°·49	0'039	25°·54	5'876	101°·88	0'021	15°·16	0'270	78°·58	0'252	338°·65	0'107	323°·75	0'344	5°·59	0'723	19°·52	0'980	120°·49	0'162	17°·86	0'029	77°·32	0'043	23°·11	0'440	116°·82	0'961	90°·24	0'132	67°·51
	1885	11'745	0'082	126°48	2'397	140°05	0'088	176°94	0'007	262°46	0'005	284°04	0'009	125°30	5'890	103°95	0'026	337°43	0'289	87°74	0'241	337°74	0'101	333°93	0'323	8'36	0'737	19'47	0'716	135°16	0'189	31'59	0'064	103'82	0'024	328'93	0'250	131'54	1'052	85'62	0'137	122'10
	1886	11'937	0'082	128°12	2'365	140°19	0'078	173'82	0'010	296'31	0'002	340'02	0'015	54'77	5'897	103'42	0'027	322'80	0'275	90'74	0'239	337'71	0'104	335'01	0'323	6'88	0'751	19'40	0'589	135'87	0 195	35'58	0'011	106'70	0'004	279'48	0'412	138'95	1'145	86'28	0'346	122'77
	1887	11'982	0'075	114'21	2'366	139'80	0'081	176'25	0'011	272'14	0'003	38'05	0'039	64'38	5'907	103'44	0'040	305'24	0'290	90'42	0'242	332'21	0'104	325'89	0'313	4'84	0'761	17'66	0'710	144'43	0'223	30'86	0'025	61'00	0'030	4'11	0'448	125'85	1'207	87'73	0'416	94'95
	1887-88	11'903	0'101	111°90	2'395	140°16	0'081	173'22	0'008	258'29	0'001	63'44	0'038	72'76	5'941	104'14	0'031	286'28	0'280	91'44	0'246	333'61	0'104	322'78	0'312	5'79	0'760	18'28	0'763	147'24	0'195	32'83	0'023	89'33	0'029	38'76	0'423	120'21	1'188	90'70	0'313	66'62
	Means	12'009	0'096	114°35	2'381	139°96	0'084	176'32	0'010	276'68	0'004	350'61	0'028	68'55	5'902	103'37	0'029	325'38	0'281	87'78	0'244	335'98	0'104	328'27	0'323	6'29	0'746	18'87	0'752	136'64	0'193	29'74	0'030	87'43	0'026	350'88	0'395	126'67	1'111	88'11	0'269	94'79

* These are Riverain Stations at which A_0 is the height of mean level of the water above zero.

Statement showing the interruptions which occurred in the observations entered in S Series.

NAME OF STATION.	Year of Observation.	PERIOD OF INTERRUPTION. From	To	TOTAL NUMBER OF DAYS' INTERRUPTION. In each period.	In the year.
Galle	1884-85	6th September 1884	17th September 1884	12	12
	1885-86	27th July 1885	3rd August 1885	8	8
	1886-87	15th December 1886	16th January 1887	33	33
Colombo	1884-85	15th September 1884	21st September 1884	7	12
		29th September 1884	3rd October 1884	5	
	1885-86	13th July 1885	13th July 1885	1	35
		2nd November 1885	5th December 1885	34	
	1889-90	21st October 1889	17th November 1889	28	28
Negapatam	1886-87	1st December 1886	17th December 1886	17	17
Chittagong	1889-90	1st December 1889	7th December 1889	7	7
Elephant Point	1884	5th November 1884	7th December 1884	33	33

NAME OF STATION.	Year of Observation.	PERIOD From
Madras	1882-83	17th February 1882
		21st July 1882
	1884-85	29th June 1884
		29th August 1884
		14th October 1884
	1885-86	23rd February 1885
		12th May 1886
	1886-87	23rd May 1886
		24th June 1886
		29th July 1886
	1888-89	5th March 1889
	1889-90	10th October 1890

TABLE No. 1—(continued from Annual Report 1886-87).

(K) in degrees for each particular tide, which have been calculated from the values obtained by Tidal observations each year at the stations where the operations are completed.

K_1		K_2		P_1		J_1		Q_1		L_2		N_2		ν_2		μ_2		T_2		$(MS)_4$		$(2SM)_2$		$2N_2$		$(M_3N)_4$		$(M_3K_1)_3$		$(2M_2K_1)_3$		Lunar Monthly.		Lunar Fortnightly.		Luni-solar Fortnightly.		Solar-annual.		Solar Semi-annual.		Station.
	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	H	K	
b	48°·07	0·182	324°·00	0·300	49°·40	0·061	42°·76	0·099	64°·02	0·030	306°·67	0·427	287°·03	0·153	278°·16	0·062	247°·48	...	...	0·022	59°·73	0·002	201°·24	0·062	238°·89	0·045	342°·97	0·019	335°·49	0·009	350°·96	0·048	74°·73	0·048	13°·85	0·021	150°·99	0·306	307°·36	0·075	162°·57	} Morinugão.
3	45·78	0·179	331·45	0·305	42·88	0·085	43·16	0·119	51·56	0·053	338·19	0·438	282·22	0·104	253·59	0·042	246·35	0·068	277°·82	0·028	67·22	0·003	138·43	0·069	263·34	0·057	342·35	0·035	53·64	0·006	29·69	0·029	358·85	0·075	13·91	0·057	279·30	0·165	333·22	0·055	67·51	
6	44·84	0·205	324·14	0·289	41·74	0·075	70·57	0·111	41·80	0·039	302·74	0·427	281·15	0·018	233·27	0·058	248·30	...	...	0·025	44·40	0·007	70·18	0·074	238·87	0·022	336·98	0·039	108·23	0·005	91·58	0·015	285·62	0·089	11·24	0·041	354·01	0·291	327·53	0·133	147·38	
7	44·76	0·187	315·57	0·300	44·79	0·049	74·65	0·099	45·16	0·075	342·98	0·434	279·00	0·084	335·21	0·048	247·73	0·073	357·21	0·016	28·80	0·007	150·34	0·050	228·82	0·068	4·55	0·016	159·67	0·008	68·74	0·049	106·43	0·027	153·63	0·010	288·86	0·356	297·45	0·191	175·30	
a	44·48	0·182	320·87	0·305	43·50	0·056	44·50	0·112	56·55	0·050	309·09	0·439	278·27	0·137	301·90	0·064	262·26	0·096	312·50	0·031	39·70	0·011	121·40	0·062	228·49	0·039	16·88	0·020	349·54	0·007	69·02	0·010	300·58	0·056	317·72	0·025	305·53	0·226	301·14	0·128	139·58	
5	45·59	0·187	323·21	0·300	44·46	0·065	55·13	0·108	51·82	0·049	319·93	0·433	281·53	0·099	280·43	0·055	250·42	0·079	315·84	0·024	47·97	0·006	136·32	0·063	239·68	0·046	352·75	0·026	57·31	0·007	50·00	0·030	9·24	0·059	30·07	0·031	275·74	0·269	313·34	0·116	138·47	
5	19°·87	0·093	91°·99	0·053	26°·58	0·010	68°·55	0·023	88°·84	0·036	67°·31	0·053	47°·26	0·048	66°·52	0·025	101°·82	...	...	0·006	312°·74	0·007	23°·69	0·007	208°·91	0·026	164°·87	0·005	284°·39	0·002	135°·25	0·067	21°·93	0·020	12°·20	0·013	324°·41	0·377	314°·15	0·097	124°·75	} Galle.
5	17·59	0·089	104·40	0·049	14·67	0·006	53·28	0·024	95·68	0·028	6·56	0·066	41·97	0·038	16·39	0·025	166·19	0·041	58°·79	0·006	240·89	0·012	340·19	0·020	66·21	0·013	228·78	0·008	28·48	0·001	55·67	0·017	337·01	0·027	38·74	0·013	133·17	0·287	330·35	0·089	102·12	
5	15·66	0·154	100·97	0·037	24·19	0·012	355·41	0·028	94·72	0·042	79·98	0·054	44·77	0·013	351·33	0·026	100·12	...	...	0·009	238·24	0·008	319·94	0·009	148·64	0·024	189·31	0·005	126·55	0·003	82·31	0·017	339·95	0·066	338·73	0·030	267·51	0·346	311·78	0·142	121·83	
5	18·82	0·115	90·42	0·043	20·42	0·013	16·93	0·030	91·11	0·029	25·77	0·066	44·58	0·005	160·33	0·020	98·93	0·016	103·36	0·007	236·91	0·007	306·21	0·009	70·24	0·014	250·29	0·004	165·12	0·004	14·46	0·058	42·49	0·073	12·56	0·028	212·44	0·371	297·53	0·096	125·34	
5	17·83	0·098	88·95	0·053	19·87	0·008	57·87	0·024	104·02	0·024	75·28	0·072	46·38	0·028	82·39	0·024	102·90	0·039	72·91	0·007	258·86	0·009	4·55	0·004	171·42	0·017	181·64	0·002	10·48	0·006	11·38	0·035	22·06	0·030	55·13	0·013	47·40	0·324	304·80	0·178	84·63	
5	19·61	0·108	94·72	0·046	23·91	0·010	22·11	0·025	104·13	0·020	32·98	0·071	53·69	0·030	46·46	0·021	87·81	0·024	39·43	0·005	243·16	0·012	7·54	0·009	49·31	0·016	258·78	0·002	5·73	0·007	335·54	0·038	42·16	0·012	17·96	0·020	213·83	0·392	296·59	0·159	135·85	
4	18·23	0·110	95·24	0·047	21·61	0·010	35·69	0·026	96·42	0·030	47·98	0·063	46·44	0·027	60·57	0·024	99·63	0·030	68·62	0·007	255·13	0·009	347·02	0·010	119·12	0·018	212·28	0·004	283·46	0·004	52·44	0·039	14·27	0·038	19·22	0·020	259·79	0·350	309·20	0·127	115·75	
2	35°·72	0·072	108°·98	0·082	34°·05	0·030	36°·95	0·029	80°·79	0·028	53°·79	0·063	28°·53	0·023	39°·47	0·020	105°·63	...	...	0·005	258°·28	0·008	279°·95	0·011	50°·96	0·031	252°·45	0·004	154°·35	0·005	181°·94	0·043	18°·39	0·033	320°·88	0·014	35°·96	0·328	308°·75	0·123	128°·39	} Colombo.
2	35·67	0·104	82·45	0·062	11·86	0·006	59·88	0·027	88·34	0·018	46·01	0·050	46·72	0·014	49·84	0·017	96·51	0·041	353°·08	0·008	267·88	0·005	348·65	0·012	122·83	0·014	256·23	0·002	107·03	0·002	83·42	0·035	321·39	0·064	13·97	0·012	60·25	0·267	326·88	0·060	83·27	
2	29·26	0·126	84·74	0·068	29·87	0·013	1·80	0·031	81·74	0·038	64·41	0·073	29·94	0·011	76·34	0·018	122·45	...	...	0·009	260·33	0·008	357·28	0·008	15·61	0·009	262·00	0·007	27·42	0·005	86·55	0·040	23·98	0·049	343·51	0·026	274·83	0·323	314·71	0·155	121·94	
2	30·70	0·115	90·42	0·066	27·72	0·022	26·24	0·036	86·57	0·028	27·22	0·075	31·09	0·022	47·53	0·016	111·12	0·014	117·48	0·009	237·22	0·005	321·69	0·015	91·58	0·013	306·29	0·009	91·86	0·005	49·39	0·028	76·28	0·066	22·76	0·025	280·39	0·331	298·52	0·105	116·65	
2	33·48	0·127	93·12	0·071	36·65	0·017	56·47	0·035	90·82	0·035	54·67	0·085	33·40	0·021	22·13	0·019	108·33	0·033	77·94	0·010	243·94	0·007	334·31	0·008	342·25	0·027	281·20	0·010	140·40	0·005	355·63	0·051	16·47	0·015	65·08	0·010	261·77	0·276	303·70	0·190	88·52	
2	31·77	0·105	81·39	0·081	17·12	0·008	45·03	0·031	99·45	0·016	57·11	0·090	31·44	0·017	11·07	0·014	82·94	0·047	27·24	0·012	251·55	0·014	5·41	0·008	79·30	0·037	280·19	0·001	174·28	0·005	314·72	0·026	67·06	0·030	304·32	0·016	277·82	0·353	296·17	0·165	130·01	
1	32·77	0·108	90·18	0·072	26·21	0·016	36·73	0·032	87·95	0·027	50·54	0·073	33·52	0·018	41·06	0·017	104·50	0·034	53·93	0·009	253·20	0·008	334·55	0·010	57·09	0·022	273·06	0·006	115·89	0·005	58·61	0·037	27·26	0·043	358·42	0·017	318·50	0·313	308·12	0·133	111·46	
3	345°·11	0·071	280°·50	0·083	342°·47	0·006	348°·09	0·007	143°·17	0·022	278°·33	0·164	242°·78	0·048	228°·46	0·018	131°·73	...	...	0·019	95°·94	0·007	160°·57	0·027	213°·32	0·015	72°·18	0·012	154°·04	0·007	331°·17	0·081	345°·28	0·061	34°·83	0·084	1°·78	0·543	230°·61	0·400	125°·53	} Negapatam.
3	345·32	0·082	290·52	0·085	350·18	0·016	307·30	0·007	218·60	0·031	278·85	0·152	245·55	0·047	266·21	0·024	112·94	0·050	254°·78	0·017	96·39	0·006	216·11	0·026	219·95	0·032	83·72	0·012	184·11	0·007	346·54	0·032	310·44	0·017	338·46	0·097	13·12	0·522	232·64	0·316	134·13	
3	346·55	0·078	285·04	0·080	339·72	0·019	356·72	0·007	284·01	0·039	264·92	0·168	237·00	0·039	209·02	0·016	127·70	...	...	0·018	85·61	0·006	198·15	0·035	219·33	0·024	120·70	0·010	69·02	0·006	334·53	0·076	318·25	0·080	354·06	0·025	81·65	0·348	248·80	0·300	128·63	
3	348·58	0·097	286·09	0·075	347·52	0·014	34·82	0·001	310·17	0·047	219·13	0·151	231·62	0·015	273·36	0·015	103·32	0·037	243·38	0·018	107·12	0·003	230·46	0·015	183·27	0·048	181·63	0·015	143·81	0·009	335·54	0·008	346·87	0·098	5·40	0·026	51·16	0·444	229·60	0·328	129·04	
3	349·04	0·091	281·93	0·074	344·40	0·008	355·74	0·003	34·46	0·030	272·14	0·157	239·46	0·020	279·22	0·014	104·27	...	...	0·024	111·26	0·006	207·74	0·020	213·73	0·022	155·28	0·020	195·41	0·007	336·23	0·048	352·42	0·073	351·26	0·043	15·11	0·364	227·97	0·377	120·86	
3	346·92	0·084	284·82	0·079	344·86	0·013	352·53	0·005	270°·08	0·034	262·67	0·158	239·28	0·034	239·25	0·017	115·99	0·044	249·08	0·019	99·26	0·006	202·61	0·025	209·92	0·028	122·70	0·014	149·28	0·007	336·80	0·049	334·65	0·066	0·80	0·055	32·56	0·444	233·92	0·344	127·64	
1	339°·58	0·121	277°·59	0·093	340°·64	0·029	336°·70	0·004	140°·43	0·037	277°·81	0·246	242°·97	0·053	208°·58	0·046	183°·67	...	...	0·004	176°·87	0·020	228°·14	0·064	231°·35	0·019	81°·73	0·011	33°·46	0·008	79°·00	0·040	40°·65	0·030	4°·84	0·001	84°·35	0·372	200°·56	0·275	110°·83	} Madras.
1	338·26	0·120	276·44	0·094	341·06	0·012	314·06	0·003	150·02	0·017	334·52	0·235	240·19	0·007	287·30	0·048	167·31	0·056	256°·61	0·001	54·27	0·022	219·84	0·026	248·36	0·050	81·83	0·016	98·25	0·007	68·35	0·047	130·38	0·050	349·21	0·034	45·82	0·335	224·82	0·383	148·67	
1	342·06	0·094	285·72	0·103	350·05	0·021	303·71	0·009	43·21	0·054	309·82	0·238	242·38	0·027	317·66	0·030	183·46	...	...	0·004	280·06	0·023	177·87	0·023	254·08	0·029	199·81	0·010	185·05	0·006	65·64	0·055	68·07	0·055	24·86	0·021	44·09	0·449	211·31	0·257	114·65	
1	342·39	0·116	268·22	0·091	344·11	0·022	317·89	0·002	68·08	0·037	287·20	0·229	244·21	0·079	255·43	0·046	190·28	0·019	19·34	0·002	36·52	0·018	232·71	0·044	229·24	0·040	140·39	0·014	290·88	0·005	51·89	0·027	284·73	0·044	64·88	0·023	29·70	0·520	234·73	0·300	139·09	
1	340·85	0·086	269·19	0·104	346·29	0·030	346·06	0·007	280·23	0·026	359·29	0·265	238·02	0·145	224·36	0·063	194·85	...	...	0·015	256·91	0·021	256·55	0·061	201·21	0·102	76·94	0·025	10·18	0·006	14·48	0·017	0·23	0·020	25·41	0·026	128·19	0·366	215·09	0·362	137·41	
1	345·82	0·118	305·28	0·090	348·17	0·006	323·27	0·009	96·31	0·040	298·72	0·193	250·21	0·050	177·44	0·063	170·03	0·080	224·68	0·010	269·98	0·009	236·08	0·032	287·81	0·021	100·87	0·010	85·49	0·007	102·88	0·056	335·70	0·054	343·37	0·035	334·12	0·351	227·84	0·289	140·09	
1	343·29	0·163	276·11	0·070	343·84	0·014	249·39	0·019	87·07	0·094	275·37	0·183	242·09	0·118	341·31	0·037	154·02	0·067	264·22	0·010	296·62	0·012	110·57	0·041	245·55	0·041	95·25	0·004	202·92	0·003	34·10	0·005	104·90	0·055	75·83	0·006	135·60	0·491	201·37	0·363	128·63	
1	350·62	0·108	278·34	0·084	356·63	0·029	336·07	0·013	78·95	0·020	313·20	0·237	247·77	0·053	267·30	0·049	201·64	0·036	316·28	0·001	339·34	0·022	247·90	0·038	221·60	0·029	175·20	0·014	312·63	0·004	62·27	0·023	308·39	0·044	318·19	0·004	121·71	0·286	222·83	0·307	105·48	
1	341·26	0·132	280·84	0·098	345·29	0·029	339·03	0·010	117·00	0·044	313·63	0·268	239·22	0·073	267·68	0·050	187·99	0·017	56·27	0·006	239·73	0·021	246·71	0·062	200·32	0·022	252·32	0·014	61·69	0·006	40·60	0·060	341·27	0·056	28·52	0·044	332·69	0·397	223·85	0·391	113·46	
1	338·78	0·102	255·01	0·106	334·48	0·020	322·93	0·005	175·81	0·030	224·20	0·268	231·50	0·086	249·21	0·047	160·02	0·027	284·69	0·008	221·74	0·015	197·35	0·051	214·04	0·022	216·64	0·013	301·97	0·006	69·66	0·044	20·02	0·033	2·78	0·030	121·82	0·408	203·37	0·219	114·92	
1	342·29	0·116	277·27	0·093	345·06	0·021	318·91	0·008	123·71	0·040	299·38	0·236	241·86	0·074	259·63	0·048	179·33	0·043	306·01	0·006	217·20	0·018	215·37	0·044	233·36	0·038	142·10	0·013	50·25	0·006	58·89	0·037	55·43	0·044	15·79	0·022	65·81	0·398	216·58	0·315	126·22	
2	340°·18	0·175	286°·38	0·099	344°·27	0·028	338°·46	0·017	35°·95	0·075	272°·21	0·308	243°·91	0·071	190°·83	0·019	256°·73	...	...	0·014	130°·69	0·015	214°·74	0·043	241°·70	0·031	120°·41	0·024	295°·91	0·011	326°·42	0·029	197°·51	0·078	54°·62	0·033	18°·60	0·853	199°·64	0·403	108°·63	} Cocanada.
2	338·20	0·160	283·50	0·089	343·11	0·036	336·26	0·008	20·99	0·082	235·22	0·326	242·06	0·018	302·68	0·032	264·01	0·064	293°·60	0·023	144·98	0·018	181·26	0·060	230·09	0·041	134·83	0·024	16·47	0·010	317·82	0·076	290·30	0·095	196·47	0·023	125·06	0·671	199·26	0·522	98·77	
2	339·03	0·161	282·07	0·100	343·00	0·035	11·20	0·002	113·10	0·066	255·89	0·316	247·39	0·105	289·52	0·024	319·18	0·087	257·62	0·027	143·13	0·020	190·66	0·041	206·38	0·055	56·68	0·017	114·42	0·009	317·08	0·089	331·68	0·084	30·03	0·061	342·22	0·583	205·36	0·403	112·06	
2	339·56	0·161	290·30	0·096	344·09	0·019	329·05	0·002	93·11	0·061	232·42	0·325	245·38	0·115	252·51	0·029	261·12	0·053	208·39	0·023	141·79	0·014	167·51	0·072	242·37	0·045	126·38	0·013	266·59	0·012	327·16	0·066	338·77	0·089	336·35	0·059	354·78	0·731	212·85	0·394	119·13	
2	339·03	0·180	279·41	0·091	341·72	0·023	299·98	0·001	325·01	0·046	266·69	0·322	247·37	0·092	208·57	0·014	271·94	0·011	276·22	0·024	120·12	0·014	156·10	0·042	247·28	0·045	90·07	0·014	313·30	0·007	317·35	0·056	85·32	0·073	344·89	0·013	54·21	0·763	190·79	0·237	85·78	
2	339·20	0·169	284·33	0·095	343·24	0·028	334·99	0·006	45·63	0·066	252·49	0·319	245·22	0·080	248·82	0·024	274·60	0·054	258·96	0·022	136·14	0·016	182·05	0·052	233·56	0·043	105·67	0·018	261·34	0·010	321·17	0·063	320·72	0·084	48·47	0·038	34·97	0·72	201·58	0·392	104·87	
1	22°·19	0·438	70°·88	0·192	26°·00	0·053	51°·47	0·016	327°·77	0·425	60°·30	0·869	23°·51	0·402	24°·23	0·268	200°·14	...	...	0·355	17°·66	0·129	299°·41	0·031	18°·86	0·143	246°·35	0·131	310°·32	0·049	262°·97	0·075	338°·70	0·181	39°·64	0·432	39°·14	1·666	136°·59	0·178	217°·27	} Chittagong.
1	20·30	0·397	65·93	0·195	31·21	0·027	98·88	0·025	358·65	0·399	39·17	0·841	24·78	0·295	1·67	0·276	205·60	0·139	246°·33	0·344	23·85	0·138	303·05	0·080	294·49	0·088	274·99	0·102	337·51	0·043	262·93	0·177	8·64	0·173	343·44	0·459	42·31	1·435	131·74	0·105	72·85	
1	21·87	0·389	68·30	0·188	31·32	0·018	17·75	0·021	55·02	0·345	39·71	0·847	24·48	0·117	19·39	0·304	196·43	0·133	164·75	0·348	22·35	0·133	306·54	0·211	340·41	0·167	237·45	0·039	326·90	0·061	279·85	0·230	11·13	0·136	22·07	0·450	39·61	1·637	132·62	0·206	277·41	
1	22·95	0·471	65·69	0·185	34·19	0·038	33·91	0·019	355·91	0·181	65·96	0·823	28·77	0·314	50·28	0·301	203·80	0·074	83·50	0·345	26·71	0·123	295·83	0·334	30·90	0·056	203·82	0·094	289·07	0·071	266·22	0·226	0·18	0·029	21·36	0·354	38·90	1·221	135·87	0·120	141·47	
1	21·14	0·458	65·57	0·219	32·52	0·059	59·94	0·034	359·00	0·342	70·35	0·824	22·81	0·368	38·03	0·300	197·41	0·106	302·21	0·338	23·40	0·133	296·42	0·112	54·06	0·167	257·10	0·134	308·63	0·073	273·24	0·253	341·66	0·184	19·53	0·443	38·82	1·877	134·51	0·158	264·76	
1	21·69	0·431	67·27	0·196	31·05	0·039	52·39	0·023	3·27	0·338	55·10	0·841	24·87	0·299	26·72	0·290	200·68	0·113	19·20	0·346	22·79	0·131	300·25	0·154	3·74	0·124	243·94	0·100	314·49	0·059	269·04	0·192	356·06	0·141	17·21	0·428	39·76	1·567	134·26	0·153	266·75	
2	19°·52	0·980	120°·49	0·162	17°·86	0·029	77°·32	0·043	23°·11	0·440	116°·82	0·961	90°·24	0·132	67°·51	0·346	273°·33	...	...	0·310	121°·72	0·163	42°·16	0·281	87°·44	0·235	33°·75	0·073	66°·26	0·069	350°·60	0·120	348°·88	0·190	9°·87	0·226	56°·23	0·812	117°·21	0·134	204°·09	} Elephant Point.
2	19·47	0·716	135·16	0·189	31·59	0·064	102·82	0·024	328·93	0·250	131·54	1·052	85·62	0·137	122·10	0·391	293·47	0·318	92°·67	0·296	127·73	0·112	34·57	0·205	84·96	0·198	44·75	0·055	344·26	0·076	353·03	0·120	6·96	0·120	24·28	0·245	52·78	0·873	141·07	0·107	219·26	
2	19·40	0·589	135·87	0·195	35·58	0·011	106·70	0·004	279·48	0·412	138·95	1·145	86·28	0·346	122·77	0·342	288·44	...	...	0·292	125·77	0·131	35·28	0·102	143·73	0·126	36·31	0·134	3·22	0·069	353·55	0·075	359·60	0·148	12·62	0·199	27·22	0·918	152·24	0·141	121·94	
2	17·66	0·710	144·43	0·223	30·86	0·025	61·00	0·030	4·11	0·448	125·85	1·207	87·73	0·416	94·95	0·329	302·38	0·142	184·87	0·277	129·08	0·134	39·19	0·105	326·54	0·199	79·77	0·151	36·12	0·073	357·12	0·056	347·45	0·044	107·55	0·221	37·25	0·764	141·20	0·150	88·91	
2	18·28	0·763	147·24	0·195	32·83	0·023	89·33	0·029	38·76	0·423	120·21	1·188	90·70	0·313	66·62	0·382	302·13	...	...	0·281	130·57	0·138	40·39	0·197	13·74	0·196	136·10	0·047	46·99	0·032	349·82	0·107	350·89	0·037	20·33	0·170	30·36	0·845	148·88	0·115	113·58	
1	18·87	0·752	136·64	0·193	29·74	0·030	87·43	0·026	350·88	0·395	126·67	1·111	88·11	0·269	94·79	0·358	291·95	0·230	138·77	0·291	126·97	0·136	38·32	0·178	59·28	0·191	66·14	0·092	27·37	0·064	352·82	0·096	354·76	0·108	34·93	0·212	40·77	0·842	140·12	0·129	149·56	

tement showing the interruptions which occurred in the observations entered in S Series.

Interruption. To	Total Number of days' interruption. In each period.	In the year.	Name of Station.	Year of Observation.	Period of interruption. From	To	Total Number of days' interruption. In each period.	In the year.
7th September 1884	12	12	Madras	1882-83	17th February 1882	7th March 1882	19	24
3rd August 1885	8	8			21st July 1882	25th July 1882	5	
6th January 1887	33	33			29th June 1884	21st July 1884	23	
1st September 1884	7	12		1884-85	29th August 1884	28th September 1884	31	67
3rd October 1884	5				14th October 1884	26th October 1884	13	
3th July 1885	1	35		1885-86	23rd February 1885	2nd March 1885	8	8
5th December 1885	34				12th May 1886	21st May 1886	10	
7th November 1889	28	28		1886-87	23rd May 1886	3rd June 1886	12	58
					24th June 1886	16th July 1886	23	
7th December 1886	17	17			29th July 1886	10th August 1886	13	
7th December 1889	7	7		1888-89	5th March 1889	9th March 1889	5	5
7th December 1884	33	33		1889-90	10th October 1890	2nd November 1890	24	24

TABLE No. 2—(*continued from Annual Report 1886-87*).

Table showing the comparison between the Analysed and Equilibrium theoretical values of the co-efficients of the various Tides in terms of the Main Lunar Tide M_2 for the Stations at which observations have been completed.

Station.	Year.	Semi-diurnal Tides.								Diurnal Tides.							Over Tides.							Compound Tides.					Long Period Tides.				
		Main Solar.	Luni-Solar.	Lunar Elliptic.		Evectional.	Lunar Elliptic, 2nd order.	Solar Elliptic.	Variational.	Luni-Solar.	Declinational.		Elliptic.		Lunar.	Solar.	Lunar.			Solar.				Ter diurnal.	Quarter diurnal.	Ter diurnal.	Quarter diurnal.	Semi-diurnal.	Lunar Monthly.	Lunar Fortnightly.	Luni-solar Fortnightly.	Solar-annual.	Solar Semi-annual.
		S_2	K_2	N_2	L_2	ν_2	$2N_2$	T_2	μ_2	K_1	O_1	P_1	Q_1	J_1	M_1	S_1	M_3	M_4	M_6	M_8	S_4	S_6	S_8	$(M_2K_1)_3$	$(MS)_4$	$(2M_2K_1)_3$	$(M_3N)_4$	$(2SM)_2$	M_m.	M_f.	MS_f.	S_{sa}.	S_{ssa}.
Equilibrium Theoretical Values		0·465	0·127	0·194	0·028	0·038	0·026	0·027	0·024	0·584	0·415	0·193	0·080	0·033	0·036		0·013							0·121	0·096	0·086	0·040		0·046	0·086	0·007		0·040
Mormugão	1884-85	0·361	0·103	0·242	0·017	0·087	0·035	...	0·035	0·578	0·292	0·170	0·056	0·035	0·025	0·045	0·010	0·023	0·006	0·007	0·005	0·002	0·002	0·011	0·012	0·005	0·025	0·001	0·027	0·027	0·012	0·173	0·042
	1885-86	0·352	0·098	0·241	0·029	0·057	0·038	0·037	0·023	0·568	0·288	0·168	0·065	0·047	0·030	0·023	0·008	0·026	0.007	0·006	0·005	0·003	0·002	0·019	0·015	0·003	0·031	0·002	0·016	0·041	0·031	0·091	0·030
	1886-87	0·350	0·112	0·233	0·021	0·010	0·040	...	0·032	0·559	0·283	0·157	0·060	0·041	0·008	0·026	0·009	0·028	0·007	0·009	0·004	0·002	0·002	0·021	0·014	0·003	0·012	0·004	0·008	0·049	0·022	0·159	0·072
	1887-88	0·351	0·103	0·238	0·041	0·046	0·027	0·040	0·026	0·564	0·287	0·165	0·054	0·027	0·009	0·025	0·010	0·027	0·008	0·007	0·005	0·003	0·001	0·009	0·009	0·004	0·037	0·004	0·027	0·015	0·005	0·196	0·105
	1888-89	0·356	0·101	0·243	0·028	0·076	0·034	0·053	0·035	0·564	0·289	0·163	0·062	0·031	0·006	0·028	0·011	0·027	0·004	0·007	0·006	0·002	0·002	0·011	0·017	0·004	0·022	0·006	0·006	0·031	0·014	0·125	0·071
	Means	0·354	0·103	0·239	0·027	0·055	0·035	0·043	0·030	0·567	0·288	0·166	0·059	0·036	0·016	0·029	0·010	0·026	0·006	0·007	0·005	0·002	0·002	0·014	0·013	0·004	0·025	0·003	0·017	0·033	0·017	0·149	0·064
Galle	1884-85	0·679	0·177	0·101	0·068	0·091	0·013	...	0·048	0·314	0·084	0·101	0·044	0·019	0·019	0·021	0·027	0·017	0·008	0·004	0·004	0·002	0·002	0·010	0·011	0·004	0·049	0·013	0·127	0·038	0·025	0·717	0·184
	1885-86	0·680	0·170	0·126	0·053	0·072	0·038	0·078	0·048	0·314	0·099	0·093	0·040	0·011	0·015	0·023	0·023	0·021	0·006	0·004	0·008	0·000	0·002	0·015	0·011	0·002	0·025	0·023	0·032	0·051	0·025	0·547	0·170
	1886-87	0·698	0·291	0·102	0·079	0·025	0·017	...	0·049	0·317	0·087	0·070	0·053	0·023	0·008	0·058	0·026	0·025	0·006	0·002	0·004	0·008	0·002	0·009	0·017	0·006	0·045	0·015	0·032	0·125	0·057	0·653	0·268
	1887-88	0·704	0·219	0·115	0·055	0·010	0·017	0·031	0·038	0·324	0·094	0·082	0·057	0·025	0·013	0·021	0·023	0·027	0·004	0·002	0·006	0·002	0·002	0·008	0·013	0·008	0·027	0·013	0·111	0·139	0·053	0·708	0·183
	1888-89	0·679	0·186	0·137	0·046	0·053	0·008	0·074	0·046	0·315	0·093	0·101	0·046	0·015	0·013	0·023	0·025	0·028	0·004	0·002	0·008	0·002	0·006	0·004	0·013	0·011	0·032	0·017	0·066	0·057	0·025	0·615	0·338
	1889-90	0·680	0·203	0.134	0·038	0·056	0·017	0·045	0·040	0·313	0·077	0·087	0·047	0·019	0·006	0·021	0·019	0·023	0·004	0·004	0·006	0·000	0·002	0·004	0·009	0·013	0·030	0·023	0·072	0·023	0.038	0·738	0·299
	Means	0·687	0·208	0·119	0·057	0·051	0·018	0·057	0·045	0·316	0·089	0·089	0·049	0·019	0·012	0·028	0·024	0·024	0·005	0·003	0·006	0·002	0·003	0·008	0·012	0·007	0·035	0·017	0·073	0·072	0·037	0·663	0·240
Colombo	1884-85	0·663	0·132	0·115	0·051	0·042	0·020	...	0·037	0·434	0·170	0·150	0·053	0·055	0·015	0·033	0·027	0·027	0·004	0·000	0·007	0·004	0·002	0·007	0·009	0·009	0·057	0·015	0·079	0·060	0·026	0·600	0·225
	1885-86	0·691	0·185	0·089	0·032	0·025	0·021	0·073	0·030	0·410	0·179	0·110	0·048	0·011	0·023	0·053	0·027	0·025	0·005	0·002	0·007	0·004	0·002	0·004	0·014	0·004	0·025	0·009	0·062	0·114	0·021	0·474	0·107
	1886-87	0·085	0·214	0·124	0·064	0·019	0·014	...	0·031	0·405	0·154	0·115	0·053	0·022	0·010	0·005	0·024	0·029	0·008	0·000	0·007	0·003	0·000	0·012	0·015	0·008	0·015	0·014	0·068	0·083	0·044	0·547	0·263
	1887-88	0·681	0·194	0·126	0·047	0·037	0·025	0·024	0·027	0·405	0·155	0·111	0·061	0·037	0·012	0·010	0·027	0·030	0·007	0·002	0·010	0·002	0·000	0·015	0·015	0·008	0·022	0·008	0·047	0·111	0·042	0·558	0·177
	1888-89	0·638	0·213	0·143	0·059	0·035	0·013	0·055	0·032	0·403	0·104	0·119	0·059	0·029	0·025	0·007	0·020	0·029	0·007	0·002	0·008	0·003	0·000	0·017	0·017	0·008	0·045	0·012	0·086	0·025	0·017	0·463	0·319
	1889-90	0·672	0·179	0·154	0·027	0·029	0·014	0·080	0·024	0·406	0·155	0·138	0.053	0·014	0·024	0·027	0·027	0·031	0·007	0·002	0·009	0·003	0·002	0·002	0·020	0·009	0·063	0·024	0·044	0·051	0·027	0·602	0·282
	Means	0·658	0·186	0·125	0·047	0·031	0·018	0·058	0·030	0·411	0·163	0·124	0·055	0·028	0·018	0·023	0·025	0·029	0·006	0·001	0·008	0·003	0·001	0·010	0·015	0·008	0·038	0·014	0·064	0·074	0·030	0·541	0·229
Negapatam	1881-82	0·381	0·100	0·230	0·031	0·067	0·038	...	0·025	0·312	0·129	0·117	0·010	0·008	0·004	0·067	0·004	0·032	0·014	0·007	0·008	0·000	0·001	0·017	0·027	0·010	0·021	0·010	0·114	0·086	0·118	0·763	0·562
	1882-83	0·381	0·113	0·209	0·043	0·065	0·036	0·069	0·033	0·312	0·122	0·117	0·010	0·022	0·008	0·061	0·004	0·025	0·018	0·006	0·006	0·001	0·001	0·017	0·023	0·010	0·044	0·008	0·044	0·023	0·133	0·718	0·435
	1885-86	0·384	0·106	0·227	0·053	0·053	0·047	...	0·022	0·303	0·118	0·108	0·009	0·026	0·023	0·054	0·005	0·023	0·015	0·005	0·008	0·001	0·001	0·014	0·024	0·008	0·032	0·008	0·103	0·108	0·034	0·471	0·406
	1886-87	0·370	0·137	0·214	0·067	0·021	0·021	0·052	0·021	0·306	0·123	0·106	0·001	0·020	0·023	0·030	0·003	0·030	0·014	0·004	0·008	0·001	0·001	0·021	0·025	0·013	0·068	0·004	0·011	0·139	0·037	0·629	0·465
	1887-88	0·381	0·139	0·440	0·046	0·031	0·031	...	0·021	0·321	0·135	0·113	0·005	0·012	0·012	0·084	0·006	0·047	0·014	0·002	0·006	0·003	0·000	0·031	0·037	0·011	0·034	0·009	0·073	0·112	0·066	0·557	0·576
	Means	0·379	0·119	0·224	0·048	0·047	0·035	0·061	0·024	0·311	0·125	0·112	0·007	0·018	0·014	0·059	0·004	0·031	0·015	0·005	0·007	0·001	0·001	0·020	0·027	0·010	0·040	0·008	0·069	0·094	0·078	0·628	0·489
Madras	1880-81	0·417	0·116	0·235	0·035	0·051	0·061	...	0·044	0·281	0·090	0·089	0·004	0·028	0·018	0·035	0·004	0·002	0·010	0·002	0·002	0·002	0·001	0·011	0·004	0·008	0·018	0·019	0·038	0·029	0·001	0·355	0·263
	1881-82	0·423	0·114	0·224	0·016	0·007	0·025	0·053	0·046	0·277	0·091	0·089	0·003	0·011	0·001	0·025	0·003	0·001	0·010	0·001	0·002	0·001	0·000	0·015	0·001	0·007	0·048	0·021	0·045	0·048	0·032	0·319	0·364
	1882-83	0·419	0·090	0·227	0·051	0·069	0·022	...	0·029	0·279	0·096	0·098	0·009	0·020	0·004	0·011	0·006	0·005	0·009	0·002	0·001	0·001	0·001	0·010	0·004	0·006	0·028	0·022	0·052	0·052	0·020	0·428	0·245
	1883-84	0·422	0·112	0·222	0·036	0·076	0·043	0·018	0·045	0·282	0·093	0·088	0·002	0·021	0·003	0·025	0·004	0·002	0·006	0·002	0·002	0·001	0·000	0·014	0·002	0·005	0·039	0·017	0·026	0·043	0·022	0·503	0·290
	1884-85	0·423	0·081	0·250	0·025	0·137	0·058	...	0·060	0·280	0·095	0·098	0·007	0·028	0·036	0·053	0·003	0·018	0·008	0·001	0·005	0·001	0·001	0·024	0·014	0·006	0·096	0·020	0·016	0·019	0·025	0·346	0·342
	1885-86	0·422	0·120	0·196	0·041	0·051	0·033	0·081	0·064	0·291	0·091	0·092	0·009	0·006	0·018	0·017	0·003	0·014	0·006	0·003	0·003	0·001	0·001	0·010	0·010	0·007	0·021	0·009	0·057	0·055	0·036	0·357	0·294
	1886-87	0·434	0·160	0·180	0·092	0·116	0·040	0·066	0·036	0·276	0·105	0·069	0·019	0·014	0·014	0·077	0·004	0·008	0·011	0·003	0·002	0·002	0·001	0·004	0·010	0·003	0·040	0·012	0·005	0·054	0·006	0·482	0·356
	1887-88	0·414	0·114	0·249	0·021	0·056	0·040	0·038	0·052	0·295	0·094	0·088	0·014	0·031	0·014	0·005	0·004	0·003	0·004	0·003	0·003	0·001	0·000	0·015	0·001	0·004	0·031	0·023	0·024	0·046	0·004	0·301	0·323
	1888-89	0·434	0·124	0·252	0·041	0·063	0·058	0·016	0·047	0·283	0·092	0·092	0·009	0·027	0·018	0·022	0·006	0·009	0·008	0·001	0·002	0·001	0·001	0·013	0·006	0·006	0·021	0·020	0·056	0·053	0·041	0·373	0·368
	1889-90	0·407	0·095	0·251	0·028	0·080	0·048	0·025	0·044	0·285	0·097	0·099	0·005	0·019	0·007	0·033	0·005	0·007	0·008	0·001	0·003	0·001	0·002	0·012	0·007	0·006	0·021	0·014	0·041	0·031	0·028	0·382	0·205
	Means	0·422	0·113	0·229	0·039	0·071	0·043	0·042	0·047	0·283	0·094	0·090	0·008	0·021	0·013	0·030	0·004	0·007	0·008	0·002	0·003	0·001	0·001	0·013	0·006	0·006	0·036	0·018	0·036	0·043	0·022	0·385	0·305
Cocanada	1886-87	0·433	0·118	0·207	0·050	0·048	0·029	...	0·013	0·234	0·090	0·067	0·011	0·019	0·013	0·024	0·004	0·017	0·009	0·001	0·002	0·002	0·002	0·016	0·009	0·007	0·021	0·010	0·020	0·052	0·022	0·574	0·271
	1887-88	0·406	0·109	0·211	0·033	0·012	0·039	0·041	0·021	0·228	0·089	0·058	0·005	0·023	0·015	0·024	0·006	0·017	0·010	0·001	0·005	0·003	0·002	0·016	0·015	0·006	0·027	0·012	0·049	0·061	0·015	0·434	0·338
	1888-89	0·421	0·106	0·207	0·043	0·069	0·027	0·057	0·016	0·228	0·090	0·066	0·001	0·023	0·012	0·022	0·004	0·021	0·011	0·001	0·005	0·002	0·002	0·011	0·018	0·006	0·036	0·013	0·058	0·055	0·040	0·382	0·264
	1889-90	0·423	0·108	0·218	0·041	0·077	0·048	0·035	0·019	0·232	0·096	0·064	0·001	0·013	0·015	0·023	0·005	0·020	0·011	0·002	0·004	0·001	0·001	0·009	0·015	0·008	0·030	0·009	0·044	0·060	0·040	0·490	0·264
	1890-91	0·427	0·119	0·212	0·030	0·061	0·028	0·007	0·009	0·227	0·089	0·060	0·001	0·015	0.007	0·025	0·006	0·022	0·012	0·002	0·005	0·001	0·001	0·009	0·016	0·005	0·030	0·009	0·037	0·048	0·009	0·503	0·156
	Means	0·422	0·112	0·211	0·043	0·053	0·034	0·035	0·016	0·230	0·091	0·063	0·004	0·019	0·012	0·024	0·005	0·019	0·011	0·001	0·004	0·002	0·002	0·012	0·015	0·006	0·029	0·011	0.042	0·055	0·025	0·477	0·259
Chittagong	1886-87	0·354	0·099	0·196	0·096	0·091	0·007	...	0·061	0·131	0·067	0·043	0·004	0·012	0·006	0·014	0·009	0·095	0·032	0·008	0·011	0·002	0·000	0·030	0·080	0·011	0·032	0·029	0·017	0·041	0·098	0·376	0·040
	1887-88	0·350	0·089	0·189	0·090	0·066	0·018	0·031	0·062	0·130	0·065	0·044	0·006	0·006	0·005	0·013	0·010	0·089	0·034	0·008	0·012	0·002	0·000	0·023	0·077	0·010	0·020	0·031	0·040	0·039	0·103	0·323	0·024
	1888-89	0·358	0·083	0·191	0·078	0·026	0·048	0·030	0·069	0·135	0·065	0·042	0·005	0·004	0·011	0·016	0·009	0·091	0·028	0·007	0·013	0·001	0·001	0·009	0·079	0·014	0·038	0·030	0·052	0·031	0·102	0·370	0·047
	1889-90	0·353	0·105	0·184	0·040	0·070	0·024	0·016	0·067	0·133	0·064	0·041	0·004	0·008	0·010	0·017	0·007	0·087	0·031	0·006	0·014	0·002	0·001	0·021	0·077	0·016	0·012	0·027	0·050	0·006	0·079	0·272	0·027
	1890-91	0·353	0·103	0·185	0·077	0·083	0·025	0·024	0·067	0·138	0·066	0·049	0·008	0·013	0 001	0·015	0·003	0·094	0·032	0·007	0·012	0·002	0·001	0·030	0·076	0·016	0·038	0·030	0·057	0·041	0.100	0·422	0·036
	Means	0·354	0·097	0·189	0·070	0·067	0·034	0·025	0·065	0·133	0·065	0·044	0·005	0·009	0·007	0·015	0·008	0·091	0·031	0·007	0·012	0·002	0·001	0·023	0·078	0·013	0·028	0·029	0·043	0·032	0·096	0·353	0·035
Elephant Point	1884	0·406	0·167	0·164	0·075	0·022	0·048	...	0.059	0·123	0·059	0·028	0·007	0·005	0·007	0·024	0·004	0·046	0·043	0·018	0·016	0·002	0·002	0·012	0·053	0·012	0·040	0·028	0·020	0·032	0·038	0·138	0·033
	1885	0·407	0·122	0·179	0·042	0·023	0·035	0·054	0·066	0·125	0·055	0·032	0·004	0·011	0·002	0·014	0·004	0·049	0·041	0·017	0·015	0·001	0·001	0·009	0·050	0·013	0·034	0·019	0·020	0·020	0·042	0·148	0·018
	1886	0·401	0·100	0·194	0·070	0·059	0·017	...	0·058	0·127	0·055	0·033	0·001	0·002	0·003	0·014	0·005	0·047	0·041	0·018	0·013	0·002	0·000	0·023	0·050	0·012	0·021	0·022	0·013	0·025	0·034	0·156	0·024
	1887	0·401	0·120	0·204	0·076	0·070	0·018	0·024	0·056	0·129	0·053	0·038	0·005	0·004	0·007	0·013	0·007	0·049	0·041	0·018	0·014	0·002	0·001	0·026	0·047	0·012	0·034	0·023	0·009	0·007	0·037	0·129	0·025
	1887-88	0·403	0·128	0·200	0·071	0·053	0·033	...	0·064	0·128	0·053	0·033	0·005	0·004	0·006	0·017	0·005	0·047	0.041	0·018	0·014	0·001	0·000	0·008	0·047	0·005	0·033	0·023	0·018	0·006	0·029	0·142	0·019
	Means	0·404	0·127	0·188	0·067	0·045	0·030	0·039	0·061	0·126	0·055	0·033	0·004	0·005	0·005	0·016	0·005	0·048	0·041	0·018	0·014	0·002	0·001	0·016	0·049	0·011	0·032	0·023	0·016	0·018	0·036	0·143	0·022

An inspection of the observatory, lasting from the 15th to the 21st May, was made by Mr. Belcham, who found that the tide gauge and aneroid were in adjustment and working well, but much in need of cleaning. He had the several instruments thoroughly cleaned, and after setting up a new anemometer, which he took with him, brought away the damaged instrument for repair. During the inspection the observatory was frequently visited by Colonel Cadell, V.C., the Chief Commissioner of the Andamans, who directed the Sub-Engineer to include it in his rounds of inspection, and to see that the communication holes in the cylinder were kept open so as to ensure a correct record of the tides.

If the unfortunate discontinuance of tidal registrations at Madras, and the disappointing nature of the recent tidal observations at Aden, be excepted, I think we are entitled to congratulate ourselves on the results obtained at the various tidal stations during the year under report. It is specially satisfactory to note the great, and it is to be hoped permanent, improvement which has taken place at Port Blair, to which, being a permanent ocean station, we look for data which ought to prove of great general interest and utility.

Reduction of the Tidal Observations.

The observations at 15 tidal stations have been reduced, and two years' calculations having been made in the case of three of them, the total calculations are thus equivalent to the reduction of 18 years' observations at one station. The tabulated values of the tidal constants so obtained are appended.

Two other tables marked No. 1 and No. 2, giving the results of the tidal registrations at eight stations closed since the General Report 1886-87 was submitted, are also appended. Table No. 1 gives the actual values in feet and degrees of the mean amplitudes and epochs of the tidal components, and Table No. 2 their values in terms of the main lunar tide M_2 for comparison with the equilibrium theoretical values. Similar tables were published in the above-mentioned General Report for the stations closed up to the 30th September 1887.

It was mentioned in the General Report for 1887-88 that a commencement had been made tentatively towards utilising the meteorological records of the tidal observations for tidal purposes, three years observations at Karwar having been selected for treatment; and Mr. Roberts of the Nautical Almanac Office was requested to run off, by means of the tide predicting machine at the India Office, certain constituent tides required in the investigation. Nothing, however, has as yet been heard from him on the subject, and the investigation must be postponed until we receive the curves applied for.

The present state of the ordinary tidal computations is shown in the table following, together with their state at the end of September 1890. The letters A. P. in the table indicate that the actual times and heights of high and low water have been measured in duplicate from the tidal diagrams and compared with their predicted values published in the tide tables. The actual amount of work done during the year under report can thus be seen at a glance.

The extra tidal work is not entered in the table. This consisted in furnishing the Calcutta Municipal Corporation with the actual time and height of every high and low water at Kidderpore, for the 15 months, extending from 1st August 1889 to 30th November 1890, for use in connection with the important works contemplated for the improvement and extension of the drainage of Calcutta, and in submitting reports as before, on the tidal operations carried on in the Bombay Presidency and in Burma, to the Local Governments.

In the annual report of this party submitted last year I find it stated under the heading 'Reduction of the tidal observations' that "every endeavour was made to clear off as much of the arrears as possible." With reference to this I would remark that, while every endeavour has always been made by Mr. Connor and his computers to reduce the observations of each tidal observatory as soon as possible after the completion of each year of observation, the reductions take time; and it frequently happens that in an annual report recording the completion of a year's observations at an observatory, the completion of their reduction cannot at the same time be announced. Such unfinished calculations cannot properly be termed arrears. When I went on furlough in 1888 the reductions were not in arrear, and I find that no arrears have accumulated since then under any of the three officers who held charge of this party during my absence.

State of the ordinary reductions of the yearly tidal-registrations at the beginning and end of the Survey year 1890-91.

Tidal Observatory.	State at end of September 1890.	State at end of September 1891.
Aden . .	1888-89, calculations completed. 1889-90, diagrams read off. A. P.	1889-90, calculations completed. 1890-91, observations rejected in part. A. P. 1890.
Kurrachee . .	1887-88, calculations completed. 1888-89, calculations completed. 1889-90, diagrams read off. A. P.	1889-90, calculations completed. 1890-91, calculations completed. A. P. 1890.

State of the ordinary reductions of the yearly tidal-registrations at the beginning and end of the Survey year 1890-91—continued.

Tidal Observatory.	State at end of September 1890.	State at end of September 1891.
Bhávnagar .	1889, calculations completed. A. P.	1890, calculations completed. A. P. 1890.
Bombay (Apollo Bandar.)	1889, calculations completed. A. P.	1890, calculations completed. A. P. 1890.
Bombay (Prince's Dock)	1888-89, calculations completed. 1889, calculations completed. A. P.	1890, calculations completed. A. P. 1890.
Cochin . . .	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Minicoy (started 12th January 1891).	.....	Newly started observatory.
Colombo (closed 29th March 1890).	1889-90, calculations completed. A. P.	A. P. 1890.
Galle (closed 11th April 1890).	1888-89, calculations completed. 1889-90, calculations completed. A. P.	A. P. 1890.
Trincomalee (started 10th November 1890).	.....	Newly started observatory.
Tuticorin . .	1889-90, calculations completed.	1890-91, calculations completed. A. P. 1890.
Madras (closed 10th October 1890).	1888-89, calculations completed. A. P.	1889-90, calculations completed. A. P. 1890.
Cocanada (closed 18th April 1891).	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Kidderpore . .	1888-89, calculations completed. A. P.	1889-90, calculations completed. 1890-91, calculations completed.
Chittagong (closed 22nd July 1891).	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Akyab . . .	1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.
Rangoon . . .	1888-89, calculations completed. A. P.	1889-90, calculations completed. 1890-91, calculations completed. A. P. 1890.
Mergui . . .	1889-90, calculations completed.	1890-91, calculations completed.
Port Blair . .	1888-89, calculations completed. 1889-90, calculations completed. A. P.	1890-91, calculations completed. A. P. 1890.

Values of the Tidal Constants, Aden, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

$A_0 = 5{\cdot}835$ feet.

S_1	$H = R =$	·101	M_6	$R =$	·002	Q_1	$R =$	·145	T_2	$R =$	·067
	$\kappa = \zeta =$	173°·08		$\zeta =$	36°·03		$\zeta =$	52°·42		$\zeta =$	283°·19
S_2	$H = R =$	·682		$H =$	·002		$H =$	·145		$H =$	·067
	$\kappa = \zeta =$	243°·39		$\kappa =$	300°·79		$\kappa =$	39°·91		$\kappa =$	222°·90
S_4	$H = R =$	·002	M_8	$R =$	·004	L_2	$R =$	·031	$(MS)_4$	$R =$	·014
	$\kappa = \zeta =$	281°·31		$\zeta =$	178°·26		$\zeta =$	341°·27		$\zeta =$	180°·87
S_6	$H = R =$	·008		$H =$	·004		$H =$	·025		$H =$	·014
	$\kappa = \zeta =$	201°·40		$\kappa =$	51°·28		$\kappa =$	228°·88		$\kappa =$	149°·12
S_8	$H = R =$	·001	O_1	$R =$	·650	N_2	$R =$	·428	$(2SM)_2$	$R =$	·026
	$\kappa = \zeta =$	323°·13		$\zeta =$	305°·43		$\zeta =$	353°·36		$\zeta =$	60°·40
				$H =$	·654		$H =$	·426		$H =$	·025
				$\kappa =$	35°·36		$\kappa =$	219°·17		$\kappa =$	92°·14

Short Period Tides—contd.

$A_0 = 5{\cdot}835$ feet.

M_1	R =	·035	K_1	R =	1·307	λ_2	R =	...		R =	·096
	ζ =	118°·26		ζ =	151°·20		ζ =	...	$2N_2$	ζ =	73°·89
	H =	·034		H =	1·311		H =	...		H =	·095
	κ =	267°·29		κ =	33°·63		κ =	...		κ =	197°·27
M_2	R =	1·576	K_2	R =	·200	ν_2	R =	·129		R =	·057
	ζ =	255°·33		ζ =	293°·66		ζ =	151°·51	$(M_2N)_4$	ζ =	220°·96
	H =	1·566		H =	·206		H =	·128		H =	·056
	κ =	223°·58		κ =	238°·53		κ =	192°·56		κ =	55°·03
M_3	R =	·019	P_1	R =	·413	μ_2	R =	·102		R =	·009
	ζ =	229°·10		ζ =	281°·28		ζ =	240°·61	$(M_2\ K_1)_3$	ζ =	287°·59
	H =	·019		H =	·413		H =	·101		H =	·009
	κ =	181°·48		κ =	2ϕ°·95		κ =	177°·12		κ =	138°·27
M_4	R =	·004	J_1	R =	·084	R_2	R =	...		R =	·012
	ζ =	11°·89		ζ =	70°·05		ζ =	...	$(2M_2K_1)_3$	ζ =	311°·88
	H =	·004		H =	·083		H =	...		H =	·012
	κ =	308°·40		κ =	50°·81		κ =	...		κ =	5°·96

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·030	252°·30	·029	354°·74
,, Fortnightly ,, . . .	·042	44·06	·043	12·45
Luni-Solar ,, ,, . . .	·024	191·21	024	222·95
Solar-Annual ,, . . .	·381	14·44	·381	355·76
,, Semi-Annual ,, . . .	·083	155·30	·083	117·96

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

$A_0 = 7{\cdot}143$ feet

S_1	H = R =	·095	M_6	R =	·042	Q_1	R =	·156		R =	·053
	κ = ζ =	165°·17		ζ =	346°·92		ζ =	160°·38	T_2	ζ =	163°·13
S_2	H = R =	·946		H =	·043		H =	·147		H =	·053
	κ = ζ =	324°·44		κ =	202°·93		κ =	53°·85		κ =	45°·01
S_4	H = R =	·010	M_8	R =	·006	L_2	R =	·092		R =	·032
	κ = ζ =	42°·94		ζ =	294°·94		ζ =	159°·44	$(MS)_4$	ζ =	272°·41
S_6	H = R =	·007		H =	·006		H =	·089		H =	·033
	κ = ζ =	302°·99		κ =	222°·97		κ =	308°·40		κ =	344°·42
S_8	H = R =	·002	O_1	R =	·700	N_2	R =	·616		R =	·023
	κ = ζ =	25°·02		ζ =	270°·85		ζ =	88°·87	$(2SM)_2$	ζ =	183°·22
				H =	·658		H =	·622		H =	·024
				κ =	45°·53		κ =	279°·68		κ =	111°·22
M_1	R =	·111	K_1	R =	1·364	λ_2	R =	...		R =	·097
	ζ =	320°·14		ζ =	105°·17		ζ =	...	$2N_2$	ζ =	321°·50
	H =	·069		H =	1·311		H =	...		H =	·098
	κ =	55°·96		κ =	46°·09		κ =	...		κ =	271°·11
M_2	R =	2·558	K_2	R =	·301	ν_2	R =	·204		R =	·069
	ζ =	221°·90		ζ =	263°·73		ζ =	235°·62	$(M_2N)_4$	ζ =	213°·91
	H =	2·580		H =	·277		H =	·206		H =	·070
	κ =	293°·91		κ =	325°·14		κ =	262°·91		κ =	116°·72
M_3	R =	·034	P_1	R =	·371	μ_2	R =	·059		R =	·068
	ζ =	35°·20		ζ =	355°·36		ζ =	118°·10	$(M_2K_1)_3$	ζ =	45°·19
	H =	·035		H =	·371		H =	·060		H =	·065
	κ =	323°·27		κ =	46°·18		κ =	262°·11		κ =	58°·11
M_4	R =	·037	J_1	R =	·106	R_2	R =	...		R =	·028
	ζ =	210°·94		ζ =	226°·57		ζ =	...	$(2M_2K_1)_3$	ζ =	194°·60
	H =	·038		H =	·100		H =	...		H =	·027
	κ =	354°·95		κ =	45°·10		κ =	...		κ =	37°·70

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·071	27°·01	·073	268°·21
,, Fortnightly ,, . . .	·014	37·40	·012	20·06
Luni-Solar ,, ,, . . .	·023	111·55	·023	39 54
Solar-Annual ,, . . .	·171	43·58	·171	82·76
,, Semi Annual ,, . . .	·227	85·89	·227	164 25

Values of the Tidal Constants, Kurrachee, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0=7·155 feet.

S_1	H=R=	·087	M_6	R=	·046	Q_1	R=	·131	T_2	R=	·048
	κ=ζ=	180°·66		ζ=	284°·27		ζ=	173°·22		ζ=	32°·44
S_2	H=R=	963		H=	·046		H=	·130		H=	·048
	κ=ζ=	323°·61		κ=	197°·91		κ=	55°·48		κ=	274°·06
S_4	H=R=	·013	M_8	R=	·001	L_2	R=	·108	$(MS)_4$	R=	·048
	κ=ζ=	24°·96		ζ=	150°·26		ζ=	344°·51		ζ=	2°·26
S_6	H=R=	·006		H=	·001		H=	·088		H=	·048
	κ=ζ=	308° 05		κ=	35°·10		κ=	287°·77		κ=	333°·47
S_8	H=R=	·001	O_1	R=	·660	N_2	R=	·615	$(2SM)_2$	R=	·026
	κ=ζ=	341°·57		ζ=	10°·92		ζ=	99°·47		ζ=	96°·71
				H=	·657		H=	·613		H=	·026
				κ=	45°·67		κ=	278°·20		κ=	125°·50
M_1	R=	·011	K_1	R=	1°·306	λ_2	R=	...	$2N_2$	R=	·110
	ζ=	231°·51		ζ=	106°·09		ζ=	...		ζ=	206° 97
	H=	·011		H=	1·302		H=	...		H=	·109
	κ=	35°·01		κ=	46°·62		κ=	...		κ=	233°·22
M_2	R=	2·564	K_2	R=	255	ν_2	R=	·208	$(M_2N)_4$	R=	·100
	ζ=	322°·72		ζ=	258°·76		ζ=	204°·97		ζ=	258°·67
	H=	2·554		H=	·258		H=	·207		H=	·099
	κ=	293°·9		κ=	319°·77		κ=	301°·99		κ=	48°·61
M_3	R=	·045	P_1	R=	·402	μ_2	R=	·079	$(M_2K_1)_3$	R=	·046
	ζ=	2°·38		ζ=	355°·83		ζ=	339°·42		ζ=	110°·21
	H=	·044		H=	·402		H=	·078		H=	·046
	κ=	319°·19		κ=	46°·41		κ=	281°·84		κ=	21°·96
M_4	R=	·033	J_1	R=	·058	R_2	R=	...	$(2M_2K_1)_3$	R=	·023
	ζ=	59°·56		ζ=	334° 28		ζ=	...		ζ=	44°·63
	H=	033		H=	·057		H=	...		H=	·023
	κ=	1°·90		κ=	63°·23		κ=	...		κ=	46°·52

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·061	133°·89	·060	286°·36
,, Fortnightly ,, . . .	·039	253·43	·039	335·16
Luni-Solar ,, ,, . . .	·029	185·78	·029	214·57
Solar-Annual ,, . . .	·087	16·42	·087	55·84
,, Semi-Annual ,, . . .	·177	90 91	·177	169·76

Values of the Tidal Constants, Bhavnagar, 1890.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890 observations at Bhavnagar; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890 observations :—

Short Period Tides.

A_0=22·742 feet.

S_1	H=R=	·158	M_6	R=	·228	Q_1	R=	·179	T_2	R=	·035
	κ=ζ=	182°·11		ζ=	125°·44		ζ=	269°·74		ζ=	79°·46
S_2	H=R=	3·482		H=	231		H=	·172		H=	·035
	κ=ζ=	176°·30		κ=	119°·74		κ=	96°·09		κ=	79°·63
S_4	H=R=	·107	M_8	R=	·014	L_2	R=	·682	$(MS)_4$	R=	·636
	κ=ζ=	236°·28		ζ=	208°·96		ζ=	89°·62		ζ=	73°·97
S_6	H=R=	·019		H=	·015		H=	·593		H=	·639
	κ=ζ=	310°·93		κ=	321°·35		κ=	152°·05		κ=	192°·07
S_8	H=R=	·005	O_1	R=	1·016	N_2	R=	2·335	$(2SM)_2$	R=	·091
	κ=ζ=	38°·66		ζ=	143°·76		ζ=	108°·82		ζ=	124°·84
				H=	·972		H=	2·346		H=	·092
				κ=	83°·31		κ=	113°·71		κ=	6°·74
M_1	R=	·051	K_1	R=	2·375	λ_2	R=	…	$2N_2$	R=	·423
	ζ=	177°·08		ζ=	268°·36		ζ=	…		ζ=	205°·30
	H=	·039		H=	2·309		H=	…		H=	·424
	κ=	281°·47		κ=	90°·68		κ=	…		κ=	96°·98
M_2	R=	10·845	K_2	R=	·761	ν_2	R=	·435	$(M_2N)_4$	R=	·213
	ζ=	15°·39		ζ=	348°·38		ζ=	148°·93		ζ=	319°·14
	H=	10·894		H=	·723		H=	·437		H=	·215
	κ=	133°·49		κ=	172°·70		κ=	140°·46		κ=	82°·13
M_3	R=	·071	P_1	R=	·679	μ_2	R=	·376	$(M_2K_1)_3$	R=	·186
	ζ=	305°·19		ζ=	286°·56		ζ=	23°·36		ζ=	134°·44
	H=	·071		H=	·679		H=	·379		H=	·182
	κ=	302°·34		κ=	95°·67		κ=	259°·55		κ=	74°·86
M_4	R=	·820	J_1	R=	·173	R_2	R=	…	$(2M_2K_1)_3$	R=	·154
	ζ=	272°·62		ζ=	235°·13		ζ=	…		ζ=	296°·65
	H=	·828		H=	·165		H=	…		H=	·151
	κ=	148°·82		κ=	166°·89		κ=	…		κ=	350°·52

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·083	187°·64	·084	300°·85
„ Fortnightly „ . . .	·076	234·95	·069	293·94
Luni-Solar „ „ . . .	·137	162·30	·138	44·21
Solar-Annual „ . . .	·215	167·02	·215	87·91
„ Semi-Annual „ . . .	·234	4·87	·234	206·65

Values of the Tidal Constants, Bombay (Apollo Bandar), 1890.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890 observations at Bombay (Apollo Bandar); and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890 observations :—

Short Period Tides.

A_0 = 10·230 feet.

S_1	H=R =	·073	M_6	R =	·006	Q_1	R =	·133	T_2	R =	·057
	κ=ζ =	201°·51		ζ =	52°·50		ζ =	225°·40		ζ =	350°·67
S_2	H=R =	1·581		H =	·006		H =	·127		H =	·057
	κ=ζ =	6°·16		κ =	46°·93		κ =	51°·82		κ =	350°·84
S_4	H=R =	·018	M_8	R =	·001	L_2	R =	·156	$(MS)_4$	R =	·158
	κ=ζ =	180°·96		ζ =	56°·31		ζ =	258°·80		ζ =	280°·95
S_6	H=R =	·003		H =	·001		H =	·136		H =	·158
	κ=ζ =	222°·27		κ =	168°·89		κ =	321°·26		κ =	39°·10
S_8	H=R =	·002	O_1	R =	·696	N_2	R =	·972	$(2SM)_2$	R =	·034
	κ=ζ =	166°·76		ζ =	108°·45		ζ =	312°·18		ζ =	233°·97
				H =	·666		H =	·976		H =	·035
				κ =	48°·06		κ =	317°·14		κ =	115°·83

Short Period Tides—contd.

A_0=10·230 feet.

M_1	R =	·039	K_1	R =	1·441	λ_2	R =	...	$2N_2$	R =	·159
	ζ =	230°·33		ζ =	223°·45		ζ =	...		ζ =	21°·01
	H =	·029		H =	1·402		H =	...		H =	·160
	κ =	334°·75		κ =	45°·77		κ =	...		κ =	272°·79
M_2	R =	4·009	K_2	R =	·403	ν_2	R =	·144	$(M_3N)_4$	R =	·093
	ζ =	213°·71		ζ =	174°·24		ζ =	14°·11		ζ =	184°·42
	H =	4·027		H =	·383		H =	·145		H =	·093
	κ =	331°·85		κ =	358°·55		κ =	5°·72		κ =	307°·53
M_3	R =	·056	P_1	R =	·403	μ_2	R =	·187	$(M_2K_1)_3$	R =	·093
	ζ =	27°·18		ζ =	236°·48		ζ =	84°·30		ζ =	226°·97
	H =	·056		H =	·409		H =	·189		H =	·091
	κ =	24°·40		κ =	45°·59		κ =	320°·59		κ =	167°·44
M_4	R =	·144	J_1	R =	·070	R_2	R =	...	$(2M_2K_1)_3$	R =	·073
	ζ =	96°·19		ζ =	145°·45		ζ =	...		ζ =	38°·84
	H =	·145		H =	·067		H =	...		H =	·072
	κ =	332°·48		κ =	77°·17		κ =	..		κ =	92°·81

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·086	149°·79	·088	262°·98
„ Fortnightly „	·019	318·88	·017	17·82
Luni-Solar „ „	·012	96·92	·012	338·77
Solar-Annual „	·086	77·73	·086	358·62
„ Semi-Annual „	·244	7·78	·244	209·56

VALUES OF THE TIDAL CONSTANTS, BOMBAY (PRINCE'S DOCK), 1890.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890 observations at Bombay (Prince's Dock); and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890 observations:—

Short Period Tides.

A_0 = 8·290 feet.

S_1	H=R =	·086	M_6	R =	·007	Q_1	R =	·129	T_2	R =	·051
	κ = ζ =	204°·20		ζ =	217°·04		ζ =	226°·89		ζ =	339°·48
S_2	H=R =	1·640		H =	·007		H =	·124		H =	·051
	κ = ζ =	3°·99		κ =	211°·48		κ =	53°·31		κ =	339°·65
S_4	H= R =	·030	M_8	R =	·004	L_2	R =	·170	$(MS)_4$	R =	·137
	κ = ζ =	202°·87		ζ =	332°·59		ζ =	264°·10		ζ =	277°·12
S_6	H = R =	·003		H =	·004		H =	·148		H =	·138
	κ = ζ =	206°·57		κ =	85°·18		κ =	326°·56		κ =	35°·27
S_8	H = R =	·002	O_1	R =	·681	N_2	R =	·982	$(2SM)_2$	R =	·039
	κ = ζ =	262°·57		ζ =	107°·69		ζ =	309°·36		ζ =	240°·92
				H =	·651		H =	·986		H =	·039
				κ =	47°·29		κ =	314°·32		κ =	122°·77
M_1	R =	·044	K_1	R =	1·437	λ_2	R =	...	$2N_2$	R =	·163
	ζ =	215°·13		ζ =	222°·45		ζ =	...		ζ =	14°·80
	H =	·033		H =	1·397		H =	...		H =	·164
	κ =	319°·55		κ =	44°·77		κ =	...		κ =	266°·58
M_2	R =	4·084	K_2	R =	·409	ν_2	R =	·147	$(M_3N)_4$	R =	·092
	ζ =	211°·48		ζ =	173°·69		ζ =	10°·31		ζ =	179°·87
	H =	4·102		H =	·388		H =	·148		H =	·092
	κ =	329°·62		κ =	358°·01		κ =	1°·91		κ =	302°·98
M_3	R =	061	P_1	R =	·411	μ_2	R =	·190	$(M_2K_1)_3$	R =	·088
	ζ =	29°·11		ζ =	234°·77		ζ =	82°·75		ζ =	236°·00
	H =	·061		H =	·411		H =	·192		H =	·086
	κ =	26°·33		κ =	43°·88		κ =	319°·05		κ =	176°·46
M_4	R =	·133	J_1	R =	066	R_2	R =	...	$(2M_2K_1)_3$	R =	·069
	ζ =	84°·52		ζ =	146°·48		ζ =	...		ζ =	30°·86
	H =	·134		H =	·063		H =	...		H =	·067
	κ =	320°·81		κ =	78°·21		κ =	...		κ =	84°·83

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·078	152°·17	·079	265°·35
„ Fortnightly „ . . .	·025	311·24	·023	10·18
Luni-Solar „ „ . . .	·030	145·35	·030	27·21
Solar-Annual „ . . .	·083	58·32	·083	339·21
„ Semi-Annual „ . . .	·239	7·18	·239	208·96

VALUES OF THE TIDAL CONSTANTS, COCHIN, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Cochin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 2·345 feet.

S_1	H=R=	·026	M_6	R =	·008	Q_1	R =	·072	T_2	R =	·039
	κ=ζ=	186°·19		ζ =	43°·86		ζ =	85°·52		ζ =	70°·72
S_2	H=R=	·260		H =	·008		H =	·069		H =	·039
	κ=ζ=	28°·42		κ =	83°·54		κ =	69°·85		κ =	47°·25
S_4	H=R=	·004	M_8	R =	·004	L_2	R =	·022	$(MS)_4$	R =	·023
	κ=ζ=	188°·13		ζ =	12°·72		ζ =	209°·78		ζ =	256°·03
S_6	H=R=	·005		H =	·004		H =	·019		H =	·023
	κ=ζ=	250°·77		κ =	305°·64		κ =	1°·79		κ =	149°·26
S_8	H=R=	·002	O_1	R =	·313	N_2	R =	·146	$(2SM)_2$	R =	·005
	κ=ζ=	277°·43		ζ =	8°·68		ζ =	116°·92		ζ =	226°·79
				H =	·298		H =	·147		H =	·005
				κ =	59°·63		κ =	303°·53		κ =	333°·56
M_1	R =	·033	K_1	R =	·598	λ_2	R =	...	$2N_2$	R =	·021
	ζ =	181°·03		ζ =	206°·22		ζ =	...		ζ =	148°·08
	H =	·024		H =	·580		H =	...		H =	·021
	κ =	356°·30		κ =	52°·24		κ =	...		κ =	268°·07
M_2	R =	·716	K_2	R =	·088	υ_2	R =	0·16	$(M_2N)_4$	R =	·023
	ζ =	80°·04		ζ =	152°·29		ζ =	155°·03		ζ =	45°·56
	H =	·720		H =	·083		H =	·016		H =	·023
	κ =	333°·27		κ =	23°·98		κ =	10°·22		κ =	125°·40
M_3	R =	·016	P_1	R =	·163	μ_2	R =	·008	$(M_2K_1)_3$	R =	·039
	ζ =	6°·71		ζ =	267°·85		ζ =	13°·69		ζ =	41°·50
	H =	·016		H =	·163		H =	·008		H =	·038
	κ =	206°·55		κ =	53°·31		κ =	160°·15		κ =	140°·75
M_4	R =	·027	J_1	R =	·032	R_2	R =	...	$(2M_2K_1)_3$	R =	·018
	ζ =	293°·87		ζ =	171°·82		ζ =	...		ζ =	170°·11
	H =	·027		H =	·031		H =	...		H =	·018
	κ =	80° 33		κ =	80°·72		κ =	...		κ =	110°·54

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·053	163°·06	·054	229°·68
„ Fortnightly „ . . .	·028	60·49	·025	31·82
Luni-Solar „ „ . . .	·015	31·34	·015	138·11
Solar-Annual „ . . .	·352	354·92	·352	299·46
„ Semi-Annual „ . . .	·109	304·34	·109	193·41

Values of the Tidal Constants, Tuticorin, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Tuticorin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 2·119 feet.

S_1	H = R =	·057	M_6	R =	·014	Q_1	R =	·042	T_2	R =	·008
	$\kappa = \zeta$ =	59°·38		ζ =	345°·42		ζ =	328°·83		ζ =	322°·70
S_2	H = R =	·478		H =	·015		H =	·039		H =	·008
	$\kappa = \zeta$ =	82°·70		κ =	23°·14		κ =	73°·54		κ =	173°·07
S_4	H = R =	·005	M_8	R =	·006	L_2	R =	·031	$(MS)_4$	R =	·011
	$\kappa = \zeta$ =	232°·70		ζ =	195°·46		ζ =	290°·36		ζ =	248°·39
S_6	H = R =	·007		H =	·006		H =	·032		H =	·012
	$\kappa = \zeta$ =	201°·16		κ =	245°·76		κ =	78°·48		κ =	260°·97
S_8	H = R =	·014	O_1	R =	·127	N_2	R =	·085	$(2SM)_2$	R =	·009
	$\kappa = \zeta$ =	227°·92		ζ =	2°·58		ζ =	319°·51		ζ =	327°·58
				H =	·119		H =	085		H =	·009
				κ =	46°·17		κ =	33°·21		κ =	315°·01
M_1	R =	·028	K_1	R =	·313	λ_2	R =	...	$2N_2$	R =	·020
	ζ =	329°·98		ζ =	55°·32		ζ =	...		ζ =	268°·58
	H =	·017		H =	·300		H =	...		H =	·021
	κ =	39°·21		κ =	27°·85		κ =	...		κ =	43°·41
M_2	R =	·660	K_2	R =	·135	υ_2	R =	·031	$(M_2N)_4$	R =	·014
	ζ =	30°·13		ζ =	316°·49		ζ =	58° 75		ζ =	5°·36
	H =	·666		H =	·123		H =	·031		H =	·014
	κ =	42°·71		κ =	81°·09		κ =	24°·83		κ =	91°·63
M_3	R =	·022	P_1	R =	·078	μ_2	R =	·025	$(M_2K_1)_3$	R =	·002
	ζ =	320°·79		ζ =	344°·00		ζ =	67°·72		ζ =	279°·87
	H =	·022		H =	·078		H =	·025		H =	·002
	κ =	159°·65		κ =	3°·31		κ =	92°·87		κ =	264°·97
M_4	R =	·024	J_1	R =	·022	R_2	R =	...	$(2M_2K_1)_3$	R =	·007
	ζ =	130°·00		ζ =	124°·40		ζ =	...		ζ =	244°·61
	H =	·024		H =	·021		H =	...		H =	·007
	κ =	155°·15		κ =	32°·27		κ =	...		κ =	297°·24

Long Period Tides

	R	ζ	H	κ
Lunar Monthly Tide . . .	·007	187°·08	·007	125°·95
„ Fortnightly „ . . .	·043	259·07	·037	4·48
Luni-Solar „ „ . . .	·011	271·38	·011	258·80
Solar-Annual „ . . .	·289	243·11	·289	313·80
„ Semi-Annual „ . . .	·109	295·87	·109	77·25

Values of the Tidal Constants, Madras, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Madras; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889 90 observations:—

Short Period Tides.

A_0 = 2·353 feet.

S_1	H = R =	·035	M_6	R =	·009	Q_1	R =	·006	T_2	R =	·027
	$\kappa = \zeta$ =	65° 52		ζ =	44°·00		ζ =	10°·31		ζ =	220°·44
S_2	H = R =	·435		H =	·009		H =	·005		H =	·027
	$\kappa = \zeta$ =	271° 25		κ =	114°·30		κ =	175°·81		κ =	284°·69
S_4	H = R =	·003	M_8	R =	·001	L_2	R =	·036	$(MS)_4$	R =	·008
	$\kappa = \zeta$ =	276°·12		ζ =	201°·80		ζ =	148° 93		ζ =	318°·30
S_6	H = R =	·001		H =	·001		H =	·030		H =	·008
	$\kappa = \zeta$ =	53° 97		κ =	175°·55		κ =	224°·20		κ =	221°·74
S_8	H = R =	·002	O_1	R =	·107	N_2	R =	·268	$(2S\,M)_2$	R =	·015
	$\kappa = \zeta$ =	304°·70		ζ =	173°·02		ζ =	311°·75		ζ =	100°·78
				H =	·104		H =	·268		H =	·015
				κ =	322°·22		κ =	231°·50		κ =	197°·35

Short Period Tides—contd.

A_0=2·353 feet.

M_1	R=	·009	K_1	R=	·311	λ_2	R=	...	$2N_2$	R=	·051
	ζ=	178°·07		ζ=	220°·68		ζ=	...		ζ=	277°·99
	H=	·008		H=	·305		H=	...		H=	·051
	κ=	344°·93		κ=	338°·78		κ=	...		κ=	214°·04
M_2	R=	1·067	K_2	R=	·105	ν_2	R=	·086	$(M_2 N)_4$	R=	·022
	ζ=	339°·20		ζ=	199°·06		ζ=	96°·51		ζ=	33°·46
	H=	1·069		H=	·102		H=	·086		H=	·022
	κ=	242°·64		κ=	255°·01		κ=	249°·21		κ=	216°·64
M_3	R=	·005	P_1	R=	·106	μ_2	R=	·047	$(M_2 K_1)_3$	R=	·013
	ζ=	215°·94		ζ=	101°·28		ζ=	353°·15		ζ=	280°·43
	H=	·005		H=	·106		H=	·047		H=	·013
	κ=	71°·10		κ=	334°·48		κ=	160°·02		κ=	301°·97
M_4	R=	·008	J_1	R=	·021	R_2	R=	...	$(2M_2 K_1)_3$	R=	·006
	ζ=	29°·48		ζ=	225°·00		ζ=	...		ζ=	20°·90
	H=	·008		H=	·020		H=	...		H=	·006
	κ=	196°·35		κ=	322°·93		κ=	...		κ=	69°·66

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·044	36°·33	·044	20°·02
,, Fortnightly ,, . . .	·035	217·74	·033	2·78
Luni-Solar ,, ,, . . .	·030	25·25	·030	121·82
Solar-Annual ,, . . .	·408	346·57	·408	203·37
,, Semi-Annual ,, . . .	·219	41·32	·219	114·92

Values of the Tidal Constants, Cocanada, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Cocanada; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 5·308 feet.

S_1	H=R=	·038	M_6	R=	·018	Q_1	R=	·001	T_2	R=	·011
	κ=ζ=	81°·31		ζ=	128°·66		ζ=	318°·37		ζ=	3°·74
S_2	H=R=	·648		H=	·018		H=	·001		H=	·011
	κ=ζ=	284°·73		κ=	95°·24		κ=	325°·01		κ=	276°·22
S_4	H=R=	·007	M_8	R=	·003	L_2	R=	·049	$(MS)_4$	R=	·024
	κ=ζ=	121°·66		ζ=	341°·57		ζ=	127°·49		ζ=	11°·26
S_6	H=R=	002		H=	·003		H=	·046		H=	·024
	κ=ζ=	142°·43		κ=	57°·01		κ=	266°·69		κ=	120° 12
S_8	H=R=	·002	O_1	R=	·143	N_2	R=	·320	$(2SM)_2$	R=	·014
	κ=ζ=	24°·23		ζ=	129°·43		ζ=	334°·14		ζ=	64°·96
				H=	·135		H=	·322		H=	·014
				κ=	331°·70		κ=	247°·37		κ=	156°·10
M_1	R=	·016	K_1	R=	357	λ_2	R=	...	$2N_2$	R=	·042
	ζ=	305°·71		ζ=	68°·79		ζ=	...		ζ=	169°·67
	H=	·010		H=	·344		H=	...		H=	·042
	κ=	56°·66		κ=	339° 03		κ=	...		κ=	247°·28
M_2	R=	1·506	K_2	R=	·194	ν_2	R=	·091	$(M_2 N)_4$	R=	·044
	ζ=	143°·00		ζ=	279°·35		ζ=	153°·12		ζ=	67°·97
	H=	1·517		H=	·180		H=	·092		H=	·045
	κ=	251°·86		κ=	279°·41		κ=	208°·57		κ=	90°·07
M_3	R=	·009	P_1	R=	·091	μ_2	R=	·014	$(M_2 K_1)_3$	R=	·015
	ζ=	32°·81		ζ=	260°·31		ζ=	54°·22		ζ=	294°·21
	H=	·009		H=	·091		H=	·014		H=	·014
	κ=	16°·10		κ=	341°·72		κ=	271°·94		κ=	313°·30
M_4	R=	·033	J_1	R=	·024	R_2	R=	...	$(2M_2 K_1)_3$	R=	·007
	ζ=	245°·63		ζ=	197°·75		ζ=	...		ζ=	9° 87
	H=	·034		H=	·023		H=	...		H=	·007
	κ=	103°·35		κ=	299°·98		κ=	...		κ=	317°·35

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·054	249°·70	·056	85°·32
„ Fortnightly „ . . .	·083	100·56	·073	344·89
Luni-Solar „ „ . . .	·013	163·07	·013	54·21
Solar-Annual „ . . .	·763	182·20	·763	190·79
„ Semi-Annual „ . . .	·237	68·60	·237	85·78

Values of the Tidal Constants, Kidderpore, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 011·364 feet.

S_1	H = R =	·081	M_6	R =	·144	Q_1	R =	·043	T_2	R =	·115
	κ = ζ =	195°·60		ζ =	62°·49		ζ =	357°·86		ζ =	154·13
S_2	H = R =	1·498		H =	·147		H =	·041		H =	·115
	κ = ζ =	97°·39		κ =	328°·58		κ =	351°·07		κ =	75°·49
S_4	H = R =	·093	M_8	R =	·065	L_2	R =	·186	$(MS)_4$	R =	677
	κ = ζ =	112°·92		ζ =	53°·93		ζ =	190°·31		ζ =	109°·39
S_6	H = R =	·003		H =	·066		H =	·172		H =	·682
	κ = ζ =	101°·69		κ =	288°·72		κ =	71°·21		κ =	78°·08
S_8	H = R =	·004	O_1	R =	·212	N_2	R =	·685	$(2SM)_2$	R =	·071
	κ = ζ =	187°·13		ζ =	312°·83		ζ =	158°·39		ζ =	335°·92
				H =	·200		H =	·690		H =	·071
				κ =	23°·86		κ =	49°·27		κ =	7°·22
M_1	R =	·016	K_1	R =	·399	λ_2	R =	...	$2N_2$	R =	·101
	ζ =	304°·10		ζ =	152°·18		ζ =	...		ζ =	230°·44
	H =	·010		H =	·385		H =	...		H =	·102
	κ =	163°·96		κ =	53°·50		κ =	...		κ =	43°·49
M_2	R =	3·547	K_2	R =	·458	ν_2	R =	·280	$(M_2N)_4$	R =	·147
	ζ =	87°·85		ζ =	109°·42		ζ =	344°·55		ζ =	35°·99
	H =	3·572		H =	·427		H =	·282		H =	·149
	κ =	56°·55		κ =	91°·67		κ =	1°·87		κ =	255°·57
M_3	R =	·024	P_1	R =	·120	μ_2	R =	·220	$(M_2K_1)_3$	R =	·139
	ζ =	341°·80		ζ =	313°·03		ζ =	253°·05		ζ =	150°·92
	H =	·024		H =	·120		H =	·224		H =	·135
	κ =	294°·85		κ =	43°·34		κ =	190°·44		κ =	20°·94
M_4	R =	·732	J_1	R =	·005	R_2	R =	...	$(2M_2K_1)_3$	R =	·033
	ζ =	98°·12		ζ =	86°·76		ζ =	...		ζ =	281°·84
	H =	·743		H =	·005		H =	...		H =	·032
	κ =	35°·52		κ =	62°·25		κ =	...		κ =	317°·92

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·393	278°·16	·404	355°·98
„ Fortnightly „ . . .	·293	12·04	·260	18·68
Luni-Solar „ „ . . .	·887	10·07	·893	41·37
Solar-Annual „ . . .	3·554	153·79	3·554	153·49
„ Semi-Annual „ . . .	1·177	330·06	1·177	329·46

Values of the Tidal Constants, Kidderpore, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Kidderpore; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0 = 11·232 feet.

S_1	H = R =	·087	M_0	R =	·147	Q_1	R =	·034	T_2	R =	·180
	κ = ζ =	184°·76		ζ =	359°·13		ζ =	12°·18		ζ =	194°·15
S_2	H = R =	1·520		H =	·145		H =	·034		H =	·180
	κ = ζ =	98°·45		κ =	322°·92		κ =	354°·06		κ =	115°·26
S_4	H = R =	·099	M_8	R =	·058	L_2	R =	·215	$(MS)_4$	R =	·697
	κ = ζ =	113°·79		ζ =	70°·61		ζ =	39°·37		ζ =	207°·75
S_6	H = R =	·002		H =	·056		H =	·175		H =	·694
	κ = ζ =	104°·62		κ =	262°·33		κ =	74°·15		κ =	75°·68
S_8	H = ζ =	·001	O_1	R =	·209	N_2	R =	·731	$(2SM)_2$	R =	·063
	κ = ζ =	236°·31		ζ =	54°·18		ζ =	163°·98		ζ =	240°·45
				H =	·210		H =	·727		H =	·063
				κ =	25°·17		κ =	42°·61		κ =	12°·52
M_1	R =	·033	K_1	R =	·389	λ_2	R =	...	$2N_2$	R =	·145
	ζ =	145°·35		ζ =	154°·36		ζ =	...		ζ =	119°·78
	H =	·033		H =	·390		H =	...		H =	·145
	κ =	68° 30		κ =	55°·40		κ =	...		κ =	9°·51
M_2	R =	3·657	K_2	R =	·403	ν_2	R =	·343	$(M_2N)_4$	R =	·057
	ζ =	188°·04		ζ =	112°·02		ζ =	292°·99		ζ =	66°·17
	H =	3·638		H =	·413		H =	·341		H =	·056
	κ =	55°·97		κ =	94°·09		κ =	20°·07		κ =	172°·93
M_3	R =	·030	P_1	R =	·133	μ_2	R =	·224	$(M_2K_1)_3$	R =	·079
	ζ =	287°·62		ζ =	312°·25		ζ =	90°·26		ζ =	249°·70
	H =	·030		H =	·133		H =	·222		H =	·078
	κ =	269°·52		κ =	42°·32		κ =	186°·12		κ =	18°·67
M_4	R =	·750	J_1	R =	·009	R_2	R =	...	$(2M_2K_1)_3$	R =	·020
	ζ =	297°·85		ζ =	171°·96		ζ =	...		ζ =	146°·80
	H =	·742		H =	·009		H =	...		H =	·020
	κ =	33°·71		κ =	58°·00		κ =	...		κ =	341°·63

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·316	5°·17	·311	354°·27
„ Fortnightly „ . . .	·219	275·54	·221	21·49
Luni-Solar „ „ . . .	·987	272·17	·982	44·24
Solar-Annual „ . . .	2·837	159·32	2·837	159·25
„ Semi-Annual „ . . .	·900	336·66	·900	336·53

Values of the Tidal Constants, Chittagong, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Chittagong; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 7·977 feet.

S_1	H = R =	·067	M_0	R =	·139	Q_1	R =	·036	T_2	R =	·106
	κ = ζ =	106° 70		ζ =	88°·12		ζ =	46°·57		ζ =	95°·74
S_2	H = R =	1·571		H =	·143		H =	·034		H =	·106
	κ = ζ =	69°·88		κ =	196°·04		κ =	359°·00		κ =	302°·21
S_4	H = R =	·054	M_8	R =	028	L_2	R =	·339	$(MS)_4$	R =	·334
	κ = ζ =	66°·66		ζ =	112°·91		ζ =	326°·97		ζ =	107°·43
S_6	H = R =	·010		H =	·029		H =	·342		H =	·338
	κ = ζ =	150°·83		κ =	136°·80		κ =	70°·35		κ =	23°·40
S_8	H = R =	·004	O_1	R =	·313	N_2	R =	·816	$(2SM)_2$	R =	·132
	κ = ζ =	215°·91		ζ =	68°·67		ζ =	97°·47		ζ =	212°·40
				H =	·293		H =	·824		H =	·133
				κ =	11°·72		κ =	22°·81		κ =	296°·42

Short Period Tides—contd.

$A_0 = 7{\cdot}977$ feet.

M_1	R =	·010	K_1	R =	·640	λ_2	R =	...	$2N_2$	R =	·111
	ζ =	88°·85		ζ =	44°·70		ζ =	...		ζ =	119°·35
	H =	·006		H =	·613		H =	...		H =	·112
	κ =	110°·16		κ =	21°·14		κ =	..		κ =	54°·06
M_2	R =	4·402	K_2	R =	·501	ν_2	R =	·365	$(M_2N)_4$	R =	·164
	ζ =	120°·51		ζ =	293°·14		ζ =	213°·38		ζ =	55°·78
	H =	4·445		H =	·458		H =	·368		H =	·167
	κ =	36°·49		κ =	65°·57		κ =	38°·03		κ =	257°·10
M_3	R =	·012	P_1	R =	·219	μ_2	R =	·295	$(M_2K_1)_3$	R =	·138
	ζ =	107°·07		ζ =	17°·12		ζ =	5°·46		ζ =	56°·22
	H =	·012		H =	·219		H =	·300		H =	·134
	κ =	161°·03		κ =	32°·52		κ =	197°·41		κ =	308°·63
M_4	R =	·410	J_1	R =	·063	2	R =	...	$(2M_2K_1)_3$	R =	·074
	ζ =	154°·34		ζ =	96°·39		ζ =	...		ζ =	57°·74
	H =	·418		H =	·059		H =	...		H =	·073
	κ =	346°·29		κ =	59°·94		κ =	...		κ =	273°·24

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·244	351°·03	·253	341°·66
„ Fortnightly „	·213	169·68	·184	19·53
Luni-Solar „ „	·439	314·79	·443	38·82
Solar-Annual „	1·877	59·92	1·877	134·51
„ Semi-Annual „	·158	115·57	·158	264·76

Values of the Tidal Constants, Akyab, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Akyab; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

$A_0 = 7{\cdot}535$ feet.

S_1	H = R =	·049	M_6	R =	·022	Q_1	R =	·018	T_2	R =	·109
	κ = ζ =	75°·32		ζ =	127°·67		ζ =	319°·47		ζ =	47°·63
S_2	H = R =	1·146		H =	·023		H =	·017		H =	·109
	κ = ζ =	307°·38		κ =	123°·84		κ =	268°·24		κ =	281°·69
S_4	H = R =	·007	M_8	R =	·007	L_2	R =	·124	$(MS)_4$	R =	·019
	κ = ζ =	179°·13		ζ =	281°·31		ζ =	243°·23		ζ =	358°·41
S_6	H = R =	·003		H =	·008		H =	·121		H =	·019
	κ = ζ =	53°·97		κ =	156°·20		κ =	302°·72		κ =	237°·13
S_8	H = R =	·001	O_1	R =	·194	N_2	R =	·528	$(2SM)_2$	R =	·030
	κ = ζ =	85°·60		ζ =	41°·14		ζ =	17°·28		ζ =	87°·52
				H =	·182		H =	·533		H =	·031
				κ =	334°·69		κ =	271°·22		κ =	208°·80
M_1	R =	·005	K_1	R =	·466	λ_2	R =	...	$2N_2$	R =	·090
	ζ =	324°·06		ζ =	34°·55		ζ =	...		ζ =	344°·55
	H =	·003		H =	·447		H =	...		H =	·091
	κ =	324°·04		κ =	343°·30		κ =	...		κ =	253°·72
M_2	R =	2·538	K_2	R =	·357	ν_2	R =	·195	$(M_2N)_4$	R =	·040
	ζ =	39°·14		ζ =	227°·40		ζ =	152°·72		ζ =	335°·03
	H =	2·561		H =	·328		H =	·197		H =	·041
	κ =	277°·86		κ =	304°·48		κ =	257°·02		κ =	107°·70
M_3	R =	·019	P_1	R =	·137	μ_2	R =	·024	$(M_2K_1)_3$	R =	·032
	ζ =	23°·44		ζ =	305°·04		ζ =	204°·50		ζ =	306°·91
	H =	·020		H =	·137		H =	·024		H =	·031
	κ =	21°·52		κ =	348°·04		κ =	321°·95		κ =	134°·39
M_4	R =	·006	J_1	R =	·031	R_2	R =	...	$(2M_2K_1)_3$	R =	·012
	ζ =	157°·22		ζ =	56°·98		ζ =	...		ζ =	258°·79
	H =	·006		H =	·029		H =	...		H =	·011
	κ =	274°·66		κ =	346°·94		κ =	...		κ =	67°·48

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·021	256°·97	·022	241°·74
„ Fortnightly „	·103	156·31	·090	347·05
Luni-Solar „ „	·059	289·54	·060	50·81
Solar-Annual „	1·138	97·54	1·138	144·54
„ Semi-Annual „	·112	71·70	·112	165·70

Values of the Tidal Constants, Rangoon, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Rangoon; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 10·598 feet.

S_1	H = R =	·114	M_6	R =	·193	Q_1	R =	·025	T_2	R =	·136
	κ = ζ =	137°·45		ζ =	82°·24		ζ =	351°·36		ζ =	230°·82
S_2	H = R =	2·144		H =	·197		H =	·024		H =	·136
	κ = ζ =	169°·40		κ =	85°·94		κ =	72°·56		κ =	172°·90
S_4	H = R =	·079	M_8	R =	·074	L_2	R =	·406	$(MS)_4$	R =	·426
	κ = ζ =	252°·46		ζ =	328°·56		ζ =	43°·76		ζ =	92°·91
S_6	H = R =	·012		H =	·076		H =	·369		H =	·429
	κ = ζ =	25°·71		κ =	93°·49		κ =	161°·75		κ =	214°·15
S_8	H = R =	·003	O_1	R =	·299	N_2	R =	1·060	$(2SM)_2$	R =	·191
	κ = ζ =	100°·89		ζ =	142°·50		ζ =	160°·65		ζ =	175°·13
				H =	·283		H =	1·067		H =	·192
				κ =	26°·88		κ =	118°·71		κ =	53°·90
M_1	R =	·047	K_1	R =	·697	λ_2	R =	...	$2N_2$	R =	·223
	ζ =	64°·47		ζ =	152°·31		ζ =	...		ζ =	331°·00
	H =	·032		H =	·674		H =	...		H =	·225
	κ =	178°·15		κ =	32°·86		κ =	...		κ =	125°·88
M_2	R =	5·794	K_2	R =	·653	ν_2	R =	·254	$(M_2N)_4$	R =	·112
	ζ =	9°·83		ζ =	222°·44		ζ =	31°·84		ζ =	319°·27
	H =	5·832		H =	·611		H =	·256		H =	·113
	κ =	131°·06		κ =	163°·16		κ =	79°·59		κ =	38°·56
M_3	R =	·016	P_1	R =	·174	μ_2	R =	·577	$(M_2K_1)_3$	R =	·193
	ζ =	183°·37		ζ =	303°·37		ζ =	49°·47		ζ =	85°·51
	H =	·016		H =	·174		H =	·585		H =	·187
	κ =	185°·22		κ =	54°·39		κ =	291°·94		κ =	87°·29
M_4	R =	·450	J_1	R =	·015	R_2	R =	...	$(2M_2K_1)_3$	R =	·128
	ζ =	289°·85		ζ =	319°·44		ζ =	...		ζ =	52°·55
	H =	·455		H =	·014		H =	...		H =	·125
	κ =	172°·31		κ =	359°·48		κ =	...		κ =	54°·47

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·209	185°·16	·214	348°·34
„ Fortnightly „ . . .	·130	206·02	·116	18·51
Luni-Solar „ „ . . .	·522	168·56	·526	47·32
Solar-Annual „ . . .	1·535	164·09	1·535	143·07
„ Semi-Annual „ . . .	·370	17·42	·370	335·38

Values of the Tidal Constants, Rangoon, 1889-90.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1889-90 observations at Rangoon; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1889-90 observations:—

Short Period Tides.

A_0 = 10·523 feet.

S_1	H = R =	·125	M_6	R =	·204	Q_1	R =	·017	T_2	R =	·254
	$\kappa = \zeta$ =	126°·34		ζ =	23°·54		ζ =	356°·59		ζ =	180°·91
S_2	H = R =	2·102		H =	·200		H =	·017		H =	·254
	$\kappa = \zeta$ =	170°·60		κ =	84°·99		κ =	66°·41		κ =	122°·74
S_4	H = R =	·086	M_8	R =	·079	L_2	R =	·451	$(MS)_4$	R =	·409
	$\kappa = \zeta$ =	259°·37		ζ =	7°·64		ζ =	219° 52		ζ =	192°·06
S_6	H = R =	·012		H =	·077		H =	·368		H =	·407
	$\kappa = \zeta$ =	46°·41		κ =	89°·56		κ =	131°·28		κ =	212°·55
S_8	H = R =	·005	O_1	R =	·287	N_2	R =	1·083	$(2SM)_2$	R =	·175
	$\kappa = \zeta$ =	138°·01		ζ =	242°·48		ζ =	174° 12		ζ =	72°·05
				H =	·289		H =	1·077		H =	·174
				κ =	26°·75		κ =	120°·15		κ =	51°·56
M_1	R =	·076	K_1	R =	·659	λ_2	R =	...	$2N_2$	R =	·226
	ζ =	342°·16		ζ =	155°·05		ζ =	...		ζ =	222°·14
	H =	·074		H =	·661		H =	...		H =	·225
	κ =	156°·85		κ =	35°·36		κ =	...		κ =	93°·71
M_2	R =	5·851	K_2	R =	·666	ν_2	R =	·463	$(M_2N)_4$	R =	·247
	ζ =	111°·33		ζ =	228°·08		ζ =	340°·72		ζ =	59°·78
	H =	5·810		H =	·686		H =	·461		H =	·244
	κ =	131°·81		κ =	168°·73		κ =	98°·24		κ =	26°·29
M_3	R =	·023	P_1	R =	·165	μ_2	R =	·530	$(M_2K_1)_3$	R =	·174
	ζ =	304°·97		ζ =	305°·53		ζ =	251°·58		ζ =	163°·29
	H =	·023		H =	·165		H =	·524		H =	·173
	κ =	335°·69		κ =	56°·31		κ =	292°·54		κ =	64°·09
M_4	R =	·436	J_1	R =	·037	R_2	R =	...	$(2M_2K_1)_3$	R =	·132
	ζ =	130°·55		ζ =	132°·25		ζ =	...		ζ =	253°·14
	H =	·430		H =	·037		H =	...		H =	·131
	κ =	171°·51		κ =	82°·92		κ =	...		κ =	53°·79

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·195	308°·48	·191	22°·94
„ Fortnightly „	·167	111·58	·170	23·52
Luni-Solar „ „	·495	64·56	·492	44·08
Solar-Annual „	1·130	178·14	1·130	157·36
„ Semi-Annual „	·159	83·73	·159	42·17

Values of the Tidal Constants, Mergui, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Mergui; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

A_0 = 12·983 feet.

S_1	H = R =	·073	M_6	R =	·069	Q_1	R =	·028	T_2	R =	·240
	$\kappa = \zeta$ =	72°·64		ζ =	251°·39		ζ =	232°·25		ζ =	30°·97
S_2	H = R =	2·912		H =	·070		H =	·026		H =	·240
	$\kappa = \zeta$ =	350°·45		κ =	232°·72		κ =	265°·00		κ =	313°·34
S_4	H = R =	·046	M_8	R =	·016	L_2	R =	·259	$(MS)_4$	R =	·143
	$\kappa = \zeta$ =	243°·10		ζ =	92°·15		ζ =	25°·77		ζ =	187°·99
S_6	H = R =	·018		H =	·017		H =	·240		H =	·144
	$\kappa = \zeta$ =	94°·55		κ =	67°·26		κ =	278°·28		κ =	181°·77
S_8	H = R =	001	O_1	R =	·220	N_2	R =	1·061	$(2SM)_2$	R =	·204
	$\kappa = \zeta$ =	114°·78		ζ =	218°·05		ζ =	22°·36		ζ =	123°·99
				H =	·208		H =	1·068		H =	·206
				κ =	315°·18		κ =	311°·75		κ =	130°·21

Short Period Tides—contd.

$A_0 = 12{\cdot}983$ feet.

M_1	R =	·022	K_1	R =	·537	λ_2	R =	...	$2N_2$	R =	·161
	ζ =	259°·60		ζ =	74°·22		ζ =	...		ζ =	81°·09
	H =	·015		H =	·518		H =	...		H =	·162
	κ =	131°·89		κ =	334°·53		κ =	...		κ =	306°·09
M_2	R =	5·446	K_2	R =	·911	ν_2	R =	·260	$(M_2 N)_4$	R =	·222
	ζ =	317°·80		ζ =	7°·36		ζ =	202°·17		ζ =	256°·63
	H =	5·486		H =	·848		H =	·262		H =	·226
	κ =	311°·57		κ =	347°·58		κ =	256°·21		κ =	179°·80
M_3	R =	·050	P_1	R =	·160	μ_2	R =	·434	$(M_2 K_1)_3$	R =	·071
	ζ =	147°·31		ζ =	245°·43		ζ =	356°·96		ζ =	12°·31
	H =	·051		H =	·160		H =	·441		H =	·069
	κ =	137°·98		κ =	336°·74		κ =	344°·51		κ =	06°·40
M_4	R =	·118	J_1	R =	·025	R_2	R =	...	$(2M_2K_1)_3$	R =	·004
	ζ =	149°·01		ζ =	14°·65		ζ =	...		ζ =	17°·45
	H =	·120		H =	·024		H =	...		H =	·004
	κ =	136°·56		κ =	335°·68		κ =	...		κ =	104°·69

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·047	286°·13	·048	350°·51
„ Fortnightly „ . . .	·011	17·82	·010	357·34
Luni-Solar „ „ . . .	·023	340·72	·023	346·94
Solar-Annual „ . . .	·645	140·31	·645	139·00
„ Semi-Annual „ . . .	·108	101·63	·108	99·00

Values of the Tidal Constants, Port Blair, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Port Blair; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1890-91 observations:—

Short Period Tides.

$A_0 = 4{\cdot}605$ feet.

S_1	H = R =	·017	M_6	R =	·001	Q_1	R =	·025	T_2	R =	·024
	κ = ζ =	58°·87		ζ =	221°·63		ζ =	229°·84		ζ =	33°·62
S_2	H = R =	·966		H =	·001		H =	·024		H =	·024
	κ = ζ =	311°·93		κ =	240°·62		κ =	227°·32		κ =	287°·40
S_4	H = R =	·002	M_8	R =	·002	L_2	R =	·071	$(MS)_4$	R =	·013
	κ = ζ =	239°·93		ζ =	291°·04		ζ =	343°·53		ζ =	255°·16
S_6	H = R =	·001		H =	·002		H =	·068		H =	·013
	κ = ζ =	138°·81		κ =	316°·36		κ =	268°·71		κ =	261°·49
S_8	H = R =	·002	O_1	R =	·167	N_2	R =	·414	$(2SM)_2$	R =	·028
	κ = ζ =	36°·25		ζ =	218°·93		ζ =	349°·19		ζ =	150°·77
				H =	·157		H =	·417		H =	·028
				κ =	299°·89		κ =	272°·04		κ =	144°·44
M_1	R =	·009	K_1	R =	·408	λ_2	R =	...	$2N_2$	R =	·074
	ζ =	293°·63		ζ −	37°·12		ζ =	...		ζ =	73°·72
	H =	·006		H =	·393		H =	...		H =	·075
	κ =	175°·37		κ =	326°·10		κ =	...		κ =	273°·09
M_2	R =	1·974	K_2	R =	·290	ν_2	R =	·126	$(M_2 N)_4$	R =	·081
	ζ =	270°·52		ζ =	274°·48		ζ =	143°·53		ζ =	231°·02
	H =	1·990		H =	·268		H =	·127		H =	·083
	κ =	276°·85		κ =	312°·03		κ =	241°·76		κ =	160°·20
M_3	R =	·005	P_1	R =	121	μ_2	R =	·089	$(M_2 K_1)_3$	R =	·016
	ζ =	30°·02		ζ =	263°·10		ζ =	272°·03		ζ =	315°·00
	H =	·005		H =	·121		H =	·090		H =	·016
	κ =	39°·51		κ =	325°·82		κ =	284°·69		κ =	250°·32
M_4	R =	·006	J_1	R =	·016	R_2	R =	...	$(2M_2K_1)_3$	R =	·007
	ζ =	80°·54		ζ =	290°·76		ζ =	...		ζ =	132°·17
	H =	·006		H =	·015		H =	...		H =	·007
	κ =	93°·20		κ =	299°·62		κ =	...		κ =	215°·84

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·019	177°·29	·020	260°·77
„ Fortnightly „ . . .	·049	349·74	·043	14·16
Luni-Solar „ „ . . .	·012	100·73	·012	94·40
Solar-Annual „ . . .	·277	125 48	·277	152·77
„ Semi-Annual „ . . .	·027	180·10	·027	234·66

The Tide Tables.

In addition to the calculations already mentioned, the usual work has been done in connection with the issue of the Tide Tables for 1891 (which were received in my office on the 3rd January 1891, and were distributed the same day), and with the preparation of those for 1892. In connection with the latter the values of the constants, which were calculated in the usual manner, were sent to Mr. Roberts ready for use in the Tide Predictor; and in addition he was furnished with the actual values during 1890 of high and low water at 16 stations, measured in duplicate from the tidal diagrams, together with similar data for the same year at Moulmein, kindly supplied by Captain Dodd, the Port Officer, who, since the tidal observatory was closed in 1886, has been regularly sending us personal observations from a graduated staff taken at the site of the observatory. In order to save Mr. Roberts the labour of the calculation, all the predicted times and heights of high and low water for 1890 at these 17 stations were compared with the above-mentioned actual values and the errors tabulated, thus giving him, in a convenient form, information which will enable him to improve the predictions where necessary.

The volumes of Tide Tables for 1892 will contain predictions for 31 tidal stations, no new station having been added since the last issue.

The amount realised by the sale of the tide tables has been steadily increasing year by year, and the limited number of presentation copies are distributed strictly in accordance with the lists sanctioned by Government.

The newly established tidal observatories at Minicoy and Trincomalee not having been in operation for a year, the values of their final datum lines with reference to mean sea-level cannot as yet be given.

The usual tabular statements are appended, showing the percentage and amount of the errors in the predicted times and height of high and low water for the year 1890 at 17 stations, as determined by comparison of the predictions entered in the tide tables for that year with the values obtained by actual measurement.

No. 1.

Statement showing the percentage and the amount of the Errors in the Predicted Times of High Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	115	21	43	10	12	14
Kurrachee	698	21	43	18	15	3
Bhávnagar	704	31	40	12	12	5
Bombay { Apollo Bandar . .	705	33	49	11	6	1
Bombay { Prince's Dock . .	701	39	47	7	5	2
Cochin	691	24	34	12	22	8
Tuticorin	672	33	37	10	12	8
Galle	187	18	28	16	20	18
Colombo	162	21	29	10	19	21
Madras	536	38	37	12	10	3
Cocanada	706	46	44	6	3	1
Kidderpore	702	18	32	17	20	13
Chittagong	704	20	31	14	23	12
Akyab	694	46	44	5	4	1
Rangoon	704	24	35	12	22	7
Moulmein	365	37	41	11	9	2
Port Blair	694	20	37	14	17	12

No. 2.

Statement showing the percentage and the amount of the Errors in the Predicted Times of Low Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	112	25	42	7	13	13
Kurrachee	702	35	41	12	9	3
Bhávnagar	699	24	37	11	17	11
Bombay { Apollo Bandar	705	32	43	11	11	3
Bombay { Prince's Dock	703	29	46	12	9	4
Cochin	615	38	44	6	9	3
Tuticorin	670	29	40	12	13	6
Galle	180	15	28	12	26	19
Colombo	162	21	43	17	12	7
Madras	535	35	38	12	11	4
Cocanada	705	42	43	8	5	2
Kidderpore	702	21	36	12	19	12
Chittagong	703	16	28	11	19	26
Akyab	695	43	41	10	5	1
Rangoon	702	28	36	9	18	9
Moulmein	365	35	36	8	9	12
Port Blair	690	21	32	16	14	17

No. 3.

Statement showing the percentage and the amount of the Errors in the Predicted Heights of High Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Mean range at Springs in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
			Per cent.	Per cent.	Per cent.	Per cent.
Aden	646	6·7	89	11	...	...
Kurrachee	698	9·7	83	16	1	...
Bhávnagar	704	31·8	37	30	17	16
Bombay { Apollo Bandar	705	14·5	73	24	3	...
Bombay { Prince's Dock	701	14·6	63	28	8	1
Cochin	691	3·2	91	9	...	...
Tuticorin	672	3·2	77	22	1	...
Galle	187	2·2	92	8	...	...
Colombo	162	2·4	94	6	...	...
Madras	536	3·5	72	27	1	...
Cocanada	706	5·2	61	33	6	...
Kidderpore	702	11·7	35	23	15	27
Chittagong	704	13·5	34	26	22	18
Akyab	694	8·4	61	31	8	...
Rangoon	704	16·4	50	24	16	10
Moulmein	365	12·7	42	24	15	19
Port Blair	694	6·6	95	5	...	...

No. 4.

Statement showing the percentage and the amount of the Errors in the Predicted Heights of Low Water at the various Tidal Stations for the year 1890.

Stations.	Number of comparisons between the actual and predicted values.	Mean range at Springs in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
			Per cent.	Per cent.	Per cent.	Per cent.
Aden	640	6·7	92	8	...	...
Kurrachee	702	9·7	70	26	4	...
Bhávnagar	699	31·8	25	17	17	41
Bombay { Apollo Bandar	705	14·5	66	28	5	1
Bombay { Prince's Dock	703	14·6	56	31	11	2
Cochin	695	3·2	87	13	...	...
Tuticorin	670	3·2	83	17	...	...
Galle	186	2·2	91	9	...	...
Colombo	162	2·4	90	9	1	...
Madras	535	3·5	76	23	1	...
Cocanada	705	5·2	63	29	7	1
Kidderpore	702	11·7	31	21	15	33
Chittagong	703	13·5	42	24	15	19
Akyab	695	8·4	70	27	3	...
Rangoon	702	16·4	42	28	15	15
Moulmein	365	12·7	44	25	13	18
Port Blair	690	6·6	84	13	3	...

No. 5.

Table of Average Errors in the Predicted Times and Heights of High and Low Water at the several Tidal Stations for the year 1890.

Stations.	Mean Range at Springs in feet.	Average Errors					
		Of Time, in minutes.		Of Height, in terms of the Range.		Of Height, in inches.	
		H. W.	L. W.	H. W. Feet.	L. W. Feet.	H. W.	L. W.
Aden	6·7	15	15	·025	·025	2	2
Kurrachee	9·7	13	11	·026	·026	3	3
Bhávnagar	31·8	12	15	·018	·031	7	12
Bombay { Apollo Bandar	14·5	10	11	·017	·023	3	4
Bombay { Prince's Dock	14·6	9	11	·023	·029	4	5
Cochin	3·2	15	10	·052	·052	2	2
Tuticorin	3·2	13	13	·078	·078	3	3
Galle	2·2	19	20	·076	·076	2	2
Colombo	2·4	19	13	·069	·069	2	2
Madras	3·5	11	12	·071	·071	3	3
Cocanada	5·2	8	8	·064	·064	4	4
Kidderpore	11·7	17	16	·071	·078	10	11
Chittagong	13·5	16	21	·049	·049	8	8
Akyab	8·4	8	8	·040	·030	4	3
Rangoon	16·4	15	14	·030	·036	6	7
Moulmein	12·7	10	14	·046	·052	7	8
Port Blair	6·6	16	18	·025	·038	2	3

The foregoing statements may be summarised as follows:—

Percentage of Time predictions within 15 minutes of actuals.

	High water. Per cent.	Low water. Per cent.
13 Open coast stations	69	70
4 Riverain stations	60	59

Percentage of Height predictions within 8 inches of actuals.

	High water. Per cent.	Low water. Per cent.
13 Open coast stations	95	93
4 Riverain stations	65	64

Percentage of Height predictions agreeing with actuals within one-tenth of mean range at springs.

	High water. Per cent.	Low water. Per cent.
13 Open coast stations	91	91
4 Riverain stations	90	86

These figures show a slight falling off, chiefly in the time predictions, from the exceptionally good results obtained in 1889; they are nevertheless above the average, and may be considered on the whole to be very satisfactory.

Bench Marks.

During the year under report bench marks were laid down as follows:—

At the new station of Minicoy one embedded and four inscribed bench marks of reference were laid down and connected by spirit levelling with the bed plate of the tide gauge.

At the new station of Trincomalee two bench marks of reference were established and connected with the observatory. One has been placed on a large stone in the wharf wall 25 feet from the observatory door and bears the inscription $\underset{B.\ M.}{\overset{G.T.S.}{\square}}$, the other is the level surface of the sundial slate which is firmly fixed 3½ feet above the ground on the top of a solid granite pedestal about an equal distance from the observatory.

At Kidderpore, two new bench marks of reference were laid down and connected with the observatory; they each bear the inscription $\underset{B.\ M.}{\overset{G.T.S.}{\bigcirc}}$, and are situated respectively on the east and west coping of the main entrance of the new dock.

At Rangoon the bench mark selected as the principal bench mark of reference is known as Graham Smith's, which is a flat stone just outside the south-east corner of the walled enclosure of the Sailors' Home, bearing the inscription "G.S. *Datum* ○23·27 below this B.M." Two minor bench marks of reference have also been placed in the covered shed at Brooking Street wharf: each consists of the letters B.M. and a circle cut on the foot of an iron-supporting pillar, one at the north-west and the other at the south-west corner of the structure. All three bench marks have been connected with the bed plate of the tide gauge.

In addition to these bench marks of reference, 54 embedded bench marks (of which 2 are test bench marks), 352 inscribed or minor bench marks, 25 railway bench marks, 2

P. W. D. bench marks, and 2 Marine Survey bench marks were connected in the course of last season's levelling operations.

All the bench marks of reference at the tidal stations were found undisturbed and in a satisfactory condition without exception.

At Narel station of the Great Indian Peninsula Railway, embedded bench mark No. 48 of Spirit Levelled Heights, Nos. 2 and 3, Bombay Presidency and Nizam's Dominions, revised edition, 1886, was disturbed during structural alterations to the station. The Consulting Engineer was accordingly requested to destroy the bench mark, and the circumstance was reported to the Deputy Surveyor General in July, so that the necessary correction might be made in the pamphlet. As there are two permanently inscribed bench marks in the neighbourhood of Narel Railway station, it will not be necessary to place another embedded bench mark there.

The embedded test bench mark at Parambúr, No. $\frac{2}{12}$ of Spirit Levelled Heights, No. 1, Madras Presidency, seasons 1869—85, was tampered with and injured by the servants of the Carnatic Mill Company about the beginning of July. Messrs. Binny & Co. subsequently reported that it had been restored to its original condition, and it is proposed to re-level to it during the approaching field season when an officer is available for that duty, which will probably be when Cochin tidal observatory is being closed.

One more embedded bench mark was destroyed during the year under report, *viz.*, that at Lálápet Railway station, South Indian Railway, numbered 29 of Spirit Levelled Heights, No. 3, Madras Presidency, season 1886-87. The removal of this bench mark was absolutely necessary as it interfered with the extension of the siding accommodation; but as there are two permanently inscribed bench marks not far from it, its loss is not of sufficient importance to render necessary the establishment of another embedded bench mark in its place.

One inscribed bench mark was also destroyed, *viz.*, No. $\frac{2}{117}$, section I of Spirit Levelled Heights, Nos. 2 and 3, Bombay Presidency and Nizam's Dominions, 1877-80, revised edition. This bench mark was placed on the parapet of a bridge crossing the Mutha right bank canal from Khadakavásla, and it was rendered useless through the parapet having been raised in height.

About the middle of October 1889 the four following bench marks on the tops of milestones were struck off our lists as the milestones had to be removed:—

Nos. $\frac{2}{24}$, $\frac{7}{24}$, $\frac{8}{24}$, and $\frac{9}{24}$ of series IV, Spirit Levelled Heights, No. 4, Bombay Presidency, 1877-78, 1881-84.

Also in July 1890 intimation was received that, in consequence of alterations to the bridge close to the cantonment railway station at Bangalore, bench mark No. 4, section, Bangalore to Mangalore of Spirit Levelled Heights, No. 5, Madras Presidency, 1888-89, had been removed. This information is given here as it was omitted in last year's Annual Report.

Pairs of embedded bench marks, termed "Test Bench Marks," have been laid down from time to time in connection with the tidal observatories, their object being to detect secular changes of relative level between the land and the sea. The following table shows those which have been established up to the present time. They are laid down generally about 8 or 10 miles inland on solid ground and connected carefully with their respective tide gauges. According to orders received in 1884, they used to be placed in pairs, one on each side of the main line of levelling, and at least one mile distant from it. For some time this plan has been discontinued, as any embedded bench mark at a suitable distance from a tidal observatory answers the purpose of a test bench mark.

The following is a list of those at present existing:—

List of Test Bench Marks.

Tidal Observatory.	No. of Test Bench Mark published in pamphlet of Spirit Levelled Heights.	Approximate distance of Test Bench Mark from Observatory.
		Miles.
Kurrachee* . .	Inscribed B. M. on top step of front entrance of Kurrachee Church. Page 38, Tables of Heights in Sind, Punjab, &c., 1862.	7·3
Nowanar . .	No. 5. Series I, Bombay Presidency, No. 1, 1874—78 . .	9·6
	No. 4. Ditto ditto ditto . . .	6·0
Hanstal . . .	No. 36. Ditto ditto ditto . . .	17·4
	No. 39. Ditto ditto ditto . . .	12·8
Okhá . . .	No. 42. Series II, Bombay Presidency, No. 1, 1874—78 . .	10·3
	No. 45. Ditto ditto ditto . . .	5·0
Bhávnagar . .	No. 105. Section Rájkot to Bhávnagar, 1890-91 . . .	14·5
	No. 114. Ditto ditto	7·9
Bombay . . .	No. 7. Section I, Nos. 2 and 3 Bombay Presidency, 1877—80, revised edition.	5·0
	No. 10. Ditto ditto ditto . . .	9·0

* It is intended to erect a standard bench mark for Kurrachee, which will also be the principal test bench mark for the Kurrachee tidal observatory.

Tidal Observatory.	No. of Test Bench Mark published in pamphlet of Spirit Levelled Heights.	Approximate distance of Test Bench Mark from Observatory.
		Miles.
Mormugão	No. 33. Section Kárwár to Mormugão, No. 3 Madras Presidency, 1886-87.	17·1
Kárwár	No. $\frac{2}{3\frac{1}{4}}$. Ditto ditto ditto . . .	16·7
	No. 12. Ditto ditto ditto . . .	9·7
	No. 14. Ditto ditto ditto . . .	11·7
Beypore	No. $\frac{1}{2\frac{1}{15}}$. Section Jalárpet to Beypore, No. 1 Madras Presidency, 1869—85.	30·1
	No. $\frac{2}{2\frac{1}{15}}$. Ditto ditto ditto . . .	30·1
Cochin	No. $\frac{1}{4\frac{1}{9}}$. Section Shoranur to Cochin, No. 3 Madras Presidency, 1886-87.	22·5
	No. 50. Ditto ditto ditto . . .	21·1
Tuticorin	No. $\frac{1}{3\frac{1}{4}}$. Section Ramnad to Tuticorin, No. 2 Madras Presidency, 1885-86.	10·2
	No. $\frac{2}{3\frac{1}{4}}$. Ditto ditto ditto . . .	9·8
Pámban	No. $\frac{1}{6\frac{1}{0}}$. Section Tanjore to Pámban, No. 2 Madras Presidency, 1885-86.	12·9
	No. 63. Ditto ditto ditto . . .	12·2
Negapatam	No. $\frac{1}{2\frac{1}{6\frac{1}{2}}}$. Section Madras to Nagapatam, No. 2 Madras Presidency, 1885-86.	8·6
	No. $\frac{3}{2\frac{1}{6\frac{1}{2}}}$. Ditto ditto ditto . . .	8·2
Madras	No. $\frac{1}{1\frac{1}{2}}$. Section Madras to Arkonam, No. 1 Madras Presidency, 1869—85.	6·3
	No. $\frac{2}{1\frac{1}{2}}$.* Ditto ditto ditto . . .	6·5
Cocanada	No. 11. Section Cocanada to Vizagapatam, No. 4 Madras Presidency, 1887-88.	9·9
	No. 13. Ditto ditto ditto . . .	11·5
Vizagapatam	No. 96. Ditto ditto ditto . . .	10·7
	No. 99. Ditto ditto ditto . . .	9·6
False Point	No. 4. Series I, Bengal Presidency, 1881-82-83 and 1887-88 .	8·6
	No. 17. Ditto ditto ditto . . .	30·2
Kidderpore	Nos. $\frac{1}{7\frac{1}{0}}$ & $\frac{2}{7\frac{1}{0}}$. Series III, Bengal Presidency, 1881-82-83 and 1887-88.	3·7
	No. 7. Series VII. Ditto ditto ditto . . .	10·5

Levelling Operations.

The levelling operations of the last field season comprised the following lines of double levelling:—

(*a*) Section from Rájkot along the Rájkot-Bhávnagar main road *viâ* Sardhar, Adkot and Bábra to Dhása, and thence along the Bhávnagar-Gondal-Junagad-Porbandar Railway line to Bhávnagar.

(*b*) Section from Sanosra station of the Bhávnagar-Gondal-Junagad-Porbandar Railway to Chachúda temple opposite Sálbet, with a branch line to Port Albert Victor.

(*c*) Section from Náydongri Railway station along the north-east division of the Great Indian Peninsula Railway to Bhusával, and thence to Málkhed Railway station on the Nágpur line.

Their out-turn amounts to 425 miles of double levelling, in doing which the instruments were set up at 3,137 stations, and in the course of which three Great Trigonometrical Survey stations and the bench marks enumerated above were connected. This is a good out-turn, and it would have been larger had all the sections been continuous; but three weeks were lost in changing ground. Our thanks are due to the Engineers of the Bhávnagar-Gondal-Junagad-Porbandar and Great Indian Peninsula Railways for the help invariably afforded by them to Mr. Bond and his detachment, and to Mr. Proctor-Sims, who kindly deputed an Assistant Engineer to prepare in advance the necessary bench marks, and who gave the levelling detachment every help while it was working in the Bhávnagar State.

Extract from Notes by Mr. J. Bond, *Surveyor, 4th grade, on the levelling operations executed by him,—Season 1890-91.*

The levelling detachment proceeded by rail from Poona on the 24th October and on the following day embarked at Bombay on the B. I. S. N. Company's Steamer *Pemba* for Porbandar, where we landed on the night of the 26th and proceeded at once by rail to Dhoráji, where the camp equipment and instruments were stored on the completion of the work at the end of last field season.

The party left Dhoráji on the 29th October and marched *viâ* Jetpur and Gondal to Rájkot, a distance of 60 miles, arriving there on the 2nd November. Here a few days were spent in attending to the repairs of stores, the adjustment of levels, in taking observations to determine the value of one division of the level scale, and in constructing a table of subtenses for cylindrical level.

I commenced work on the section Rájkot to Bhávnagar on the 6th November. This section emanated from the embedded bench mark at Rájkot (No. 15 of Series III of spirit levelled heights, No. 1 Bombay Presidency), laid down by Captain A. W. Baird, R.E., in field season 1875-76, and was carried along the Rájkot-Bhávnagar road to Dhása, and thence along the Bhávnagar-Gondal-Junagad-Porbandar Railway

* The level of this bench mark has to be re-determined.

line to Bhávnagar, and closed on the bench mark of reference of the Bhávnagar tidal observatory situated close to the incline plane of the steam ferry.

On the completion of the work at Bhávnagar on the 19th December, the party marched to Sanosra to take up the second section from Sanosra Railway station to Port Albert Victor and Sálbet. This section was started from the embedded bench mark at Sanosra Railway station on the 2nd January 1891, and was carried along the proposed railway line to Port Albert Victor *viá* the villages of Noghanwádar, Jesar, Khuntaora, and Dongar, and the well known tank called Potatalav near the village of Pipalváv. To avoid the salt marsh, intersected with numerous tidal creeks, the line of levels was continued from Potatalav westward, skirting the salt waste and passing through the villages of Bherai and Ranparda across the mouth of the Dhántrávádi river to Chachúda temple.

As it was impossible to level across the sea to the island of Sálbet, the bench mark of reference, G. T. S. 3 □ B. M. A. D. 1890. embedded in the low knoll at the north-east corner of Sálbet village in the vicinity of the proposed tidal observatory, was connected by means of 101 simultaneous tidal observations taken on the 26th, 27th, 28th and 29th January from about half an hour before high water to about half an hour after.

On the completion of the section to Sálbet on the 2nd February the staves were again compared with the standard bar, and on the following day the party left the island by boat, arriving at Jáfarabad the same evening, whence we proceeded by the Native passenger steamer *Krishna* to Bombay, and thence by rail to Náydongri, to take up the spirit levelling from Náydongri Railway station along the north-east division of the Great Indian Peninsula Railway to Bhusával and thence to Nágpur.

After the necessary arrangements to start the work had been made, I began operations on the 13th February from the bench mark (No. 13 of Series V of spirit levelled heights, No. 4 Bombay Presidency), embedded in the station platform at Náydongri (Great Indian Peninsula Railway), and continued the work uninterruptedly to Málkhed (Málker) Railway station on the Nágpur line, where the season's operations closed on the 11th May. On the following day the party marched to Amraoti.

After comparing the staves with the standard bar, arranging for the storage of the camp equipment, and settling with the Native establishment previous to their departure on leave, I returned to head-quarters by rail, arriving at Poona on the 17th May.

I may here remark that in the levelling from Náydongri towards Bhusával the present operations were carried over 60 miles of single levelling performed in season 1882-83 by sub-surveyor Vinayek Narayan, working with Dumpy level No. 734.

During the season I used cylindrical level No. 4 and staves Nos. B_1 B_2. Owing to an accident sustained by this level in 1888, a new spirit level had been fitted to it in Calcutta, but after its return the metal ring containing the antagonistic adjusting screws was found to be cracked, the crack running into one of the female screws. The instrument on trial was found to work well, but eventually the threads of the male screw wore away, and by the time I reached Bhávnagar the level became very unsteady, necessitating very tender handling and great loss of time in levelling the instrument. Mr. Proctor-Sims kindly had new screws made for the instrument, and on the next section I was able to get on much more rapidly.

Unfortunately on the section from Náydongri the carriers slipped and the shock to the instrument opened out the crack in the adjusting ring rendering the instrument useless. For 45 miles I had therefore to use Cushing's reversible level till I arrived at Akola, where the Resident Engineer, Mr. Hemans, had the ring cleverly repaired, and the instrument is now in excellent working order.

Sub-surveyor Narsing Das had in use cylindrical level No. 3, apparently a new instrument, which remained in excellent working order throughout the field season.

It will be seen from the following table that the differences of lengths of both pairs of staves from the 10 foot standard bar corrected for expansion are in defect, and this defect went on increasing as the season advanced, particularly staves N_1 and N_2, which being hollow were evidently much more affected by changes of temperature, and therefore the comparisons should have been made more frequently.

Results of comparison of staves.

Date of comparison.	Mean difference of length of pairs of staves from 10 feet.	
	Staves (solid) B_1 and B_2.	Staves (hollow) N_1 and N_2.
At Rájkot, 4th November 1890	—·000234	—·001114
At Sálbet, 1st February 1891	—·002202	—·006420
At Amraoti, 13th May 1891	—·002948	—·009707

FIRST MIRANZAI EXPEDITION.

Extract from the Report on the Survey Operations with the Miranzai Field Force, by CAPTAIN R. A. WAHAB, R.E., *Season 1890-91.*

The name Khanki is applied to the greater part of the valley of the Ghorbin Toi, the upper feeders of which, rising among the eastern spur of the Safed Koh, water the different glens of the Urakzai Tirah. Looking upstream from the high hills over Jandasam the river could be traced for a long distance running through an open valley, with wide stretches of level ground at intervals, into which the snow-covered hills sloped gently down. From Adugarhi, at the junction of the Daradar ravine with the main stream, the valley contracts, and thence down to its exit from the hills near Shahu Khel, it is more or less a defile flanked by high and, in places, precipitous hills, rising on an average 2,000 feet above the river bed. There are, however, numerous *kaches* or narrow strips of cultivation varying from 50 to 500 yards in breadth, and every available piece of level ground is made use of. Rice appears to be the chief product of the valley.

On the south, the crest of the Samana range runs parallel to and generally some two or three miles distant from the stream, into which it slopes abruptly in many places. Grass and firewood are found in abundance on all parts of the range; in places the trees, wild olive, holly and hill oak, grow to a considerable size, and thickly enough to give the hills a wooded appearance unusual on the north-west frontier.

On the north several ravines running down from the higher ranges break the continuity of the hills, immediately bordering the valley on that side. The most westerly of those explored was the Daradar valley, occupied by the Mamozai (Muhammadzai) section. Daradar (Starkili) is at the southern end of a small basin formed by the confluence of several hill streams, which rise under the high masses of the Mazioghar range. Several other villages lie within a radius of one and a half or two miles, and higher up, in a branch from the same valley, is Torsmats, a Shekhan village, and the furthest point reached by our reconnoitring parties. Immediately below Daradar the hills close in, and the stream forces its way through a narrow defile till it joins the Khanki, three miles to the south, at Adugarhi. Two and a half miles lower down another ravine runs in on the left bank near Nakshband, draining the Kama Karbogha basin, and at Nari a similar *tangi* comes down from Stara Karbogha. A mile below Khanrai, another tributary from the Ibrahimo and Kasha valley enters the Khanki. From here a pass leads to Dran in the Shekhan valley, which lies parallel to and about five miles north of the Khanki, and separated from the latter by a steep and rocky range of hills.

Dran consists of a group of four villages, situated in the broadest part of the Shekhan valley, here about half a mile across. Below Lakardara, the most easterly of the Shekhan villages, the valley contracts to a narrow, tortuous defile, which, if held by an active enemy, would prove a difficult one to force; it can, however, be turned by the pass leading from Kasha, which could be easily reached in one march from Shahu Khel. Above Dran the valley bifurcates, one branch leading to the Kharai Kotal above Daradar; the other, the northern, over a higher *kotal* by which a road leads to Torsmats. In both these branch valleys there are a few outlying Shekhan hamlets. The road to Daradar by the Kharai Kotal is good almost throughout, with the exception of the steep ascent from Mir China on the eastern side. There is a small plateau three-quarters of a mile long by half a mile broad at the summit, and a Mamozai hamlet on a knoll commanding the whole plateau, which would make an excellent position for a post.

Both the Khanki and Shekhan rivers join the Kohat Toi; the former at Rais, the latter at Kuz Ustarzai, on the Kohat-Thal road.

The Sturi Khel country lies in the valley of the Urakzai Toi; it was reached from Marai, at the head of the Samilzai valley, by an easy pass, though, owing to the heavy snowfall of the 10th February and the intense cold of the succeeding night, the march from Marai to Zera (only 5 miles) proved the most trying of the whole expedition. From Zera, where the force was encamped, the road leads up the rough bed of the river through a very difficult *tangi* for nearly two miles. From And Khel, the first of the Sturi villages, the valley opens out and for ten miles or more, as far as could be seen, the country appeared open and undulating, rather than mountainous. Numerous villages and towers, and the lines of terraced fields, showed up clearly amidst the snow which covered the whole valley.

Downstream from Zera the river runs between high hills south-east for about 10 miles to Usai; thence it sweeps round to the north-east, past the steep spurs of Mauleghar, till it joins the Bara river, some 10 miles above the Bara post in the Peshawar valley.

No opposition was met with at any time from the inhabitants, though the survey escorts never exceeded a strength of 12 sepoys; except in the Rabia Khel country, where the villages were deserted, the sepoys of the escort were always treated in the most friendly way by the villagers, and no difficulty was experienced in getting guides or any information about the country that was required. The most serious difficulty the surveyors had to contend with was due to the inclement weather; the deep snow on the higher hills, and the keen winds on the summits where it was necessary to climb in order to get any view of the country, were exceptionally trying.

The minimum temperature recorded was at Zera, where the thermometer stood at 21° at 7 A.M. on the 11th February; during the night it was doubtless several degrees colder, but I have no trustworthy record of the minimum night temperatures. The altitude of Zera is 3,880 feet above sea-level.

I am much indebted to Captain Mason, R.E., and the other Intelligence Officers working with him. Some reconnaissance sketches by Captain Bryan, R.A., have been of value in enabling me to fill up parts of the map, which I was unable to visit myself.

Second Miranzai Expedition.

Extract from the Report on the Survey Operations with the Miranzai Field Force, *by* Captain R. J. Mackenzie, R.E.,—*Season 1890-91.*

The Samana range is composed of limestone strata, often of great thickness, intermixed with soft loose soil. The top of the ridge, coinciding with a gentle anticlinal in these strata, consists in parts of its length of fairly level, rounded plateaux, while the broken edges of the limestone strata present impassable *khuds* on either side. The more

open parts are connected by narrow ridges where the range has been eaten away to a razor-back. Numerous spurs run north and south from the main range separated by deep and precipitous valleys. Both main range and spurs are crowned by villages which are nearly always built on commanding points. They nearly all contain, or rather did contain when the force arrived there, solid and well built towers.

Every available spot on the hillsides has been worked up with much labour into terraced fields, and the amount of cultivation is considerable. It nearly all depends on rainfall. Numerous tanks have been dug on the hillsides and crests, and furnish a large proportion of the water-supply of the country.

The upper part of the Khanki valley is much more open than the lower part described by Captain Wahab in his report after the first expedition. At Karapa, which may be considered the limit of the two parts, the Sampagha stream comes in from the north. It drains an open, fairly steep glacis-like slope, which contains the villages of Kandi Mishti as well as the Takhtak nala basin. To the north is the Sampagha pass over the Tsappar range. The latter guarded by towers of the Shekhans, Alikhels, and Mullakhels, which, perched on the top of the ridge, watch each other jealously. The pass appears quite easy, as does also the Arhanga pass into Maidan, which is only some three or four miles north-west of it.

Going up the valley from Karapa on the south are several small side valleys. On the north at Sadarai, six miles above Karapa, another open steep glacis-like valley, containing several villages, slopes down to the river. Above this the valley opens out, and is well inhabited and cultivated on either bank, the river running in a deep channel.

On the south bank, at eleven miles from Karapa, is Starkili, the principal village, or rather collection of villages of the Alisherzais, and five miles further on, on the north side of the valley, is Khanki or Massozai Bazar. This latter is counted one of the two principal places in Tirah; Mishti Bazar in the Mastura valley being the other.

At Khanki Bazar the drainage of the Kahu, Kama, and Torsmats *nalas* comes in from the north. No view was obtained up these valleys, but they appear from native information to be well inhabited by Mamezais. The Kahu is one of the chief routes into Maidan and leads into the Kambarkhel territory. To prevent misapprehension, it may be noted that the *nala* on the far side of the *kotal* is also called Kahu, which name seems to apply to the whole road from Khanki to Maidan. Above Khanki Bazar the head of the valley is formed of rounded spurs coming down from the watershed and the hills on either side, and separated by deep ravines. Villages are numerous.

From the *kotal* a view was obtained of the Karmana Dara: it seems to be of the same character as the Khanki, and numerous villages were seen.

BLACK MOUNTAIN EXPEDITION.

Extract from the Report on the Survey Operations with the Hazara Field Force, by CAPTAIN R. A. WAHAB, R.E., *Season 1890-91.*

The description of the country given in my report on the last Hazara expedition (1888) need not be repeated here. The adjoining Chagarzai country is in most respects similar; the proportion of forest is perhaps smaller, and of land under cultivation somewhat greater, while the villages generally are larger and more compact than those of their Hasanzai or Akazai neighbours: fruit trees also are more numerous. On the left bank of the Indus little could be seen beyond Judba, the spur running up thence to the crest of the Black Mountain hiding all beyond: it was evident however that any road through the cis-Indus Chagarzai country, other than that along the river bank, or along the crest of the range, would be extremely difficult.

Across the river from Didal upwards, the country is less difficult, the hill slopes are more gentle, and the height of the main range is less. Nothing was seen of the Indus itself beyond the mouth of the Itai; Kabalgram, which lies a mile or two further north, being hidden by the Domel spur. The Itai valley is about 15 miles in length from its junction with the Indus to the Ghurband Pass; it appears to be well cultivated, the principal crops being *makkai* on the higher slopes and rice in the low-lying ground.

In the range bounding it to the north and west several conspicuous peaks rise to a considerable height, the highest just exceeding 10,000 feet. The main road from the Chagarzai country to Swat leads up this valley across the Ghurband Pass (7,000 feet). It is said to be fairly good, and passable by laden mules.

The roads along both banks of the Indus between Palosi and Takot were traversed by a Havildar of the 4th Sikh Infantry under the orders of the Intelligence Officer with the force, so that the course of the Indus can now be laid down with a fair amount of accuracy. His report proves that there is at present no practicable road continuously along either bank, and that it is necessary to cross the Indus either at the Marer ferry or near Kamach, re crossing to the east bank some little distance above Kabalgram, above which point the road on the west bank is almost impracticable. One of the results of the expedition is that there is now a fair road along the east bank as far as Darbanai; and it is believed that if this were continued along the river bank to Judba the necessity for crossing the Indus would disappear. Some very heavy work would be necessary, but the advantages of a road, cis-Indus throughout, would amply repay the cost and labour.

The level of the surface of the Indus has been determined at several points. During the 1888 expedition, the level at Takot was fixed approximately at 1,700 feet; at the mouth

of the Itai river, 16 miles lower down, it is 1,500 feet, and the same distance lower down at Kunhar 1,320; this gives a fall of nearly 12 feet per mile. At Darband camp, 12 miles lower down the water-level, is about 1,200 feet, and from thence downwards the fall is much less rapid. Boats were brought up from Attock for the bridge-of-boats which was established at Kotkai, and small boats were taken up as far as the reach between Karnar and Palosi, and could have been taken up as far as Kamach without much difficulty. There is, however, a bad series of rapids between Kamach and Kotkai, beyond which it is extremely doubtful if boats could be taken; from this point upwards the only means of crossing the Indus that could be depended on would be *mussak* rafts, or rafts formed of hollowed out logs, such as are in common use at all ferries on this part of the Indus.

EXPEDITION TO MOGAUNG, ENDAWGYI, ETC., BHAMO DISTRICT.

Extract from the Narrative Report of CAPTAIN F. B. LONGE, R.E., *in charge No. 21 Party, Season 1890-91.*

I received charge of the party from Major Hobday in Mandalay on 1st December, and the head-quarters were then transferred to Bhamo, where, immediately on our arrival, we proceeded to measure a base and endeavoured to extend the triangulation towards Mogaung. We visited a small hill above the village of Pin-thet on the Irrawaddy, and one above Nyetpyawdaw village, but owing to the dense jungle we were unable to do all we wanted.

On the 26th December, Lieutenant Gordon and I, with an escort of military police, went up the river in the 'Pathfinder' as far as the village of Nansauk, where we left the steamer. Next day I ascended the hill above the village and took some observations, and on the 28th I returned to Bhamo, leaving Lieutenant Gordon and the escort at Nansauk. On the 29th I left Bhamo again and went as far as Senbo, picking up Gordon *en route*.

While at Senbo I recommenced the triangulation from a base measured by Major Hobday, and observed from three stations fixing a certain number of points on ahead, but the weather was not very favourable, and I could not fix any very distant peaks. Those I did fix, however, were very useful, as they enabled me to determine accurately the relative position of Mogaung and Senbo, adopting the position of Senbo as determined previously by Major Hobday. Unfortunately the latitude of Senbo was incorrect, and consequently a portion of my work, before the error was discovered, was vitiated, and I had subsequently to work with observed latitudes.

On the 1st January, the remainder of the Bhamo portion of the column I was to accompany arrived at Senbo, and on the 3rd we started for Mogaung, marching as far as the Narsing Chaung; we reached Mogaung in five marches. On the 9th I observed from Umantaung hill station, and on the 10th measured a base in the paddy fields and observed from it.

At Umantaung I obtained a plane-table fixing, and with the plane-table value of latitude and longitude and an observed azimuth, computed the value of some of the points I had fixed from Senbo. The values now obtained agreed within 2 seconds of latitude and 2 seconds of longitude, which satisfactorily fixed the position of Mogaung, making it considerably east of its present position on the map.

From Mogaung a column under Captain O'Donnell was to have marched to Sana, and afterwards through the Kaukkwe valley, but in consequence of rumours of a large gathering of well-armed men in Thama, we were, after considerable delay, sent to that place, which we entered on 20th February without opposition. I was enabled to make some slight additions and corrections to the survey made of this country by Mr. Ogle in 1888-89, but could visit no hills from which triangulation could be carried out, except one near Thama itself, which the Sawbwa cleared for me. We remained at Thamagale, as some paddy fields in the valley west of Thama are erroneously called, till the 2nd of March, when we marched back to Mogaung in order to be ready to start for Wuntho, in case a force should be required to co-operate against that State from the north. Captain O'Donnell, Lieutenant Wilson, the Assistant Commissioner, and Lieutenant Whitehead, Staff Officer, and I, left the column on the 3rd and rode into Mogaung accompanied by the Sawbwa.

Before proceeding to Thama I availed myself of the opportunity of visiting Kamaing, as the Assistant Commissioner was going there to obtain information regarding Thama and the possibility of obtaining guides. I took a theodolite and plane-table and observed from two stations about 10 miles apart, hoping at a later date to be able to connect up with them, but this I was never able to do, and after staying there three days I returned to Mogaung. Lieutenant Gordon arrived at Kamaing the day before I left. I had left him with boats, taking up rations, to make a proper survey of the river, but they went too fast for him, and he was unable to do so. He subsequently went up the Endaw Chaung to Endawgyi, and surveyed the whole Chaung and immediate neighbourhood, after which he returned to Mogaung in time to accompany the force under Captain O'Donnell to Taungtonlon hill, near which, at a place called Payani, we were to meet the troops under Colonel Macgregor.

We started on this expedition on Monday, 9th March, *viâ* the Namyen valley and across the hills to Endawgyi, which we reached on the morning of 14th, and here we were met, on the 16th, by the river detachment which brought up rations in boats.

On our way to Endawgyi we heard that Mohnyin had been attacked, but that the military police there had beaten off the enemy, and two days before our arrival, some people,

probably from Wuntho, made a demonstration against Endawgyi, but their courage and enterprise oozed out when they saw the little well kept stockade on the knoll above the lake, and they passed on without attempting an assault.

The column remained three days at Endawgyi, and Lieutenant Gordon and I made use of this time to fix the latitude by star observations ; we also measured a base and fixed some hills by plane-table intersection in the direction we were to go. From the far side of the lake opposite Lonton I got a ray to Taungtonlon, and this was useful subsequently.

We left Endawgyi on 17th March, and on 18th reached the Namsang Chaung, on the banks of which we bivouacked, and on the 19th marched to Mansain on the same stream. This is a small Shan village of 10 houses, stockaded. We bivouacked for the night outside the village on the river bank, the people being very friendly. The next day we continued our march and met with no villages till we reached Penling, a small and strongly stockaded village on the south-eastern slopes of Taungtonlon hill on the 24th. We took the people quite by surprise, and as soon as they were assured we meant them no harm, they produced rice, fowls, etc., the women bringing the rice into camp as usual. The march between Mansain and this place was a trying one, though in most places the track was fairly good ; we found traces of recent camps, no doubt those of the flying Wuntho Sawbwa, but met no one. On reaching Payani on 25th we found a small body of Colonel Macgregor's new Burma regiment (Gurkhas), and heard that he had gone on by another route to Endawgyi. We made ourselves more or less comfortable on the bank of the stream flowing past the village, and awaited orders. On the 29th, I rode to Na-aw to meet General Wolseley, and arranged with him that Lieutenant Gordon should accompany him to Kamaing and possibly to the Jade Mines, while I returned to Bhamo, to look after the party generally. From Na-aw I marched *viâ* Mansi, Banmauk, etc., to Katha, whence I went by steamer to Bhamo, which I reached on the 9th April.

On 14th April I removed the head-quarters to Mandalay, to which place the various detachments returned, the whole party having arrived by the 24th May. On the 27th May the head-quarters left for Rangoon and crossed over to Madras by the steamer of the 31st May, and reached recess quarters at Bangalore on the 6th June.

In conclusion, I would thank the various civil, military, and marine officers with whom the several members of the survey party have been brought in contact, for the ready assistance they have always given, and especially Mr E. C. S. George, Deputy Commissioner of Bhamo, who has gone out of his way to promote the success of the various survey detachments. To the officers of the Intelligence Branch also my thanks are due.

EXPEDITION TO THE JADE MINES.

Extract from the Narrative Report of LIEUTENANT P. J. GORDON, S.C., *Season 1890-91.*

Leaving Payani on the 1st April, I accompanied General Wolseley and the Mogaung column to Endawgyi, which we reached on the 6th. The road lay for the most part through hilly country thickly wooded, the highest point reached being Loemaw hill (4,175 feet by aneroid). The few Kachin villages we passed were almost entirely deserted, but on being assured of friendly treatment many of the villagers who had been lurking in the jungle were induced to return and furnish supplies. At about 17 miles east of Payani, we came across a plateau, apparently of considerable extent, about three miles in breadth, and at an elevation of 2 800 feet. Here we noticed wild raspberries and tomatoes growing in great profusion, and the vegetation was generally of a less tropical character than that which we had hitherto come across. On the 5th a small party under Captain O'Donnell was detached to burn the village of the Sana Sawbwa (Loemaw)—one of the few Kachin chiefs in the district who had persistently refused to submit, and who had given shelter to most of the dacoits in the neighbourhood. We found the village entirely deserted, and the only signs of the opposition we were led to expect were numbers of freshly-felled trees blocking the approaches to the village. Next morning, after burning the village, we proceeded to Endawgyi.

At Endawgyi we met Colonel MacGregor's column, which had arrived that morning from Payani by a different route. The weather during the march had been close and hot, and the British troops suffered severely. Captain Bray, of the Intelligence Branch, died here of heat apoplexy shortly before our arrival. Arrangements were made at Endawgyi for an advance to the Jade Mines (where, it was reported, the ex-Sawbwa of Wuntho had fled), in two columns, one of which was to proceed by the Sakaw road, and the other by the direct road from Endawgyi. I arranged to accompany the former column, Colonel MacGregor, who commanded the other, promising to give me a sketch of the route taken by him.

Our column made a final start from Sakaw on the 13th of April, after many difficulties about carriage. The Panthay mule drivers, who had already stayed a longer time with the troops than they had agreed upon, absolutely refused to go further. They consented, however, to sell their mules, so, as no other alternative was possible, these were bought. As the Panthays load and drive their animals on a peculiar system of their own, the confusion for the first few days may be easily imagined. The road to the Jade Mines is a fairly good mule track, crossing low thickly-wooded ranges radiating from Loi Mawmay hill, where the Uru, Namkoung, and Namsong rivers have their source; this is the route chiefly used by Chinese traders on their way from Momein to the mines.

On the 16th of April we arrived at Sanka, a large Kachin village on the right bank of the Uru river, and the site of the original mines which are now exhausted. Instead of the stubborn resistance which we were told we should meet with, we were received in the most friendly manner by the inhabitants. The leading members of the Chinese community paid us a visit and expressed much satisfaction at our coming, which, they said, would enable them to carry on their trade with safety and allay the uneasiness which had occurred on the arrival of the ex-Sawbwa of Wuntho, who had fled in the direction of Yunan on hearing of the approach of the troops.

Next morning, we visited the mines (Taw Maw), which are situated on a plateau eight miles from Sanka, and 1,600 feet above the Uru valley.

The mines are all subject to the Kausi Sawbwa, who grants a concession to work them to a syndicate of Chinese capitalists, who employ Kachins and Burman Chins as workmen. The Sawbwa, the capitalists (who supply funds for the purchase of tools, and advances for food to the workmen), and the labourers divide the profits in the proportion of one-third share to each. In the working season (December to May) about 3,000 men assemble at the mines. Most of these leave at the end of May, and during the rainy season only 40 or 50 Kachins remain there. The workings are open quarries, and the stones are broken up by having water poured on them after having been subjected to great heat from wood fires. After this the pieces are taken out with crowbars. There are other mines in the neighbourhood, but those at Taw Maw are the largest and most important. Here there are about 120 houses and shops: rice is a good deal more expensive than it is down country, but candles, biscuits, matches, tinned milk, and other European goods are sold at little over Rangoon prices. There seems to be a strict miner's law to which all adhere, which regulates affairs at the mines. Theft is punished with death, drunkenness by the drunkard being tied up till he is sober; while in the case of murder, it is left to the relatives and friends of the murdered man to avenge his death. As might be supposed, with so severe a code, crime is scarce.

The best jade is exported to China *viâ* Bhamo, Mandalay, and Rangoon, and thence by sea to Canton, where the chief market for its sale is. Some is taken up the Taping river and *viâ* Momein, but the expense and difficulties of this route prevent its being generally used. A little of an inferior quality finds its way to Canton by the Chindwin and Rangoon. The jade is sold in pieces of different sizes, some of several maunds in weight, others small water-worn pebbles, in which form the best quality is usually found from the bed of the Uru river. The duty leviable on the stone (33⅓ per cent. on its value) is collected at Bhamo by a company, which leases from Government the right to collect it.

A durbar was held on the 17th April, at which most of the Sawbwas and most important inhabitants of the mines attended. On the following day I started for Kamaing with General Wolseley and arrived there next evening. All the European troops were withdrawn, and 100 Gurkha police and two mountain battery guns were left under Captain O'Donnell to form a post on the Uru river close to the village of Sanka. We arrived at Mogaung on the 22nd of April, and remained there until the 1st of May, when we left for Bhamo. At Senbo we found that the "Path-finder" which we had expected to meet there had been prevented from ascending the rapids on account of heavy floods in the Irrawaddy, so we had to do the first ten miles of the river in country boats.

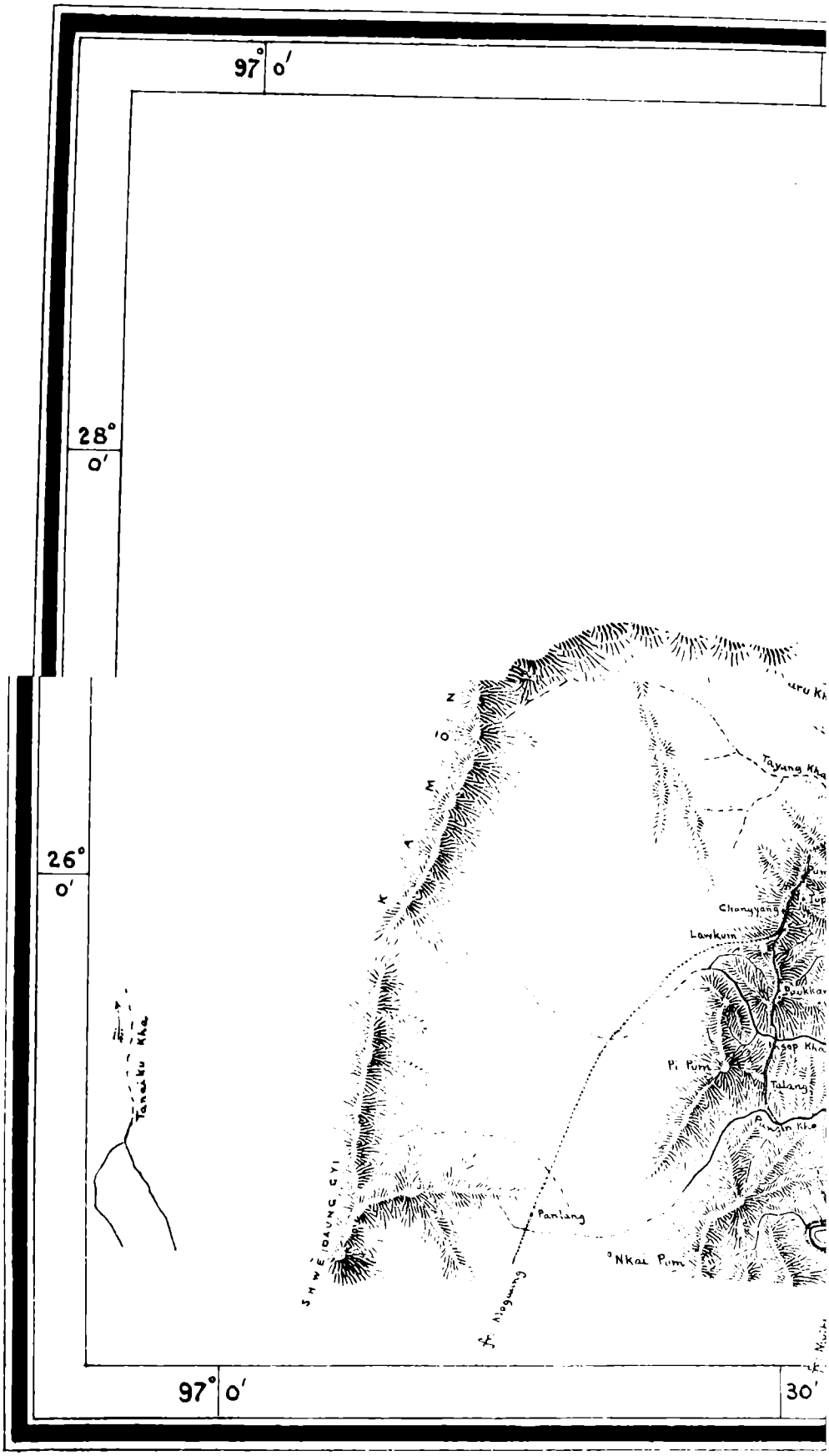
Owing to the thick haze which prevails all over Upper Burma during the month of April, and the rate at which the troops marched, I was only able, with the assistance of a soldier surveyor, to make a compass traverse of the routes gone over. The expedition did much to open the country and re-assure the inhabitants, and there ought to be no difficulty now in a survey party moving about the country with a small escort. Notwithstanding the lateness of the season, there was no sickness among my *khalásis* while in camp, although after we arrived in Mandalay several of them were attacked by fever.

EXPLORATIONS ON THE UPPER IRRAWADDY.

Report on the Survey Operations in the tracts lying to the north and north-east of the Bhamo District, by MAJOR J. R. HOBDAY, *S.C., Season 1890-91.*

Officers being required to accompany the special expeditions which were to proceed along the Yunan frontier under Lieutenants Daly and Eliott, it was arranged that I and Captain Renny-Tailyour should be attached to them, and that the latter with two sub-surveyors should go with the expedition along the southern frontier of Yunan under Lieutenant Daly, whilst I accompanied Lieutenant Eliott to explore the tracts to the north and north-east of the Bhamo districts. Sub-surveyor Sher Shah was attached to the expedition under Lieutenant Burton proceeding to the Kachin hills east of Bhamo. I arrived at Bhamo on the 8th December 1890. Our party consisted of Lieutenant Eliott, Assistant Commissioner (in charge), Lieutenant Blewitt, King's Royal Rifles, Intelligence Officer, and myself, with an escort of 70 Gurkhas of the military police of the Mogaung levy under a Native officer, whilst we had some 100 Panthay mules as transport animals. Sub-surveyor Mahomed Sayid, a soldier surveyor, and a Native doctor, also accompanied us.

We left Bhamo on the 22nd of December, arriving at Senbo above the first defile of the Irrawaddy on the same day in the Government steam launch *Buccaneer*, which was subsequently wrecked in the defile. After halting a day at Senbo we commenced our



Reg. No. 127, S. I. D.—Mar 92. 550.

Map

TO ILLUSTRATE

REPORT ON FRONTIER EXPEDITION 1890-91.

Scale 1 Inch = 8 Miles.

10 5 0 10 MILES

Roads .....

Village sites from native information shown thus .....o

Trade Routes .....

Kanti Shan Country surveyed by Col. Woodthorpe, C.B., R.E., in 1884-85.

J.R. Hobday. Major.
Survey of India

Reg. No. 127, S. I. D.—Mar. 92. 550.

Published under the direction of Colonel H. R. Thuillier, R.E., *Surveyor-General of* June 1891

Photozincographed at the Survey of India Offices, Calcutta.

Map

TO ILLUSTRATE

REPORT ON FRONTIER EXPEDITION

1890-91.

Scale 1 Inch = 8 Miles.

10 5 0 10 MILES

Roads..............................

Village sites from native information shown thus....................○

Caravan Routes..............................

J. R. Hobday. Major.
Survey of India

Reg. No. 127. S. I. D.—Mar. 92. 550.

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

June. 1891

Photozincographed at the Survey of India Offices

march northwards along the right bank of the Irrawaddy, a few rifles being detached to escort some half dozen boats, which were engaged to carry up the bulk of our rations by river. I went with the boats in the hope of carrying on a triangulation, whilst sub-surveyor Mahomed Sayid traversed the route followed by the column from Senbo to Hokat, about 36 miles by road, where we all met again on the 26th December. From Hokat I made a trip to Kayon Taung, a hill about 5 miles to the south-west, but the weather was unfortunately cloudy and unfavourable for observations. On the 28th we resumed our march, when I sent the sub-surveyor with the boats, and kept with the column myself It soon became evident that triangulation was out of the question, for the track lay along flat country covered with dense primeval forest, through which we had to cut a way for the mules; a wall of stupendous trees, bamboos, and creepers on either side of the path, shutting out all view of the surrounding country With the exception of a tract of open country in the neighbourhood of the village of Myitkyina, our track led through this dense forest up to Pumlum Pum, the most northern point reached by us.

We arrived at Myitkyina on the 31st December, and reached the confluence of the two main branches of the Irrawaddy on the 5th January, the boats coming in a day after, having been delayed by the rapids near the village of Lapè. The water was near its lowest, and running very strong in both the eastern and western branches of the Irrawaddy, which are known by the Kachins respectively as the 'Nmaikha and Malikha or the "Bad River" and the "Good River", and amongst the Burmese as the Myit Ngè and "Myit Gyi," or the "Small River" and the "Big River." Although we proved beyond doubt that the eastern branch is the larger of the two, it is not navigable for boats at low water for any distance owing to a succession of formidable rapids that exist about 6 to 8 miles from the confluence, hence its name "Bad River" or "Small River." On the other hand, the Malikha is navigable for boats for some distance, certainly as far as Sawan, and probably much further.

We determined to send back the boats and surplus rations from here to Myitkyina under an escort of 20 rifles; so taking about six weeks' supplies on the mules we continued our march northwards up the right bank of the Malikha. The path now commenced to enter the hills. After ascending and descending these, and crossing several tributaries, which rise in the Kamôn Taung and flow into the Malikha from the west, we at length reached the summit of a hill known as Pumlum Pum, in latitude 26° 15″ or 7 marches north of the confluence. Here we suddenly found ourselves in a densely populated locality, and the inhabitants far from polite or friendly. We halted a day to attempt to parley and come to some understanding with them, but signally failed; in fact matters were becoming rather serious, for they refused to come into our camp, abused and insulted our messengers, strongly objected to their country being surveyed, and commenced sending armed men in various directions to warn the tribes to oppose us if we advanced. With our small escort of 50 rifles, and the long string of mules, stretching for a mile along the road, it was hardly prudent to attempt to force our way further under the circumstances, so to avoid collision there was no option left but to retrace our steps. A few shots were fired by them at some distance behind our rear guard, which presumably signified bravado at having turned us back, or else anger at our having eluded the trap they intended to lay for us on ahead.

Fortunately from Pumlum Pum a fine view was obtained, and the valley of the Malikha could be traced almost as far as the Kanti Shan country (Meung Lang), which was visited by Woodthorpe and Macgregor in 1884-85; the intervening hills being quite insignificant. To the west rose the Kamôn Taung, running north and south, apparently in an unbroken chain of peaks from 7,000 to 8,000 feet in altitude, forming the watershed between the Malikha and Hukong valleys, and far away to the north were hills of 10,000 feet elevation and upwards, whilst to the north, north-east, and east snow was lying in patches on the higher ranges. To the east five clusters of hills, known as Sangaw Pum, form the eastern flank of the Malikha basin. In every direction the hill slopes were studded with numerous villages and clearings for cultivation. The next march would have brought us to Marao Sata, a trade centre, where there were said to be some 100 Chinamen trading in India-rubber. Here also salt is obtained by boiling the water which contains it in solution in iron pans, but the supply is not in sufficient quantity to meet the demand.

From Pumwai we returned by another route east to Sabaw, and then south along the right bank of the Malikha to Kwitao, where we crossed to the opposite bank, and struck the 'Nmaikha at the Lekennoi ferry, some 20 miles above the confluence. The crossing at Kwitao is decidedly bad, the current being very swift, and no boats available. Bamboo rafts have to be constructed, and a Berthon boat which I had, proved most invaluable At the Lekennoi ferry we found a large dug-out, and the 'Nmaikha running very sluggishly through deep pools. I sounded the depth and obtained a maximum of 93 feet. From this point we returned by the road followed by "Alaga," a Burman who was sent up to explore these regions by Colonel Sandeman in 1879, to Maingna, a Burmese Shan village on the left bank of the Irrawaddy.

After replenishing our supplies we made a fresh start from Maingna on the 5th February towards the 'Nmaikha valley; but owing to the opposition shown by the Sadan tribe of Kachins at Kwitu and Lakapyang (three marches from Maingna), and the fact of there being no mule tracks up the 'Nmaikha beyond 'Nsentaru, two marches above Lakapyang, we were compelled to give up all idea of penetrating in that direction. There was an absence of all information about the valley of the 'Nmaikha and the head-quarters of that river. "Nobody goes there" was the inevitable reply we received to our

enquiries, and we could only elicit vague stories about the Marus or dog-eating Kachins, the Yawyins, and other wild tribes that inhabit those regions.

We now practically know the basin of the Malikha, but all ideas of the valley of the 'Nmaikha or eastern branch still remain involved in mere speculation. I am inclined to concur with the conclusions arrived at by the late Sir H. Yule in his introduction to Gill's "River of Golden Sand." The 'Nmaikha has probably not a much longer course than the Malikha, judging from appearances at the confluence, though I admit that appearances in such cases are often deceptive. The Kuts Kiang, Phungmai, and 'Nmaikha are probably identical, and what is known as the Lu Kiang near Bonga is probably the Salween or Namkong of the Shan States, flowing, as we know it, in a very restricted basin, though I should hardly assign its source to be at so great a distance in Tibet.

From Lakapyang we turned southwards to explore the country along the Yunan frontier down to the Taping river. Marching along the outer ranges of hills we at length reached the village of Kazu on the Nantabet or Namtabak which rises in the Yunan plateau. We then fortunately succeeded in pushing our way up the higher ranges, eastwards for about three marches, as far as the village of Paotaw close to the border. The following day Eliott and I reconnoitred a few miles beyond the village of Chinglum, where we obtained a fine view of the junction of the Nantabet and Meungka-khas, and of their course as they flow off the plateau. On our return to Kazu we travelled north-west, and completed our second trip at Waingmaw on the Irrawaddy on the 25th February. From Waingmaw we moved southwards and reached Talawgyi in four marches, crossing the Nantabet and Nam-mali Chaungs *en route*. From Talawgyi we started eastwards on our third trip on the 9th March, pushed into the hills as far as Ning-Chang *viâ* Kantaoyang, and then southwards to Namsangyang and Manmaeu, a Burmese Shan village on the Molé Chaung. Crossing this river we again ascended the hills to Pumpien, and finally returned to Talawgyi on the 26th March. From temporary indisposition I was now incapacitated from riding or walking, and as the work was practically finished, and the party was only going to march down to the Taping along a flat and uninteresting country which the sub-surveyor could map, I took a boat to Senbo on the 30th March, arriving there the same day, and reached Bhamo the following day in the Government launch *Pirate*. The remainder of the party returned to Bhamo about the 13th April.

The total area mapped was about 4,300 square miles on the scale of 4 miles to the inch. The whole must be treated as a reconnaissance, for triangulation and survey in detail was impossible, as we were marching for weeks together often with a wall of forest on either side of the path. As we were advancing however from south to north along a meridian, the work was well checked by careful observations for latitude at every other camp, whilst points in our rear always assisted us in determining our longitudes.

To the above area has to be added some 1,000 square miles done by sub-surveyor Sher Shah, who accompanied Lieutenant Burton's force into the Kachin hills east of Bhamo. This work joins on to mine of previous years to the south, and thus we now possess a fair knowledge of the Yunan frontier between the 24th and 26th parallels of latitude.

With regard to any future explorations in these parts, an expedition starting from Kamaing and marching up the Namkong valley to the amber mines and Meungkwom in the Hukong valley might be able to work its way across to Kanti, and thence south to Sawan on the Malikha, where supplies could be sent up by boats to meet it. From this point a fresh start could be made eastwards towards the 'Nmaikha, and finally returning to 'Nsentaru The escort should not be less than 150 men. After we have visited the Kanti country and entered into friendly relations with its Shan Sawbwas, as well as subjugated the Kachin tribes intervening between Kanti and our present borders in Burma, it will be found that a party, or a single native explorer, starting from Kanti as a base and working eastwards would have the best chance of solving the question regarding the sources of the Irrawaddy, as well as the identity of the Lu and Salween rivers.

EASTERN FRONTIER OF NORTHERN SHAN STATES.

Report on the Survey Operations in the NORTHERN SHAN STATES, *by* CAPTAIN T. F. B. RENNY-TAILYOUR, R.E., *Season 1890-91.*

On the 25th of November 1890 I left Mandalay, accompanied by sub-surveyors Bapu Jadu and Ali Nawaz Khan, and reached Lashio, the head-quarters of the Superintendent of Northern Shan States, on the 14th December.

It had been arranged to send out two expeditions from Lashio. The objects of the one under Lieutenant Daly, the Superintendent of the Northern Shan States, were to visit the capitals of the western Mangleun, east Mangleun, Meunglem, and Keng-nung States, and to ascertain, as far as possible, the relations between these and other States with Burma and with China. The objects of the other expedition under Mr. Saunders were first to visit and find out as much as possible about the Kachins near the Chinese frontier, north of the North Theinni State, and then in the Taungbaing State, to visit every village and obtain full particulars of the number of people, houses, cattle, etc., in each. The geography of the country covered to be mapped in both instances.

It was arranged that I should go with Lieutenant Daly's party, taking sub-surveyor Ali Nawaz with me, while sub-surveyor Bapu Jadu should accompany Mr. Saunders' party; unfortunately Bapu Jadu was suffering from bad inflammation of the eyes, and he was unable to start with Mr. Saunders, but he joined the party when they had got into the Taungbaing State. However Lieutenant Prowse of the Intelligence Branch with a military surveyor accompanied the party, and as they could nearly always see some of the peaks fixed by my triangulation in the beginning of 1889, a fairly accurate sketch of the route was made. During my stay at Lashio I observed from two of my old hill stations and took some star observations for azimuth. On the 21st December I started from Lashio with Ali Nawaz, the other members of our party being Lieutenant Daly who was in charge, Mr. Warry of the Chinese Consular service, and Captain Burrows of the Intelligence Branch; the remainder consisting of 56 Military Police (Gurkhas), 50 followers, and about 30 Panthay muleteers with 120 mules.

We reached Meungyaw on the 23rd December, stopped over Christmas Day and starting again on the 26th, reached Manmak on the following day. This place is the capital of the Manmak sub-division of north Theinni, and is situated in a fine broad valley which unfortunately, owing to Kachin raids, had been almost entirely deserted. We left Manmak on the 31st December and arrived at Nawngleng on the 1st January. This place, at an elevation of about 5,400 feet, is the capital of a sub-division of south Theinni, called Loimaw; the people are mostly Chinese, and grow a large amount of opium; a number of Chinese and Panthay caravans passing through here on purpose to get the opium to take with them to Burma. We halted at Nawngleng for two days, and I was able to ascend and partially clear a peak of Loimaw, called Loilan, about 7,300 feet elevation. The weather was unfortunately very cloudy, and a good view was not obtainable.

We started again on the 4th January and reached Nawng-hpa on the 5th. While here we were met by representatives from west Mangleun and east Mangleun States, the latter bringing some presents of fruit, etc., including two dried squirrels; these being regarded by the Was as a special token of good faith and friendship. Leaving Nawng-hpa on the 8th January we crossed the Salween river (Namkong) at Takwi-hpong: the descent to the river is in places steep, the banks are very rocky and the current extremely rapid; the width is from 90 to 100 yards, and the depth from 60 to 70 feet in the centre. The elevation of the Salween here is about 1,350 feet, but I was only able to get the height approximately from barometer readings, as the banks of the river were very steep and jungly, and I could not observe to any of my triangulation points. Our baggage and mules took nearly twelve hours to cross. On the 9th January we reached Man-hpang, a large village on the top of a hill, and the capital of a small State tributary to east Mangleun, called Mot-hai. The Sawbwa and most of the people here are Was; they are, however, far more civilized than their kinsfolk further east. During the two days we halted at Man-hpang I went out to a hill to the east and formed a station, while Ali Nawaz took out his plane-table to the north.

Leaving Man-hpang on the 12th January, we re-crossed the Salween river and passing through Nawng-hpa on the 15th reached Nalau, which, although it is the capital of the West Mangleun State, is only an ordinary sized village situated in a small valley. The Sawbwa had run away before we arrived, and, although we waited for four days, he was too afraid to come in. The halt, however, enabled me to form two stations on neighbouring hills and to take some star observations for azimuth in camp. We started from Nalau on the 20th January and crossed the Salween river at the Hsupket ferry. The crossing here was much easier than at Takwi-hpong, for, although the river itself was much the same, the banks were less rocky and not nearly so steep. I was again unable to obtain the exact height of the river, but the barometers made it about 1,250 feet or 100 feet below our last crossing. Along the banks of the Salween here, great quantities of betel leaf creeper are found and people come from very long distances to get them. We also passed through several orange groves near the river. Marching on daily until the 26th January we arrived at Pangyang. This place used to be the capital of east Mangleun, but the Sawbwa moved to Takeut about ten years ago, making that his capital. As Takeut is situated on a sharp ridge, without any particularly good camping ground in the vicinity, and is also about 8 miles off the main road along which we were going, it was considered advisable to halt at Pangyang, and the Sawbwa came here to see us.

Pangyang is at an elevation of 4,650 feet, and is situated on a flat topped spur running out from the Pemeung range. This range extends the whole way from Man-hpang to Pangyang, and has a height in one place of nearly 7,000 feet. We halted seven days at Pangyang, and during this time I made a trip with Ali Nawaz of about 20 miles along the Pemeung range. I formed two stations on prominent peaks, and a lot of country was mapped on the plane table. The people at Pangyang are a very civilized species of Was, but prefer to be called Shans; the Sawbwa was a pleasant, rough mannered old man, and appeared very glad to see us.

On the 3rd February we marched to Katmaw, halting the next day so as to pay the Sawbwa a visit at his palace at Takeut about 8 miles off. Round Katmaw there are several mines which formerly used to yield silver, but now they are only worked for lead. Starting again on the 5th February we reached Meung-nga on the 10th. Meung-nga is situated on the left bank of the Namkha, and just inside Meunglem State; the Namkha (which runs here at an elevation of about 1,700 feet, and was only just fordable) being the boundary for a greater part of its course between the east Mangleun

and Meunglem States. These two States had been fighting against each other at Meung-nga for two months, but on our approach they made peace. During the fighting only about 20 men were killed and wounded and about 15 villages were burnt. All the villages within 10 or 12 miles of Meung-nga had been deserted since the fighting commenced, but the villagers returned within a few days of our arrival. We halted at Meung-nga a couple of days, and as my triangulation was getting shaky owing to the hazy weather, I measured a base and took observations for azimuth. I also ascended a hill and formed a station, but had the greatest difficulty in getting any of the warriors to guide me, eventually having to pay them three rupees each: they were very much afraid of tigers, which they said had carried off people on several occasions during the previous three or four months. We left Meung-nga on the 13th February, halted for the night at Meungma, and arrived at Meunglem, the capital of the State, on the 15th. Two miles from the town we were met by a party of officials who read us an address of welcome, and a mile further on we were received by the Sawbwa and all his ministers. The Sawbwa who had a pig-tail, wore a Chinese dress and is very Chinese in appearance, but curiously can only speak Shan.

The town of Meunglem is large, and is situated on one side of a small paddy plain, at an elevation of about 3,300 feet. Halting four days here, we were enabled to survey a good deal of country in the vicinity. The latitude and longitude of Meunglem are given by M. Garnier, and probably one of the French Commission had been here; the latitude was almost identical with mine, but the longitude was about ten minutes too great. The Meunglem State is large, but at present the Sawbwa, who is a Lem, has very little influence beyond the Shan and Lem communities who occupy the low country. The Las, Was, and Muhseus who inhabit the hilly country, which comprises at least two-thirds of the State, consider themselves more or less independent, and cause a good deal of trouble. The Chinese have also during the last few years been encroaching on the north of the State. Leaving Meunglem on the 20th February we marched through hilly and very sparsely populated country, crossed the Namlam on the 26th, halted a day at Meungmang, and reached Meungse on the 1st March.

The Nam Lam for a greater part of its course marks the boundary between the Meunglem and Kenghung States: where we crossed it the banks were very rocky and the river unfordable, the men and baggage having to cross over a very rickety bamboo bridge, the animals swimming. The town of Meungse contains between one and two thousand houses, and is situated on a knoll in the middle of a large circular paddy plain, from seven to ten miles in diameter, and at about 4,000 feet elevation. When we arrived there was a civil war going on between the Meungse Myoza and the Kenghung Sawbwa, the centre of hosilities being about three miles off. The fighting had been going on for several months in the usual Shan style. Meungse was used as a city of refuge by the inhabitants of the surrounding villages, and at night probably contained nearly 15,000 people and 10,000 head of cattle.

We halted at Meungse three days, during which time Lieutenant Daly was in communication with both sides, who seemed thoroughly sick of fighting, but neither cared to be the first to suggest stopping. On the 5th March we marched to where they were fighting, and Daly pulled down and burnt all their stockades, sending the opposing forces to their own districts. We arrived at Meunghai on the 6th and found the Kenghung Sawbwa had taken up his abode here temporarily so as to superintend the fighting. The Sawbwa was a young man, but appeared to be very weak minded, and, from all accounts, entirely in the hands of his wife and a few others. He seemed glad to see us and to hear that we had stopped the fighting.

While at Meunghai we were joined by the main body of the Kyaington-Chiengmai mission under Mr. Scott. Mr. Kennedy, who was in charge of the survey with the mission, was not with them, having gone by an alternative route to Kengtung (Kyaing-ton). There was, however, a military surveyor, and his road sketch will be of use for the map.

Leaving Mr. Scott's party at Meunghai, we started on the 10th of March and arrived at Kenghung, the capital of the State, on the 12th. The Kenghung State is very large, and divided into two fairly equal parts by the Cambodia river (Mékong). The capital is a very wretched town, considering the size of the State, containing only two or three hundred houses, and situated on a small hill on the right bank of the Cambodia. The river for two or three miles above Kenghung widens out considerably, and in the rains is probably a couple of miles in width; it has here an elevation of about 1,950 feet.

The haze, which since leaving Nalau had been gradually thickening, was now like pea soup, and four or five miles was about the limit we could see. My triangulation was pretty good up to a little beyond Meung-nga, but there I had a gap of about 10 miles to Meunglem. At Meunglem I took the plane table values and commenced anew from a measured base and an observed azimuth. I ran this triangulation under difficulties to a little beyond Meunghai, measuring bases and observing for azimuth at Meungmang, Meungse, and Meunghai; this rough triangulation, although not accurately connected with the original series, gave points for the plane tabling; and as Ali Nawaz ran a rope traverse along the road, the position we obtained for Kenghung is probably very nearly correct. M. Garnier had been to Kenghung and had made very careful observations for latitude and longitude, having with him besides other instruments two or three first-rate chronometers. His position of Kenghung agrees within about a mile with mine, which is a most satisfactory connection. On the return from Kenghung the haze continued, and I was

unable to do any more triangulation; and as we were making longish marches, very little, besides a simple road traverse, was possible.

We left Kenghung on the 15th of March, and proceeding by a new route arrived at Meungma in Kengtung State on the 22nd, having re-crossed the Namlam at Talaw; this river was easily forded by our party. We were joined at Meunghun by Mr. Scott's party and they marched with us to Meungma. From here our roads separated and we turned northwards, cutting into our old route at Meungma in Meunglem State on the 28th March, having crossed the boundary between the Kengtung and Meunglem States the same morning. On the 30th March we arrived at Pang-hsang, a village on the right bank of the Namkha opposite to Meung-nga, and here found that the inhabitants had all returned to their villages.

Halting a day we left Pang-hsang on the 1st April by a new route, running almost due north, and from here to Panglong we passed through a succession of small States and circles, part of the route being through the western corner of the celebrated wild Wa country. The wild Was we met were supposed not to be quite so bad as the ones further to the east, but were quite repulsive enough in appearance, wearing little or no clothes, and being coated with dirt. At the entrances to their villages there were generally from 10 to 20 human skulls stuck up on posts beside the road. On certain occasions, such as sowing time, harvest time, the prevalance of a disease, etc., their spirits whom they worship, require a human head to be offered to them so as to bring luck. Most of these heads they get in fights or by purchase, but when very hard up they make a head-hunting raid and prefer getting a Lem's head to any other. In consequence some of the roads in Meunglem state and part of the main road we traversed are considered unsafe at certain seasons, and the Lems will only travel along them in large parties. The wildest Was are also supposed to be cannibals.

On the 15th we passed through Pangkwawn, the capital of the Sumu State, the people of which are Las. Here we only just escaped being fired upon, the villagers running out and pointing their guns at us, but fortunately some Panthays who had been sent out from Panglong to meet us had just arrived, and they rushed in front and managed to calm down the villagers sufficiently; eventually we found their fears were all owing to a misunderstanding of the objects of our visit, and that they thought we intended to arrest the Sawbwa. We arrived at Panglong on the 7th April, and were received in great style by the whole male population. Panglong, with probably 400 or 500 houses, is situated at an elevation of about 4,700 feet in a kind of saucer, with small volcanic looking peaks all round. It is a particularly cool place considering its elevation, and in winter there are severe frosts and often heavy falls of snow.

The inhabitants of Panglong are all Panthays, and represent the great majority of the remnant who escaped the vengeance of the Chinese after the great Panthay rebellion in Yunan, and are consequently deadly enemies of the Chinese. They seem a most excellent people and were delighted to see us, doing all they could to make us comfortable. The Panthays are all Mahomedans, and several of the old men had actually visited Mecca. Their principal cultivation is opium, and they breed mules for pack purposes. which have come in most usefully as transport for the numerous expeditions since we took over Upper Burma. While at Pangyang we had a very severe thunderstorm accompanied by a heavy shower of hail; our tents were nearly blown away, and it made us very uncomfortable for several hours. From the date of our arrival at Panglong until we reached Mandalay there were showers of rain almost every day, which, although very unpleasant for marching in, helped to clear away part of the haze and made it possible to plane table a fair amount of country on each side of the road.

Leaving Panglong on the 20th April, we crossed the Namting on the 21st and encamped at Nam-hu on the right bank; the river was not fordable. We were now back again in North Theinni State and met a convoy of rations, having hit off the time exactly, only one day's rations remaining from our original supply.

Nam-hu is about 5 miles from Kunlong ferry on the Salween; but as we wished to visit Tunyeo, the capital of the Kokang sub-division of north Theinni, we turned away from the Salween and arrived at Tunyeo on the 24th. The population in Kokang is mostly Chinese Shan, and at Tunyeo the Myoza, and most of the people could only speak Chinese; they seem to be a good lot, and produce much better fighting-men than the ordinary Shans. Leaving Tunyeo on the 26th April we crossed the Salween at an elevation of a little under 1,500 feet on the 27th at Tanamsom and arrived at Theinni on the 4th of May, having joined the Meungse-Theinni road at Yungmaw. Lashio was reached on the 7th and Mandalay on the 22nd May. At Lashio I found sub-surveyor Bapu Jadu waiting for me. He had been out with Mr. Saunders since the end of January, and had done very good work, having surveyed the whole of the Taungbaing State. Mr. Saunders spoke very highly of his energy and zeal. Sub-surveyor Ali Nawaz had also worked well with me, and, although on several occasions suffering from slight fever, he never stopped work.

During the season I confined my attention almost entirely to triangulation, attempting to keep Ali Nawaz supplied with points for his detail survey. In all I observed from about 50 stations and camps and worked out nearly 200 intersected points. The area surveyed was approximately 5,250 square miles, including about 1,250 square miles executed by Bapu Jadu. I must record my very best thanks to Lieutenant Daly, who throughout our tour did his utmost to ensure the survey work being successful, and took the greatest trouble to get me the correct spelling of all names.

KYAINGTON-CHIENGMAI FRONTIER MISSION.

Report on the Survey Operations with the KYAINGTON-CHIENGMAI MISSION, *by* MR J. M. KENNEDY, *Assistant Surveyor, Season 1890-91.*

Early in November, having previously received orders to join the Kyaington-Chiengmai frontier mission, I placed myself under the orders of Captain Fulton at Rangoon, by whom I was directed to proceed to Meiktila road station and to report myself to Dr. Gray who had gone on in advance. I was accompanied by sub-surveyors Mahomed Hussein and Abdul Rahim. The necessary transport having been collected there, the party moved on to Fort Stedman by double stages along the main road, a good fair-weather track.

A halt was made at Fort Stedman for a day or two to arrange for an escort from the post, and the party then marched on by well known routes over ground already surveyed to Moné, the easternmost post in the Shan States, and thence to Möngtun, where Mr. Archer, who had come up from Zimmé (Chiengmai) to take charge of the mission, was awaiting our arrival.

From Möngtun a route traverse had been run the previous season during the course of the Anglo-Siamese Boundary Commission, by Captain Jackson north-eastward to Maingthat. I therefore struck off the road to re-visit the last of Mr. Ogle's stations of observation during the same mission, Loi Pakulin, and to this point, though I had two guides from Möngtun who had accompanied Mr. Ogle there the previous year, I was obliged to find my own way, as the guides lost themselves before midday in the first day's climb. The survey party reached the hill top at noon next day, and after finishing the necessary observations and waiting two hours more for the guides to come up, began the descent to Tongtun to the north. It had been arranged that the main body would await us here, but the guides again delayed, and we found, on our arrival on the third day at Tongtun, that the party had moved on. Having no supplies for the day we were obliged to follow immediately with our tired coolies, and after a severe march over a pass 3,000 feet high came up with the main party in camp at 7 P.M., having this day marched without food or rest for 13 hours.

From Maingthat, the next place where a halt was made, one of the sub-surveyors was sent into the hills to the south, the other directed south-eastward to Hongluk, where he was to turn down by a selected route, south-west and west, to Wiengkhé, a village (found afterwards to be deserted) at the north-east end of the Muang Fang valley. I went north-east up the Mekôk, and returned to rejoin the main body before the party moved; the sub-surveyor sent southwards, came into camp at the same time. Crossing the Mekôk on the 31st December, we travelled for the next week down the east bank of the Mekôk at the rate of three or four miles a day, having to clear a track with the help of coolies and sepoys, and sometimes to fell heavy timber to open camping places. From Hwéha, a village one day's march above Wiengkhé, I ascended to Loi Pahampup, the highest of the hills west of the Mekôk. I was delayed here by sickness and by the greater part of my men losing their way, having been misdirected by my Shan interpreter: when they rejoined me at Muang Fang they were on the verge of starvation. This was not the last freak of my intelligent interpreter, for I found him throughout the season fiendishly ingenious in upsetting my arrangements for work, and I should have been glad to be rid of him at some expense to myself; he showed throughout great willingness to do everything but his proper work. Muang Fang is a small decaying town with the remains of a palisaded wall; on the east face there is a daily market poorly furnished and scantily attended.

At Muang Fang we found a messenger from Mr. Archer, and as directed by him, marched through to Wiengkhé, another distressing march of 18 miles over swampy ground, most of us being still ill. We came into camp late at night and moved next day; one of the sub-surveyors who had previously rejoined the main party being sent to Kyainghai down the Mekok in boats. This man re-appeared later on, clad in various coloured lengths of towel stuff and reported that he had lost all his belongings by the wreck of one of the boats. Accompanied by the other sub-surveyor, Mahomed Hussein, I went across the hills to Hongluk, while Mr. Archer's party took the longer but easier route previously traversed by Mahomed Hussein. I had attempted to get to the head of the Mekham, a stream which Mr. Archer wished to have accurately laid down, but having failed in this, Mahomed Hussein was sent back with men from Hongluk, and with some trouble made his way there and rejoined us a week later.

To the south-east of the Hongluk plain, beyond some low hills, is the large town of Kyaingsen, which, with Muang Fang and the small post near Takhileik, are the frontier posts of Siam in this direction. The line of the Mekong valley railway through Kyainghai has been surveyed as far as Kyaingsen; and there would be no difficulty in the further extension of the line through Hongluk and Meunglen to the crossing of the Mekong at Kyanglap and following the route taken by the mission to Mongsin (Möungsin).

Two days' journey south-west of Hongluk, in the Mesolong, a tributary of the Mekham or (Gold River), gold is found in the sands of the stream, and the high hills west of the Mekham-Takhiliek road appear to be worth prospecting. There is gold too in the upper course of the Mesai stream; and this is worked by the hill people during the months when they are not required to labour in the fields.

The party next proceeded *viâ* Meunglen to the Mekong at Kyanglap. Sub-surveyor Abdul Rahim, who had been sent on previously from Hongluk to Kyaingsen, crossed and re-crossed the river above Kyaingsen and rejoined the party at Meunglen. The crossing of

the Mekong detained the party four days, the work being delayed by a heavy and continuous rain.

From Kyanglap, Mahomed Hussein was sent back *viâ* Meunglen to Kyaington and ordered to await the arrival of the party there; Abdul Rahim was sent northward to Möngyu and directed to turn across the hills from Möngyu eastward to Möngsin, while I accompanied the main body up the Namma valley. I made two excursions into the hills south of the Namma, one from Ban Mon, and another longer trip from Möngsin: these hills were covered with poppies: opium and some dye-stuff being grown largely here.

Möngsin (Meungsin) is a large village enclosed by a low wall and ditch, which stands in the middle of a cultivated plain four or five miles square, the east, south, and west sides being shut in by high hills which are broken by a gorge on the south through which the road up the Namma valley enters; on the north and north-east are low broken hills. The ascent of about 700 feet from the Mekong at Kyanglap to the Möngsin valley is gradual and almost imperceptible.

From Möngsin Mr. Archer and the other officers with the mission went north-eastward, while I and a sub-surveyor started for Kyaington, each going by a different route to Möngyu, where we met and proceeded together to Kyaington. We arrived four or five days before the remaining body of the mission.

The country between Möngsin and Kyaington, though difficult to move about in, is fairly well populated. Small villages exist along the Mekong, about a day's journey apart from one another: the valleys of the smaller streams where they open out are almost entirely under cultivation. The clearings on the hills are large and numerous, and the hill villages are densely packed, several families or numerous members of a family apparently occupying the same hut. The names of these hill villages are changeable, the places being called after the headmen at the time being.

I could not utilise as I wished, the work of the military surveyors under Captain Fulton. Their route traverses were plotted on a large scale, and my own time during the few halts made while I was with the main body of the expedition, was fully taken up in putting together the detached pieces of work brought in from time to time by the sub-surveyors, and in copying the entire map. I was unable to make any copies or reductions of any of the military work, except a traverse round from Möngsin to Kyaington, which connected the work of this party with that done by Captain Renny-Tailyour on the north. The party left Kyaington for the return march on Easter Sunday and arrived at Rangoon early in May 1891.

DRAWING OFFICE, CALCUTTA.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

Statement showing the work performed during the year 1890-91.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
Atlas of India.			
Sheets Nos. 9 S. E., 11 S. W., 21 S. E., 22 N. E., 35 S. W., 36 N. W., 39 S. W., 42 N. E., 42 S. E., 51 S. W., 52 S. E., 57 N. W., 59 N. W., 78 N. W., 78 S. W., 88 S. E., 104 N. W., 145 N. E., and 145 S. E.	19	4	Additions to names and outline for engraving.
Sheets Nos. 22 N. E., 25 S. E., 26 N. E., 36 N. W., 36 S. W., 49 S. W., 50 N. W., 59 S. W., 60 S. W., 60 S. E., and 61 N. W.	11	4	Hills brush-shaded for engraving.
Sheets Nos. 15 N. E., 15 N. W., 35 N. W., 35 N. E., 47 N. W., 47 N. E., 47 S. W., 47 S. E., 48 N. W., 48 N. E., 48 S. W. 48 S. E., 49 S. E., 79 N. W., 86 S. W., 87 N. W., 90 N. W., 90 N. E., 90 S. E., 91 N. E., 104 N. E., 105 S. E., 124 S. E., 125 N. E., 129 N. E., 129 S. E., 130 N. W., 130 N. E., 130 S. W., and 130 S. E.	30	4	Additions to railways, canals, and changes in boundaries.
Sheets Nos. 68, 106, and 115	3	4	Ditto ditto.
General Maps.			
India (Engraved)	6	32	Additions to date.
Do. do. (Railway)	1	96	Ditto.
Do. do.	1	128	A new compilation in progress.
Do. do.	1	256	Orthography revised.
Do. (Lithographed)	6	32	3rd edition, additions to date.
Do. do. (Railway)	4	48	Additions to date.
Do. do	2	64	Ditto.
Burma and adjacent countries	2	32	2nd edition, completed.
Provincial Maps.			
Burma (Upper)	1	16	A new compilation in progress.
Assam (Engraved)	1	16	Additions to Aka and Daphla hills and Kubo Valley.
Do. (Lithographed)	1	16	
Punjab (Engraved)	2	16	Additions to railways.
Central Provinces (Engraved)	2	16	Ditto
Punjab (Skeleton)	1	16	Ditto.
Bengal, Behar, and Orissa	2	16	Ditto.
Do. do. do.	2	16	A new compilation in progress.
Do. do. do. (Lithographed)	2	16	Additions to railways.
Burma and Assam (Skeleton)	1	32	Ditto.
Central Provinces	1	32	Ditto and corrections to boundaries.
N.-W. Provinces and Oudh	1	32	Ditto ditto.
Assam (2 copies)	1	48	Corrected to date.
Divisional Maps.			
Presidency	2	8	Additions to date.
Chota Nagpur	8	4	In progress for reduction to ½ scale.
Orissa and Tributary States	4	4	Ditto.
Chittagong	2	8	Completed.
Gorakhpur and Benares	1	4	Additions to date.
Rajshahi	1	8	Completed.
District Maps.			
Burdwan, Durbhunga, Gya, Monghyr, Moorshedabad, Noakholly, Patna, Rajshahi, Shahabad, Naga Hills	10	4	Additions to railways, roads, canals, and corrections to boundaries.
Akyab	1	8	Ditto.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
Standard Maps.		Miles per inch.	
Berar Circle.			
Sheets (Nos. 6—12) . . .	1	1	Roads inserted.
BHOPAL AND MALWA—			
Sheets Nos. 11, 13, 15, 17, 18, and 48	6	1	Additions to roads.
CENTRAL PROVINCES—			
Sheets Nos. 31, and 32 . .	2	1	Completed to margin.
CENTRAL INDIA AGENCY AND RAJPUTANA—			
Sheets Nos. 254, 283, 368, 379, 389, 390, 391, 392, 468, 477, and 479	11	1	Ditto.
Sheets Nos. 335, 396, 397, 408, 409, 410, 421, 429, 430, 441, 447, 449, 450, 473, 474, 478, 480, 481, 482, and 483 .	20	1	In progress.
GUJARAT SURVEY—			
Sheets Nos. 77, 78, and 79 .	3	1	Railways inserted.
GWALIOR AND CENTRAL INDIA AGENCY—			
Sheets Nos. 3(*a*), 4(*a*), 9(*a*), 10(*a*), 2(*b*), 4(*b*), and 368 . .	7	1	Roads inserted.
KHASI AND JAINTIA HILLS—			
Sheets Nos. 21 and 22 . .	2	2	Additions to boundaries.
Sheets Nos. 18, 20, and 23 .	3	1	Ditto.
LOWER PROVINCES—			
Sheets Nos. 1, 2, 3, and 6 .	4	1	Completed up to margin.
MADRAS—			
Sheets Nos. 32, 33, 51, and 52	4	1	Compilation from 2-inch settlement maps in progress.
Sheets Nos. 150, 151, and 152.	3	1	In progress.
N.-W. PROVINCES AND OUDH—			
Sheets Nos. 12(*a*) 26, and 43 .	3	1	Completed to margin.
PUNJAB—			
Sheets Nos. 262, 280, and 325	3	1	Ditto.
UPPER BURMA (NORTH-EAST FRONTIER SERIES)—			
Sheets Nos. 23 N. W., 23 S. W., (4th edition)	1	4	Additions to date.
UPPER BURMA (SOUTH-EAST FRONTIER SERIES)—			
Sheets Nos. 1 S. W., 1 N. W. .	2	4	Completed.
Sheet No. 1	1	8	Additions to July 1891.
Sheets Nos. 2, 4, and 6 . .	3	8	In progress.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
Administration Report Maps, Bengal.		Miles per inch.	
Champarun	1	8	In outline for engraving.
NORTH-WESTERN PROVINCES AND OUDH—			
Azamgarh, Bahraich, Basti, Barabanki, Bijnaur, Fyzabad, Gorakhpur, Hamirpur, Hardoi, Kheri, Lucknow, Muzaffarnagar, Partabgarh, Pilibhit, Shahjahanpur, Sultanpur, and Unao . .	17	8	Redrawn in outline for engraving.
Kumaun	1	10	Hill shading in brush for engraving.
Index Maps.			
Various descriptions . . .	9	Various.	Corrected to 30th September 1891.
Miscellaneous Maps.			
Soonderbuns	1	4	Corrected with additions.
Kubo Valley and Lekayam .	1	4	A tracing for Quarter Master General.
Western and Eastern Bengal .	20	8	Additions and corrections.
A plate showing symbols used in Topographical drawing .	1	...	In progress for departmental use.
Skeleton map of Manipur and Silchar	1	8	Prepared for Quarter Master General.
Town of Rangoon . . .	9	400 ft.	Additions and corrections.
Southern Waziristan . .	1	2	Additions about Gumal Pass.
Map of Hastadan . . .	1	2	Showing Major-General McLean's final demarcation.
Triangulation Charts.			
Chin-Lushai Expedition . .	1	4	Completed.
Himalayan Peaks between Long. 84° and 87°	1	8	Projected and drawn.
Work done for other departments.			
BENGAL—			
Income Tax	3	80	Showing (1) distribution, (2) proportion of persons assessed, (3) incidence of taxation in 1890-91.
Emigration	2	80	Showing districts of emigration and registration.
Mortality	2	80	Showing fatal fever and small-pox during 1890.
Revenue	6	80	Different maps showing sources of excise revenue.
Police	4	80	Showing different crimes.
Revenue	1	16	Showing saliferous districts.
ORISSA DIVISION—			
Revenue	1	16	To illustrate Salt Administration Report.
INDIA—			
Emigration . . .	1	96	Showing registration districts.
Emigration	1	96	Showing the native districts of Colonial emigrants.
Statistical . . .	1	64	Additions to date.
Maps of Central India Agency, Kashmir, N.-W. Provinces and Oudh, Nepal, Central Provinces, Sind and Baluchistan, Sistan, Punjab, Bombay, Madras, Rajputana, Arabia, and East Africa, Bengal, Behar, Orissa, and Chota Nagpur .	14	32	Preparing for Aitchison's Treaties.

DRAWING OFFICE, CALCUTTA.

SECTION I—*concluded.*

Statement of work.

DESCRIPTION OF WORK.	Number of Sheets.
Maps examined.	
Atlas sheets	74
General maps	21
Provincial maps	22
Divisional maps	5
District maps	14
Standard maps	84
Administration Report maps	22
Index maps	5
Statistical maps	85
Triangulation charts	15
Miscellaneous maps (departmental)	55
Do. (extra-departmental)	27
Engraved proofs of Atlas sheets in various stages	130
Engraved proofs of general and provincial maps, including index charts	62
Engraved proofs of district maps	44
Lithographic proofs of general and provincial maps, including index charts	47
Lithographic proofs of Atlas sheets and district maps transferred from copper-plates	10
Lithographic proofs of extra-departmental and statistical maps	2
Photographic proofs of standard maps, large scale plans, and various other maps	454
Colouring of maps for office use	23
Tracings of maps for various purposes	2
Projection and examination of graticules and plotting of points	47
TOTAL	1250

N.B.—In addition to the above many miscellaneous jobs, such as supply of geographical data to various officials, calculation of areas, computation of graticules for the projection of the sheets of the Indian Atlas, examination of the proof sheets of the Survey of India Notes, as to the correct orthography of names, etc., have been performed by the Examining Section.

SECTION II.—REVENUE.

Statement showing the work performed during the year 1890-91.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
STANDARD MAPS.			
PUNJAB.			
District Hissar.			
Sheet No. 256	1	1/2	Canals and village sites inserted from the Survey of 1889-90 and names retyped.
Sheet No. 241	1	1	Ditto.
Sheet No. 241	1	1/2	Names retyped, reduced to 1/2 scale, and completed to margin for a second edition.
District Jullundur.			
Ludhiana, Hoshiarpur, and Umballa.			
Sheets Nos. 211, 212, 247, and 248	4	1	Originals and proofs examined, corrected, and sent to press.
Sheets Nos. 223, 224, 234, 235, 236, 237, and 238	7	1	Originals and proofs examined.
Sheets Nos. 291 and 292	2	1	Originals examined, and completed to margin for a second edition. Proofs examined and passed with press order.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
STANDARD MAPS—*contd.*			
District Jullundur—continued.			
Sheets Nos. 213, 227, 294, 315, and 316	5	1	Proofs under examination.
Sheets Nos. 239, 240, 254, and 255	4	1	Canals, village sites and names inserted from the Survey of 1889-90; also contours from tracings received from the Irrigation Department. Proofs under examination.
District Hasara.			
Sheets Nos. 1, 2, 5, 10, and 13	5	1	Originals passed with press order.
Districts Jhang and Dera Ismail Khan.			
Sheets Nos. 99, 118, and 144	3	1	Proofs examined. Press order given.
Sheets Nos. 116, 117, 142, 143, 145, 168, and 169	7	1	Examined and proofs under correction.
District Peshawar.			
Sheets Nos. 5 and 9	2	1	Originals passed with press order.
District Gurdaspur and Jummoo Territory.			
(Chak Andhar.)			
Sheets Nos. 231 $\left(\frac{NE}{9}, \frac{SE}{2,3,5,6,9}\right)$, 232 $\left(\frac{NE}{3}\right)$, 246 $\left(\frac{SW}{1,4,7}\right)$, 247 $\left(\frac{NW}{1}\right)$	11	$\frac{1}{8}$	Examined, proofs passed, and press order given.
NORTH-WESTERN PROVINCES.			
Districts Gorakhpur and Basti.			
Sheets Nos. 188, 189, 190, 191, 192, 203, 204, 205, 206, 213, 214, and 215	12	1	Proofs passed and press order given.
District Basti.			
Sheets Nos. 163, 173, 174, 175, and 176	5	1	Ditto.
District Mirzapur.			
Sheets Nos. 167, 168, 181, 184, 197, 198, and 199	7	1	Proofs passed and press order given.
OUDH.			
Sheets Nos. 99, 100, 113, 114, 115, 145, 158, 159, 172, and 173	10	1	Ditto.
Sheets Nos. 160 and 161	2	1	Proofs under examination.
BENGAL.			
District Mymensingh.			
Sheets Nos. 343, 361, 363, and 374	4	1	Proofs examined.
Sheets Nos. 344, 345, and 360	3	1	Proofs examined and sent to press.
District Darjeeling.			
Sheets Nos. 269, 270, 271, 292 and 293	5	1	Corrected up to date. Proofs under examination.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per Inch.	
STANDARD MAPS—*concld.*			
ASSAM.			
Districts Darrang and Kamrup.			
Sheet No. 138 . . .	1	½	Fair maps under examination.
Sheets Nos. 26, 27, 28, 40, 41, 49, 50, and 51	8	½	Names typed. Held in abeyance.
District Lakhimpur.			
Sheets Nos. 1 to 15 . . .	15	½	Graticule lines inserted, names inserted and boundaries corrected.
CENTRAL PROVINCES.			
District Sambalpur.			
Sheets Nos. 236, 237, 238, 239, 251, 252, 253, 254, 262, 263, 264, and 265 . . .	12	1	Fair maps and proofs examined and press order given.
BOMBAY.			
Sheets Nos. 145, 146, 233, 277, 332, and 333 . . .	6	1	Proofs passed with press order.
Sheets Nos. 179, 185, 244, 331, 352, 353, and 353*a* . .	7	1	Fair maps examined and press order given.
BURMA (LOWER).			
Sheets Nos. 229, 230, 235, 236, 275, 277, 278, and 322 . .	8	1	Proofs passed with press order.
Sheets Nos. 282, 283, 323, 324, 325, 327, and 328 . . .	7	1	Proofs examined and press order given.
Sheet No. 227	1	1	New material added for a second edition. Proof examined and sent to press.
Sheets Nos. 180 and 228 . .	2	1	Corrected to date and proofs passed with press order.
Sheet No. 181	1	1	Corrected to date for a second edition.
District Akyab.			
Sheets Nos. 7, 8, 9, 24, 25, 26, 27, 43, 44, and 46 . . .	10	1	Proofs passed.
PARGANA MAPS.			
BENGAL.			
District Balasore.			
Sheets Nos. 1 to 9 . . .	9	1	Printed sheets touched up for reproduction by photography, proofs passed, and press order given.
District Backergunge.			
Sheets Nos. 2, 6, and 10 . .	3	1	Ditto ditto.
District Bankoora.			
Main Circuit map No. 1 . .	1	1	Ditto ditto.
District Bogra.			
Main Circuit No. 5 . . .	1	1	Ditto ditto.
District Chittagong.			
Sheets Nos. 1 to 5 . . .	5	1	Ditto ditto.

DRAWING OFFICE, CALCUTTA.

SECTION II—*continued.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
PARGANA MAPS—*contd.*			
District Cuttack.			
Sheets Nos. 1 to 9 . . .	9	1	Printed sheets touched up for reproduction by photography, proofs passed, and press order given.
Irrigation Survey.			
Sheets Nos. 6, 9, 18, 19, 22, and 23	6	$\frac{1}{4}$	Ditto ditto.
District Dacca.			
Sheets Nos. 1 to 6 . . .	6	1	Ditto ditto.
District Manbhoom.			
Sheets Nos. 1, 3, 11, 17, and 18	3	1	Ditto ditto.
District Monghyr.			
Sheets Nos. 1 to 13 . . .	13	1	Ditto ditto.
District Nuddea.			
Sheets Nos. 1 to 8 . . .	8	1	Ditto ditto.
District Pubna.			
Sheets Nos. 1, 2, 7, 11, 12, and 13	6	1	Ditto ditto.
District Sarun.			
Sheets Nos. 1, 4, 9, 10, 11, 12, 15, 16, 19, and 23 . . .	10	1	Ditto ditto.
CENTRAL PROVINCES.			
District Jubbulpore.			
Sheets Nos. 3 and 17A. . .	2	1	Ditto ditto.
PLANS OF CITIES AND CANTONMENTS.			
City of Calcutta . . .	2	$\frac{1}{8}$	Proofs passed. Press order given.
Ditto	1	$\frac{1}{3}$	Alterations and additions made.
Ditto	1	$\frac{1}{2}$	Number and boundaries of wards inserted, proofs examined, and press order given.
City of Lahore and Mean Meer Cantonments . . .	6	$\frac{1}{8}$	Fair maps and proofs examined and press order given.
Peshawar Cantonment . .	4	$\frac{1}{8}$	Rendered suitable for photography.
Kamptee Ditto . .	4	$\frac{1}{8}$	Drawn on scale 16 inches = 1 mile for reduction to $\frac{1}{2}$ scale.
City and Cantonment of Satara .	1	$\frac{1}{6}$	Proofs received for examination.
MISCELLANEOUS.			
District map of Kumaun and Garhwal	3	4	Route with names and heights of stages inserted for His Excellency the Viceroy of India.
Usar map of Oudh . . .	1	8	Proof passed with final press order.
Reh map of Punjab . . .	8	4	Proofs under examination.
INDEX MAPS.			
For Annual Administration Report	7	...	Drawn.
Ditto ditto . . .	14	...	Corrected to date.

DRAWING OFFICE, CALCUTTA.

SECTION II—*concluded.*

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
PROOFS EXAMINED.			
Photozincographed maps . .	329	...	
Lithographed maps . . .	37	...	
TRACINGS PREPARED.			
Tracings of sheets . . .	45	...	
Ditto village plans .	264	...	
MAPS COLOURED.			
Maps on various scales . .	123	...	For Surveyor General's Office.
Ditto ditto . .	123	...	For Deputy Surveyor General's Office.
Ditto ditto . .	580	...	For India Office.

DESCRIPTION OF WORK.	REMARKS.
Computations examined.	
District Saugor, seasons 1886-89.	
Traverse Data, etc., supplied.	
Kathjori and Alanka Rivers, district Cuttack . .	For No. 8 Party.
Main circuits Nos. 3 and 4, ditto . .	Ditto.
Nimar and Hoshangabad boundary	For No. 9 Party.
Narsinghpur and Hoshangabad boundary . .	Ditto.
Main circuit No. 8, district Seoni (portion of) . .	Ditto.
Moradabad and Rampur boundary	For No. 5 Party.
Detached portions of Moradabad in Rampur State .	Ditto.
Exterior portion of main circuit No. 2, Moradabad .	Ditto.
Rungpore and Cooch-Behar boundary . . .	
Village traverses supplied, 305 pages . . .	To public officers.
Field area statements of *pargana* Raipur, 241 pages .	To settlement officer.
Alphabetical lists of villages of 22 *parganas*, district Cuttack.	Ditto.
Values and description of Level Bench Marks, district Hamirpur (34 pages).	To Executive Engineer, Betwa Canal.
Rectangular co-ordinates of triangulated stations in district Nimar.	For No. 14 Party.
Miscellaneous.	
Calculated spherical co-ordinates of Revenue Survey Stations in districts Lakhimpur, Jubbulpore, and Saugor; also of points on Sylhet and Tipperah boundary; plotted 4 villages on 4-inch and 16-inch scales; prepared a traverse circuit and plotted 10 sheets Nerbudda River in district Narsinghpur on 4-inch scale; also 6 sheets of Bhagirathi River in district Moorshedabad; compiled map of disputed boundary between Rungpore and Cooch-Behar.	
Calculated areas by *parganas* of 10 sheets North-West Provinces, 12 sheets Central Provinces, and also areas of districts Rohtak, Karnal, Hissar, Jullundur, Gujranwala, Shahpur, Hoshiarpur, Gujrat, Montgomery, Ludhiana, Ferozepore, Jhelum, Rawalpindi, Amritsar, Muzaffergarh, Jhang, Simla, Mooltan, Kohat, Lahore, Peshawar, Dera Ghazi Khan, Sialkot, and Gurdaspur. Prepared a Table of distances in chains corresponding to a subtense of 10 feet, and examined another corresponding to a subtense of 20 feet. Calculated offset areas and completed traverses of the *jaghir* villages of district Ajmere-Merwara left incomplete by survey party. Calculated areas of Native States in Central India Agency and also of those in Rajputana Agency.	

DRAWING OFFICE, CALCUTTA.

SECTION III.—CADASTRAL.

State of Publication of Cadastral Maps on the 30th September 1891.

DISTRICTS.	NUMBER OF SHEETS.							REMARKS.
	MAPS PREPARED.			PUBLISHED.				
	Up to 30th September 1890.	Added during past 12 months.	Total up to 30th September 1891.	Up to 30th September 1890.	By Surveyor-General's Office during past 12 months.	Total to 30th September 1891.	Remaining to be published.	
North-West Provinces.								
Agra	2,942	...	2,942	2,942	...	2,942	...	
Azamgarh	930	...	930	930	...	930	...	
Ballia	1,601(*a*)	...	1,601(*b*)	1,001	...	1,601	...	
Banda	3,317	...	3,317	3,317	...	3,317	...	
Basti	5,505	...	5,565(*b*)	4,853	712	5,565	...	
Benares	2,052	...	2,052(*b*)	2,052	...	2,052	...	
Bijnour	31	...	31	31	...	31	...	
Dehra Dun	701	...	701	701	...	701	...	
Fyzabad	14	...	14	14	...	14	...	
Ghazipur	4,021(*a*)	...	4,021(*b*)	4,021	...	4,021	...	
Gorakhpur	8,637(*a*)	...	8,637(*b*)	5,166	1,437	6,603	2,034	
Hamirpur	2,926	...	2,926	2,926	...	2,926	...	
Jaunpur	3,583(*a*)	...	3,583(*b*)	3,503	...	3,583	...	
Kumaun (Bhabar)	...	332	332	...	...	...	332	
Moradabad and Tarai	4,023	...	4,023	4,023	...	4,023	...	
Muttra	1,658	...	1,658	1,658	...	1,658	...	
Mirzapur	3,794(*a*)	...	3,794(*b*)	3,710	84(*c*)	3,794	...	
Tarai	409	453	862(*b*)	409	...	409	453	
TOTAL	46,204	785	46,989	41,937	2,233	44,170	2,819	
Burma.								
Akyab	2,785	...	2,785	2,741	44	2,785	...	
Bassein	3,437	...	3,437	3,437	...	3,437	...	
Hanthawaddy and Pegu	4,601	...	4,601	4,601	...	4,601	...	
Henzada	1,391	...	1,391	1,391	...	1,391	...	
Prome	847	...	847	847	...	847	...	
Tharrawaddy	1,363	...	1,363	1,363	...	1,363	...	
Thongwa	2,304	460	2,764	1,681	939	2,020	744	
TOTAL	16,728	460	17,188	15,461	983	16,444	744	
Bengal.								
Patna and Gya	3,054	...	3,054	3,054	...	3,054	...	
Pooree (Khorda Estate)	4,565	...	4,565	4,565	...	4,565	...	
Shahabad	4,924	...	4,924	4,924	...	4,924	...	
Mozufferpur	1	...	1	1	...	1	...	
TOTAL	12,544	...	12,544	12,544	...	12,544	...	
Assam.								
Darrang	718(*a*)	...	718	704	...	704	...	
Kamrup	1,675	...	1,675	1,675	...	1,675	...	
Nowgong	753	...	753	534	196	730	23	
Sibsagar	...	1,877	1,877	...	1,037	1,037	840	
Sylhet	61	...	61	16	...	16	45	
TOTAL	3,207	1,877	5,084	2,929	1,233	4,162	908	
Central Provinces.								
Raipur	43	...	43	43	...	43	...	
TOTAL	43	...	43	43	...	43	...	
GRAND TOTAL	78,726	3,122	81,848	72,914	4,449	77,363	4,471	

(*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.

(*c*) These maps have been printed.

Abstract of work performed during 1890-91.

PROVINCES.	NUMBER OF SHEETS.				REMARKS.
	Examined and rendered suitable for photo-zincography.	Traced and examined for zincography.	Proofs examined previous to press order.	Prints coloured and subsequently examined.	
North-West Provinces	2,243	172	2,282	2,233	Scale 16 inches = 1 mile.
Burma	410	610	966	983	Ditto.
Bengal	...	...	...	...	...
Assam	842	433	1,254	...	Ditto.
TOTAL	3,495	1,215	4,502	3,216	

ENGRAVING OFFICE, CALCUTTA.

Statement showing the work performed during the year 1890-91.

Title of Map.	Number of plates.	Outline, square inches.	Number of letters cut.	Hills, square inches.	Remarks.
Engraving.					
Atlas of India.					
Scale 1 inch = 4 miles.					
Quarter sheets (new) completed	2	10	3,980	9	
Ditto in progress	53	783	120,096	618	
Additions and corrections to published quarter sheets	37	254	11,574	88	
Additions and corrections to published full sheets	19	389	4,810	323	
New plates projected, etc.	2	...	...	...	
General Maps	26	403	57,421	56	
Provincial Maps.					
On scale 1 inch=16 miles	13	318	41,062	32	
On various scales for Administration Reports	9	33	4,461	32	
District Maps.					
On scale 1 inch=4 miles	1	94	...	...	
n various scales for Administration Reports	44	1,139	38,082	134	
Index Maps	5	77	12,952	...	
Charts	2	...	260	...	
Miscellaneous subjects	20	...	5,748	...	
Totals	233	3,500	300,455	1,292	

Copper-plate Printing.

Impressions taken	20,129
Proofs pulled	537
Transfers pulled	434
Total	21,100

Steel-Facing.

Double elephant plates steel-faced	17
Do. do. steel removed	12
Quarter sheets steel-faced	45
Do. steel removed	28
Miscellaneous plates steel-faced	14
Do. do. steel removed	6
Total	122

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE, CALCUTTA.

Extract from the Narrative Report of COLONEL J. WATERHOUSE, S.C., *Assistant Surveyor-General, Season 1890-91.*

OUT-TURN.—The out-turn again shows a very large increase in almost all items, and the office has been worked at full pressure throughout the year.

ORIGINAL SUBJECTS.—The total number of original subjects received for reproduction during the year has been 7,067 (inclusive of 4,376 cadastral maps), of which 662 have been lithographed, and the remaining 6,405 reproduced by various photographic processes and by zincography. The increase over last year on the whole is about 46. The number of departmental maps, plans, and forms lithographed was 62, or 81 less than last year: 600 original subjects were lithographed for other departments, or 12 more than last year.

The total number of subjects received for photographic reproduction was 6,405, of which 1,083 were departmental, 4,376 cadastral, and 946 extra-departmental. Last year the numbers were 1,068 departmental, 4,548 cadastral, and 674 extra-departmental, showing differences of +15, —172, and +272 respectively.

LITHOGRAPHIC DRAWING SECTION.—The total number of new drawings or additions made to maps, etc., on stone, taken up and completed during the year, was 744; of these 101 were departmental, the remaining 643 being for other departments. Last year 645 subjects were received, of which 57 were departmental and 593 extra-departmental. The section has remained under charge of Mr. H. L. Lepage, Head Assistant; beyond the heavy pressure of work throughout the year there is nothing to record.

PHOTOGRAPHIC NEGATIVE SECTION.—The total number of negatives taken during the year was 5,694, including 69 reversed negatives and transparencies for use in the heliogravure process: of these 1,320 were of departmental, 3,211 of cadastral, and 1,163 of extra-departmental maps, plans, and drawings, as against 1,308 departmental, 3,241 cadastral, and 1,051 extra-departmental last year. The section has been under charge of Mr. H. Haward, except for three months, when he was on privilege leave, and Mr. Harrold took over the charge of it. There have been no changes in the processes.

PHOTO-TRANSFER PRINTING SECTION.—The number of photo-transfer prints prepared was 5,579, of which 1,276 were departmental, 3,257 cadastral, and 1,046 extra-departmental, and there is an increase of 431 over last year. Mr. J. Harrold remained in charge of the section, except for three months as above reported, when he was in charge of the Negative Section. There have been no changes in the processes. Some fairly successful trials were made with Husband's process for half-tone work, and it was found a very great advantage to harden the glue rollers, used for inking up the transfers, by sponging them with spirit of wine and then with a saturated solution of chrome-alum. Rollers so prepared showed no tendency to mould or decompose during the rains. The following formula for preparing grained half-tone transfers was found to work well in the wet season and hot weather:—

Gelatine	135 parts.
Water	1,080 „
Chrome-alum	1 „
Salt	45 „

LITHOGRAPHIC AND ZINCOGRAPHIC PRINTING SECTIONS.—As explained last year, the work of these two sections has again been more or less combined, though the two establishments have not been formally amalgamated. In the Lithographic Printing Section the number of subjects printed from stone was 681, of which only 74 were departmental, the number of extra-departmental subjects being 96 more than last year; the number of pulls was 283,819, or about 3,255 more than last year, and of copies 329,027, as compared with 256,909 of last year. In the Zinc-Printing Section (normal) the number of plates printed was 1,127, of which 667 were departmental and 460 extra-departmental; the number of pulls was 276,602 (111,485 departmental and 165,117 extra-departmental), and of complete copies 288,822, of which 108,724 were departmental and 180,098 extra-departmental As compared with last year this shows an increase of 86 in the number of plates printed and of 66,968 in the number of pulls, though the number of copies is 17,618 less. The work has again largely increased in this section. In the Zinc-Printing Section (cadastral) 4,484 plates of cadastral maps of the North-West Provinces, Burma, and Assam were printed off, the number of pulls being 151,557, and of copies of complete villages 142,519, as against 4,499 plates, 108,799 pulls, and 99,354 complete copies printed off last year.

The two litho-printing machines have been constantly at work during the year, and have turned out a large amount of work which could not otherwise have been done. The large machine has so far not been used very much for printing from stone, as most of the current work is done on zinc for convenience, though some of the finer class of maps might well be done on stone. It was hoped that the sheets of 1-inch squares for the use of the cadastral surveys might have been printed in the large machine, but it was found impossible to print the hard, dry, hand-made paper in the machine, and they have consequently to be printed by hand. The machine-work has so largely increased that it was found desirable to provide a second machine to meet increased demands, and also to provide a reserve in case of the present machine being disabled. We have now become so dependent on the machine for getting through the work that a break-down would bring us to a standstill.

A second quad-crown machine of a rather lighter make than the present one has been indented for from England.

TYPE-PRINTING SECTION.—The work in this section is slightly in excess of last year. The number of items set up was 9,098, and the number of impressions or pulls 1,074,280, and of copies 581,690. Last year the number of items was 9,918, of pulls 1,061,577, and of copies 573,885. The section has continued under Mr. DePyvah, and the machinery attached to it has all worked well.

SILVER-PRINTING SECTION.—As was the case last year this section has been principally engaged in producing blue-prints for proofs and other purposes. The total number of these prints made during the year was 2,691 against 2,823 of last year, showing a decrease of 132. On the other hand, the number of silver prints shows a large increase of 926, the number of prints being 1,105 against 179 of last year.

HELIOGRAVURE SECTION.—This section has been under charge of Mr. Turner during the year, and has made very good progress; 70 plates have been prepared by the photo-etching process, and 34,015 copies printed from them, showing an increase of 14 in the number of plates and of 3,426 in the number of copies over last year. The process of half-tone block printing, alluded to in last year's report as under trial, has been brought into practical use for preparing the illustrations of Mr. Cotes' reports on Economic Entomology to be printed with type, and 34 blocks were thus prepared.

PHOTO-ETCHING PROCESS —No change has been made during the year in the original method of working this process. The principal part of the work done during the year has been the reproduction of the exceedingly delicate Indian ink and pencil drawings of insects prepared in the Indian Museum to illustrate Mr. Cotes' reports on Economic Entomology; and as very large numbers of prints have been required of them, it was necessary to find some way of etching the plates sufficiently deeply to stand the printing, and at the same time to print them in such a way as to preserve the delicacy of the originals. Mr. Turner successfully accomplished this by biting the plate much deeper than usual, and printing with a light grey ink containing a large quantity of zinc-white in it. In order to overcome the general greyness given to the print, a few of the very deepest shadows were deeply cut with the graver. Some very good sparkling effects were produced by this means, and large numbers of prints could be made without the plates wearing. Seventeen of these plates were prepared; the printing, amounting to 31,000 impressions, is still in hand. A very successful reproduction of a colored plate was prepared for the "*Scientific Memoirs by Medical Officers of the Army in India*." It consisted of several microscopic drawings illustrating the condition of the vessels in the initial stage of *mycetoma*: these drawings were in different shades of blue, violet, and strong reddish orange. The negative was made on an orthochromatic plate which brought out all the detail fairly well, though the transparency required a good deal of touching up. The printing of the etched copper plate was done as nearly as possible in the original colours, the different coloured inks being applied with dabbers on the several diagrams, and wiped off in the usual way, but in such a direction that they did not blend. The printing was necessarily slow, but took less time than it would have done to have printed the copies in the ordinary way and to have coloured them by hand, while the effect was really much better and a truer copy of the original. A copy of this plate is appended to this report. Twenty-one plates were done for the "*Technical Art Series*," of which 14,700 copies were printed. Trials were made with the object of bringing out an edition of the new survey of the city of Calcutta on one-fourth the original scale by joining nine reduced sheets so as to form a single sheet. The result showed that the work might be done with good effect, but as the drawings were too full of detail and had not been drawn with the object of reduction, a great deal of stopping out had to be done, and it was finally decided to prepare the reductions from fresh drawings. The plate attached to the report of this survey at page 92 shows with what delicacy such reductions can be produced, and the good effect with which shaded tints can be introduced on the copper plates by an after process of etching.

Two sections of the 24-mile map of Afghanistan were etched during the year, and it is to be regretted that this beautiful process cannot be more largely utilised for map work.

PHOTO-BLOCK PROCESS.—During the year Mr. Turner has devoted a good deal of attention to working out a method of producing good photographic half-tone blocks. The following method was found successful, and was used for preparing a large number of blocks of shaded drawings to illustrate the reports on Economic Entomology prepared by Mr. Cotes of the Indian Museum.

A grained negative has first to be obtained by placing a transparent screen of crossed and closely ruled lines (about 150 to the inch) in contact with a transparent positive cliché of the subject to be reproduced, and then taking a negative in a copying camera. The result is a negative in which the gradations of shade are broken up into a network, enclosing small points varying in size and character according to the amount of exposure received in different parts of the film. In the darkest parts of the negative, which represent the lights or white spaces of the finished print, these points have the appearance of small transparent dots joined by opaque spaces, and as the negative increases in transparency, corresponding to the increasing depth of shade on the print, the transparent dots increase and the opaque spaces lessen till in the deepest shadows the distribution of light and shade is quite reversed and the negative image is formed by very small opaque dots joined by transparent spaces and finally by absolute transparency. The screens used were photographic reproductions of some ruled prints I obtained from Herr Türcke, formerly of

Donauwirth and now of Munich, but it is difficult to photograph such fine lines sufficiently clearly and sharply to give the best results. Experiments were tried in ruling plates direct on the glass by the ruling machine in the Engraving Office. A sheet of plate glass carefully cleaned was coated evenly with a thin film of India-rubber solution, which, when set, was dusted over with fine plumbago; this gave a perfectly opaque film which cut well in the ruling machine. The difficulty is to rule the lines over a large surface with absolute regularity.

While on furlough I obtained some specimens of ruled screens from Mr. Max Levy of Philadelphia, United States of America, and trials made with them after my return have shown their great superiority over anything we could make here. I had already ordered a screen from Mr. Wolfe, another American manufacturer, before I had seen Mr. Levy's, but as soon as the requirements of the process are better known, it is probable that it will be necessary to provide ourselves with various sized screens of different rulings.

Having obtained a good grained negative the rest of the process is very simple and reliable in its working. A thin and highly polished copper-plate is coated with a very fine grain of asphalt in the dusting box, in the same way as for the photo-etching process. The grain should be very fine, so as to be eaten away during the etching of the image. The thin copper plates used are best produced by electro-typing, and are not much thicker than a sheet of stout paper. The metal is thus of good quality and surface, and can be easily cut and handled. Copper is less liable than zinc to be corroded. The further steps of the process are described by Mr Turner as follows :—

"A print in standard brown autotype tissue is now taken from the grained negative and developed in the ordinary manner on the thin copper-plate; a quantity of prints may be developed on the same plate and etched together or separately. They should be printed in the direct sun-light and take an exposure of one to two minutes. They are dried off in the usual way with spirits of wine, and the parts not requiring etching are masked out with asphalt varnish: before etching the prints should be carefully examined to see that there are no defective parts, and especially that the grain is crisp and sharp; the slightest want of contact in the printing will spoil the result.

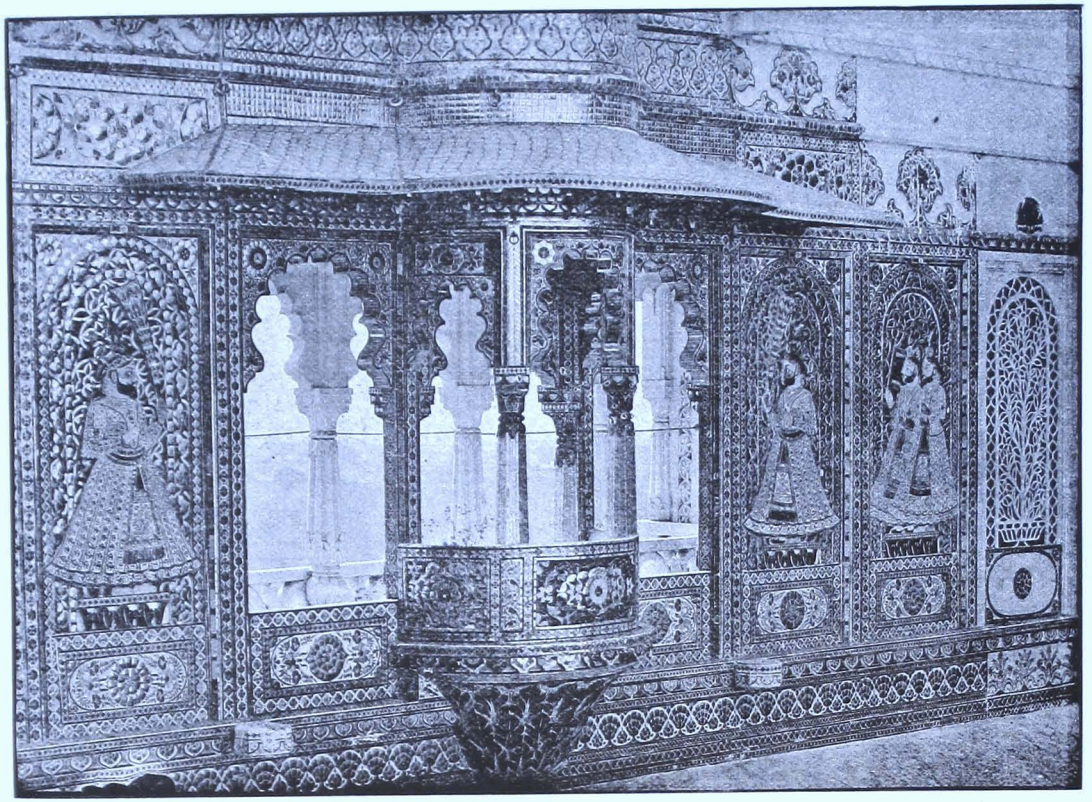
"The image on the copper-plate is now placed in a solution of perchloride of iron of 44° Baumé and the process of etching carefully watched; from the time that the perchloride first begins to attack the copper, which is easily seen, the plate should be in the solution about 10 to 12 minutes, or until the greater part of the image is etched; it is now removed to another dish containing a 40° Baumé solution of perchloride of iron, and left in this until every part of the image has been eaten into the copper, except the very deepest shadows. This generally takes about 6 to 8 minutes; the gelatine image is then washed off in a strong current of water, and the plate cleaned with ammonia and chalk. If the etching has been satisfactory, a perfect image in relief will now be obtained with every line of the grained negative reproduced clear and sharp. An advantage of this method of etching is that the grain is never underbitten; the finest lines and dots are always perfect, because if the contrast in the work makes it necessary to over-etch the fine parts, the image is attacked by the perchloride on the surface without removing the original gelatine film, as would be the case in etching an asphalt or fatty-ink image under similar circumstances. The result is that the lights of the picture are slightly below the level of the deep shadows, but not sufficiently so to interfere with the printing; in fact it should assist it considerably by causing the deep shadow to take up more ink than the lights, and so form a natural graduated method of overlaying, so important in typographic printing. The plate now obtained, though fairly deep, is not sufficiently so for printing purposes, and recourse must be had to re-biting, which is about the most important part of the process. For this purpose a hard gelatine or smooth rubber roller is required, and the image is carefully rolled up with an ink composed of equal parts of good lithographic ink and black wax thinned down with sufficient lithographic varnish to just make it workable on the slab; the ink should be as hard as possible. The black wax mentioned is composed of—

Spermaceti	56 parts.
Stearic acid	26 ,,
White wax	24 ,,
Asphalt	9 ,,

"With proper care the image is very easily rolled up with this composition, and it forms such a powerful resist to the etching solution that a very thin film will be found sufficient to protect the image. The plate is slightly warmed over a gas stove, and the back and sides of it again covered with asphalt varnish. It is then put into a 38° solution of perchloride of iron, and should stand about 2 minutes etching; this will deepen the image considerably, but will have to be repeated a second and very often a third time before sufficient depth is obtained, care being taken that between each rebiting the plate is thoroughly cleaned with benzole and turpentine. A great deal can be done with the plate to improve it during the progress of the rebiting by painting out and biting only such parts of the plate as may require it, but this of course depends entirely upon the subject and the skill of the operator.

"The plate is now cut to the exact size required and is ready for mounting. The plates being very thin, this is easily effected by fastening them to blocks of wood, type-high, with strong bichromated gelatine. The back of the plate must be first carefully

PHOTO. BLOCK. BITUMEN-GRAIN PROCESS.

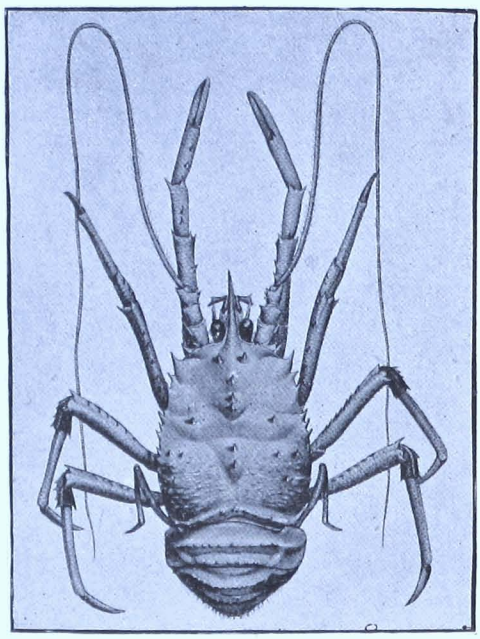


Survey of India Offices. Calcutta, January 1892.

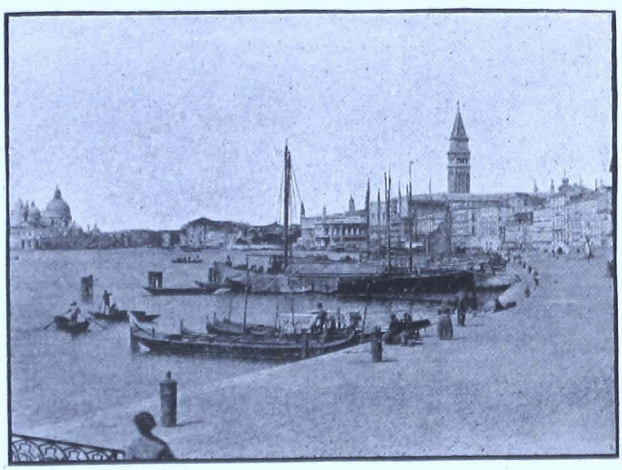
COLOURED GLASS MOSAIC IN THE PALACE AT OODEYPORE, RAJPUTANA.

From a Negative by O. S. Baudesson, Ajmir.

SPECIMEN OF PHOTO. BLOCK PRINTING.



Reduction from an Indian ink drawing.



VIEW IN VENICE.

From a Negative by Colonel J. Waterhouse.

ETCHED ON THIN ZINC BY THE ASPHALT PROCESS FROM NEGATIVES TAKEN WITH MAX LEVY'S ENGRAVED RULED SCREEN, 150 LINES TO THE INCH.

Survey of India Offices, Calcutta, March 1892.

cleaned with turpentine and afterwards with a strong solution of caustic potash; it is then dried, and a sheet of white tissue paper is attached to it, with a solution of—

Gelatine	8 parts.
Water	32 „
Bichromate of potash	1 part.

"Upon the wooden block a sheet of thin drawing paper is attached with the same solution. The plate with the tissue paper on its back is now thickly coated with the bichromated gelatine, as also the wooden block, and the two brought into close contact with each other and placed under pressure. The method adopted for this purpose is to place a sheet of oiled paper on a plate of glass, and placing the mounted blocks upon this, face downwards, to put a quantity of sheets of plate glass on top of them, these are left till the next day, when it will be found that they are firmly attached to the wooden blocks and very level. The typographic images can be easily touched up with a roulette or burnisher for the purpose of bringing out lights or deepening shadows. Thirty-four blocks were done by this method for Vol. II, Part I, of the Indian Museum Notes, and sent to the Government Printing Office to be printed with the text.

"Some further experiments were also tried with the "bitumen-grain" process described in the Annual Report for 1886-87, originally taken from the *Jahrbuch für Photographie and Reproductions Technik* for 1887, as practised at the State Printing Office at Berlin. Very promising results were obtained, as will be seen from the accompanying plate, and with further practice the process may probably be found one of great utility producing more artistic effects than a mechanically ruled plate."

Since my return from furlough, further experiments have been made with good results, using the new ruled screens and thin zinc plates and asphaltum instead of copper and gelatine. Specimens of the results obtained are annexed.

Electrotyping hand-engraved plates has been carried on steadily during the year, the number of plates electrotyped being 26, against 9 of the previous year. The demands for this kind of work have very much increased lately but have been met without difficulty. During the rainy months there has for some years past been a difficulty in avoiding a spongy deposit of the copper, and it was the same last year. This defect appears to be due to the weather, as it re-appears yearly about the same time. The leather diaphragms lose their porous nature to a great extent during the hot and moist part of the year, and seem to become soft and gelatinous.

EXPERIMENTAL AND PERSONAL WORK.—In the early part of the year under review I was fully occupied in working out the process of taking reversed positives direct in the camera, which was brought to notice in my last report. My absence on furlough to Europe for six months has prevented me from going much further into the practical working of the process than was described in last year's report. Professor Reynolds' compound salt of thio-carbamide and ammonium bromide still gives the best results. Some of this salt was prepared for me by Messrs. Hopkin and Williams. It is conveniently soluble in about 100 parts of alcohol, and of this solution about 1·5 to 2 parts may be added to the following developer:—

Eiko nogen	1
Lithia carbonate	1
Soda sulphite	1
Water	100

Very good reversals have also been obtained with a compound of thio-sinamine and ammonium bromide added in small quantity to the above developer.

I obtained some other thio-carbamides from Europe for trial, but owing to delays they did not arrive till just before my departure on leave, and I was unable to try them properly then, nor have I had the opportunity since. Some rough trials that were made showed that ethyl-thio-carbamide might be useful with a very weak eikonogen-lithia developer restrained with bromide, but it produces images of a strong yellow colour. Methyl-thio-carbamide also seemed likely to be useful. Amyl-thio-carbamide seemed to have a very powerful reversing effect, and also to exert a strongly solvent action on silver bromide. Ditolyl-thio-carbamide, though almost insoluble in water, seemed to exercise a very powerful effect on the developer. Although it showed no sign of reversal, the image on an ordinary slow plate with a very short exposure was full of detail and very dense. Some selenium-urea was kindly made up for me by Dr. Schuchardt of Görlitz, and trials made of it in Europe failed to show any reversal. It is possible, however, that the compound had become decomposed by contact with the air.

I have been able to confirm the indications of reversed electro-chemical action during the development of bromide of silver films with eikonogen developers containing thio-carbamides, and with the aid of a more delicate galvanometer obtained from Dr. Edelmann in Munich, I was also able to obtain evidence of electrical currents, in some cases amounting to nearly ·1 volt, generated during the development of ordinary dry plates with various developers. The results actually obtained are somewhat conflicting, because the currents were found to flow in different directions without apparent cause, and further investigation is required to ascertain clearly to what cause the electrical action observed is due, and what connection it has, if any, with the influence of light on the sensitive film.

Some trials were made privately of the new primuline printing process which was brought out in England during the year, but it was found quite unsuitable in its present form for ordinary photographic printing, owing to the strong yellow colour of the ground of the pictures produced by it.

While on furlough in Europe I took the opportunity of obtaining what information I could about various points connected with the office work, chiefly in the direction of copper-plate printing by machinery and the preparation of photo-blocks in half-tones. I visited the Ordnance Survey Office at Southampton, the Military Cartographic Institute at Brussels, the State Printing Office at Berlin, the National Printing Office and the Photographic Section of the Geographical Department of the Ministry of War at Paris, as well as some private firms in London, Berlin, Munich, and Paris. The result of my enquiries as to copper-plate printing machines, made from the best sources of information in London and the Continent, both official and private, was that at present there is no really satisfactory machine of the kind; the one I saw working in the Paris Exhibition of 1889 has not been a success. I was finally recommended to try what is known as a 'D' copper-plate press to be worked by steam. These presses are largely used for bank-note printing, and save a great deal of time and labour in passing the plate through the press, the yield being about one-third more, though the operations of inking and wiping the plates have still to be done by hand. On my recommendation the Secretary of State has ordered one of these presses to be sent out to the Office.

At Southampton I saw a process of cold copper-plate printing on dry paper in use, with the object of ensuring freedom from distortion, and also to permit of colour printing; the hills being engraved on a separate plate and printed in pencil-grey or some lighter tone than the black. A very heavy pressure is, however, required in printing, and a powerful press has been constructed to be worked by a small Willan's steam engine coupled on to it. The paper being printed almost dry, the blankets do not require to be constantly changed and dried, as is the case with wet paper printing. Some samples of fluid copper plate inks, to be used cold, were obtained from Messrs. Shackell and Edwards, and from B. Winstone & Co., and have been found to give very perfect heliogravure prints and to effect a large saving in gas. The heliogravure plate which serves as frontispiece to this report has been printed with cold ink.

At the Military Cartographic Institute in Brussels, I found that the old method of photo-chromo-lithography in vogue at the time of my former visits had been replaced by a process of photozincography known as *topogravure* which has been in use in the Photographic Section of the Ministry of War, Paris, for some years past. The new process is an immense improvement over the old, as is proved by comparing the old editions of sheets of the map of Belgium on the scale of 1 : 40,000 with the new maps reproduced from the same original drawings. The whole of the printing work is now done on thin zinc plates instead of on stones Colonel Hennequin, the Director of the Institute, brought to my notice the advantages of using Japanese paper for printing maps that have to be constantly folded. I ascertained that the paper is imported into England by Messrs. Mitsui and Co. of 1, Crosby Square. E. C., and obtained some samples from them. Though excellent for printing work, the paper has proved quite unsuitable for map drawing with corrections, or for hand colouring, being too soft and absorbent.

Unfortunately, at the time of my visit to Berlin, Professor Roese, the head of the Photo-engraving Department of the State Printing Office, was absent, and so I was not able to see much of the photo-engraving or block processes in use I saw the method of biting the copper-plates for the photo-etching process, which differs from that I learnt in Vienna; in that, instead of a series of baths of perchloride of iron of gradually decreasing strength, a single strong solution is used, and it is diluted with water as required during the progress of the biting in.

The collotype process in use is peculiar, the negative itself being used as the printing plate. The negatives are taken by the ordinary collodion process on plate glass about $\frac{1}{8}$th an inch thick. They are then coated with a solution of—

Gelatine	66 grammes,
Bichromate of ammonia	20 ,,
Liquid ammonia	20 c. c.
Water	1,400 c. c.

and dried in a box after setting. No heat is used for drying, but the drying box is constructed with a ventilating shaft heated by a gas jet. The printing is done with a machine constructed by Koch, of Leipsic which gives about 300 to 400 impressions an hour. A similar process was tried in this office many years ago, but it was difficult to see the subject on the dark surface of the negative, and the process had the usual defects of collotype printing in this country. I did not see any photo-block printing in progress, nor could I obtain any definite information regarding it.

At Munich I visited Dr. Albert, who has a large establishment for heliogravure and collotype. His negatives are all made with his orthochromatic collodio-bromide emulsion process, and were particularly fine. Since my return I have prepared some similar emulsion, after formulæ given by Dr. Jonas of Vienna and it seems likely to be exceedingly useful, if it may not eventually supersede the wet collodion process for all our copying work. Herr Obernetter showed me some very good specimens of his process of photo-engraving which differs from most similar processes, in that the engraved image is obtained

on the copper by electricity. A specially prepared transparency, containing chloride of silver in gelatine, is placed in close contact with the copper-plate, and, under the influence of the electric current, the choride is decomposed and etches the copper in proportion to the quantity in which it is present in different parts of the image.

At the Photographic Section of the Geographical Department of the Ministry of War at Paris I found the processes much the same as on former visits, but great improvements had been made in the topogravure process, and it was largely worked in a practical way. The principal improvement is the preparation of the plates with a solution of gallic acid, composed of—

Gum arabic	250 grammes,
Gallic acid	15 „
Water	1,000 c. c.

When these have been dissolved with heat add—

Phosphoric acid	25 c. c.

This solution is washed off carefully, and the plates are then coated with bitumen by means of a large turn-table. The plate is exposed under a glass positive produced by contact-printing from the negative upon a dry collodion plate. For colour work as many positives are produced as there are colours, and the superfluous details in each are scraped away—a much more satisfactory method than stopping out a negative. After exposure the bitumen image is developed in turpentine and the lines show clear on a brown ground. After being touched up with varnish to cover holes, etc., the plate is etched with weak nitric acid to destroy the gallic acid and gum preparation, which is protected by the bitumen in the exposed parts forming the ultimate whites of the picture. The plate is then rubbed with oil which renders the etched parts of the plate susceptible of taking up ink, while the gummed parts reject it. The bitumen is then removed and the plate is ready to print. A great deal of colour work is done by this process in connection with the new maps of Tunis and Algeria on the scale of 1 : 50,000.

At the National Printing Office there was nothing much doing in the Photographic Section at the time of my visit, and beyond seeing the establishment I gained no information about new processes.

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE.

Abstract of Departmental work done during the year 1890-91.

Specification of Plate or Print.	Sheets or Subjects.	Negatives and transparencies.	Photo-transfer Prints.	Photo-zincographic and Lithographic Printing.							Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Value.	Remarks.
				Zinc Plates transferred.	Zinc Plates printed.	Stones.	Pulls.	Number of Copies.			Pages or items.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Miscellaneous Prints.	Heliogravure Plates.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.		
								Colored.	Uncolored.	Total.												
Departmental Maps and Plans.																					*R a. p.*	
Atlas Sheets	1	...	...	...	...	1	75	...	75	75	...	...	...	...	...	...	...	...	...	...	15 12 0	Six subjects not yet printed.
General Maps	13	3	3	2	52	14	10,628	500	4,878	5,378	...	...	...	...	...	...	...	...	...	...	2,664 1 3	Two ditto ditto.
Provincial Maps	43	77	73	27	25	6	2,836	...	2,928	2,928	...	...	...	...	...	...	...	...	...	...	2,201 7 9	
Divisional Maps	23	26	22	6	2	...	250	...	250	250	...	...	...	...	26	...	...	...	...	...	426 6 0	
District Maps	8	6	6	6	19	11	3,250	...	3,250	3,250	...	...	...	...	...	...	...	...	...	...	2,327 11 0	Seven ditto ditto.
Plans of Cities and Cantonments	49	87	76	19	39	9	3,344	...	2,944	2,944	...	...	...	...	180	...	...	...	...	...	2,605 6 6	
Standard Maps	481	752	842	290	374	13	53,713	...	53,863	53,863	...	...	...	...	1,479	...	...	...	...	...	35,063 1 9	Twenty-four ditto ditto.
Index Maps	41	27	38	42	46	10	22,450	15,550	5,650	21,200	...	...	...	...	155	...	...	...	...	...	1,521 3 3	
Technical Charts	29	34	34	16	14	...	560	...	560	560	...	...	...	...	16	...	...	...	...	...	639 13 9	
Miscellaneous Maps and Plans	450	308	182	73	95	32	33,422	270	41,329	41,599	...	...	...	9	547	...	12	2,134	...	26	10,665 6 0	
Transfers and Proofs	...	...	...	...	...	...	2,715	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Departmental Forms	7	...	...	...	1	12	40,635	...	40,885	40,885	...	...	...	...	...	...	...	...	...	...	6,284 10 0	
Type Printings	...	...	...	...	...	...	...	...	...	...	9,098	1,074,280	581,690	...	...	...	...	...	...	...	16,572 5 6	
Total	1,145	1,320	1,276	481	667	108	173,878	16,320	156,612	172,932	9,098	1,074,280	581,690	9	2,403	...	12	2,134	...	26	80,987 4 9	
Cadastral Maps.																						
North-Western Provinces—																						
Photozincographs	2,140	2,140	2,120	2,110	2,110	...	40,400	...	40,400	40,400	...	...	...	...	...	...	...	...	...	...	132,127 14 6	
Zincographs	168	...	...	168	168	...	3,066	...	3,066	3,066	...	...	...	...	...	...	...	...	...	...	1,278 14 3	
Total	2,308	2,140	2,120	2,278	2,278	...	43,466	...	43,466	43,466	...	...	...	...	...	...	...	...	...	...	33,406 12 9	
Burma—																						
Photozincographs	315	315	318	384	384	...	13,065	...	13,065	13,065	...	...	...	...	...	...	...	...	...	...	5,720 6 6	
Zincographs	580	...	...	580	580	...	20,162	...	20,162	20,162	...	...	...	...	...	...	...	...	...	...	5,256 0 0	
Total	895	315	318	964	964	...	33,227	...	33,227	33,227	...	...	...	...	...	...	...	...	...	...	10,985 6 6	
Assam—																						
Photozincographs	756	756	819	825	825	...	43,725	...	43,725	43,725	...	...	...	...	...	...	...	...	...	...	16,015 5 9	
Zincographs	417	...	...	417	417	...	22,101	...	22,101	22,101	...	...	...	...	...	...	...	...	...	...	5,314 12 0	
Total	1,173	756	819	1,242	1,242	...	65,826	...	65,826	65,826	...	...	...	...	...	...	...	...	...	...	21,330 1 9	
Transfers and Proofs	...	...	...	...	...	...	9,038	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Grand Total	4,376	3,211	3,257	4,484	4,484	...	151,557	...	142,519	142,519	...	...	...	...	...	...	...	...	...	...	65,722 5 0	

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE.

Statement of work done for other Departments, etc., during the year 1890-91.

Departments, etc.	Photo-Zincographic and Lithographic Printing.									Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Value.	Remarks.
	Sheets or subjects.	Negatives and transparencies.	Photo-transfer Prints.	Zinc Plates transferred.	Plates Zinc printed.	Stones.	Pulls.	Number of Copies. Colored.	Uncolored.	Total.	Pages or items.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Miscellaneous Prints.	Heliogravure Prints.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.		
																					R a. p.	
Adjutant General in India	27	13	11	3	5	15	3,540	8,320	1,050	9,370	...	...	...	...	2	...	...	...	...	...	1,428 14 3	
Agent and Chief Engineer, Bengal and N.-W. Railway	8	8	8	4	4	...	400	...	800	800	...	...	...	...	...	...	...	...	...	...	214 14 0	
Agent and Chief Engr., Rohilkund and Kumaun Railway	7	7	7	4	8	...	800	...	1,400	1,400	...	...	...	...	...	...	...	...	...	...	298 5 0	
Assistant Adjutant General, Bangalore District	2	2	2	1	1	...	200	...	200	200	...	...	...	...	...	...	...	...	...	...	66 0 0	
Asiatic Society, Bengal	19	11	6	3	4	...	2,278	...	4,620	4,620	...	...	...	3	1	...	2	1,934	...	...	606 11 3	
Board of Revenue, Bengal	9	...	...	32	31	14	13,449	9,833	...	9,833	...	...	...	...	50	...	...	...	...	...	943 1 9	
,, ,, North-West Provinces	3	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	63 0 0	
Calcutta Municipality	8	10	4	3	2	2	2,000	...	2,000	2,000	...	...	...	3	6	...	3	1,204	...	...	694 10 6	
Chief Commissioner, Burma	3	3	3	1	3	4	1,631	760	186	946	...	...	...	...	...	...	...	...	...	...	442 5 3	
,, ,, Central Provinces	6	8	15	4	4	2	1,140	...	1,140	1,140	...	...	...	...	60	...	...	...	...	...	378 12 0	
,, Engineer, Bengal, Public Works Department	9	27	33	16	18	1	2,210	...	2,470	2,470	...	...	...	...	...	...	...	...	...	...	1,101 10 9	
,, ,, Irrigation Works, Punjab	37	55	55	19	14	3	2,780	...	3,780	3,780	...	...	...	...	...	...	...	...	...	...	1,345 14 6	
,, ,, N.-W. Provinces and Oudh P. W. D.	1	...	...	...	...	1	250	...	250	250	...	...	...	...	...	...	...	...	...	...	253 0 0	
,, ,, Zhob Valley Railway	1	...	...	2	2	2	1,000	500	...	500	...	...	...	...	...	...	...	...	...	...	92 6 0	
Commissioner of Chittagong Division	...	...	...	...	1	...	752	...	752	752	...	...	...	...	...	...	...	...	...	...	22 6 3	
,, of Chota Nagpore	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8 6 6	
,, of Excise, Bengal	6	...	...	...	...	8	3,072	2,304	...	2,304	...	...	...	...	...	...	...	...	...	...	228 10 0	
,, of Excise, Punjab	9	...	...	...	3	9	2,580	1,935	...	1,935	...	...	...	...	...	...	...	...	...	...	201 1 0	
,, of Hyderabad Assigned Districts	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12 9 6	
,, of Police, Calcutta	1	...	...	...	...	2	2,084	...	1,042	1,042	...	...	...	...	...	...	...	...	...	...	121 5 0	
,, of Settlement and Agriculture, Centl. Prov.	4	3	...	...	...	2	4,000	...	4,000	4,000	...	...	...	...	12	...	...	...	...	...	891 15 3	
Commissary-General-in-Chief	24	9	2	...	...	7	2,175	...	7,450	7,450	...	...	...	...	7	...	...	...	...	...	733 0 0	Six subjects not yet printed.
Consulting Engr. to Government of India for Railways	1	...	...	...	...	1	100	...	100	100	...	...	...	...	...	...	...	...	...	...	28 13 0	
Conservator of Forests, Punjab	...	...	...	...	...	...	1,500	300	...	300	...	...	...	...	...	...	...	...	...	...	358 2 0	
Deputy Commissioner, Bilaspur	1	...	...	...	...	1	500	...	500	500	...	...	...	...	...	...	...	...	...	...	124 7 0	
,, ,, Hissar	1	4	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	52 12 9	
,, ,, Mandalay	93	157	157	77	37	...	1,810	...	2,310	2,310	...	...	...	...	...	...	...	...	...	...	2,711 5 9	
,, Post Master General, Assam	1	...	...	...	...	1	120	...	120	120	...	...	...	...	...	...	...	...	...	...	250 0 0	
,, Surgeon-General, Central Provinces	...	...	...	...	1	...	275	...	275	275	...	...	...	...	...	...	...	...	...	...	42 6 0	
Director General of Military Works	25	34	34	12	10	3	1,138	6	1,666	1,672	...	...	...	...	...	...	...	...	...	...	642 10 6	
,, ,, of Ordnance, Western Circle	2	1	...	...	...	1	1,190	...	1,190	1,190	...	...	...	...	3	...	...	...	...	...	47 6 0	Ten subjects not yet printed.
,, ,, of Railways	153	124	125	57	63	41	26,340	1,292	41,606	42,898	...	...	...	...	...	...	...	...	...	...	4,905 10 0	
,, ,, of Telegraphs	136	6	6	5	5	46	23,145	...	54,043	54,043	...	...	...	...	...	...	...	...	...	...	3,040 10 3	
,, of Agriculture, Assam	...	...	...	...	1	...	390	...	260	260	...	...	...	...	...	...	...	...	...	...	20 0 9	
,, of Land Records and Agriculture, Bengal	30	14	4	2	2	3	3,100	500	2,100	2,600	...	...	...	...	65	...	...	...	...	...	390 3 3	
,, of Land Records and Agriculture, Burma	1	...	...	...	...	1	600	...	600	600	...	...	...	...	...	...	...	...	...	...	103 13 0	
,, of Military Education in India	5	...	...	9	3	7	6,550	900	2,950	3,850	...	...	...	...	...	...	...	...	...	...	997 15 6	
,, of Public Instruction, Bengal	4	...	...	...	...	4	2,340	2,340	...	2,340	...	...	...	...	...	...	...	...	...	...	117 6 0	
,, of Geological Survey of India	7	8	4	1	2	4	2,625	415	2,040	2,455	...	...	...	...	...	...	...	...	...	...	608 6 9	
Engineer-in-Chief, Daltongunge Railway	1	...	...	...	...	3	150	50	...	50	...	...	...	36	...	...	1	514	...	...	59 0 0	
,, ,, East Coast Railway	76	141	157	44	38	...	2,687	...	4,157	4,157	...	...	...	...	...	...	...	...	...	...	2,792 11 3	
,, ,, Mogul Sarai, Howrah Railway	2	...	...	...	...	2	150	...	150	150	...	...	...	...	...	...	...	...	...	...	38 0 0	
,, ,, Nagpur City	116	60	60	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	579 9 9	
,, Port Trust, Kidderpur Docks	5	28	28	10	10	...	1,000	...	1,000	1,000	...	...	...	...	...	...	...	...	...	...	652 0 3	
Executive Engineer, Jhansi Division	1	10	10	6	6	...	150	...	150	150	...	...	...	...	...	...	...	...	...	...	232 1 9	
,, ,, Meywar State	...	...	...	...	3	...	4,770	...	4,770	4,770	...	...	...	...	...	...	...	...	...	...	146 2 3	
Financial Commissioner, Burma	10	11	11	4	4	...	400	...	400	400	...	...	...	...	...	...	...	...	...	...	240 15 3	
,, ,, Punjab	2	8	8	2	1	...	100	...	100	100	...	...	...	...	...	...	...	...	...	...	129 3 3	
General Officer Commanding Manipur Field Force	...	...	...	1	1	...	25	...	25	25	...	...	...	...	...	...	...	...	...	...	30 13 9	
,, ,, Secunderabad District	2	3	3	2	2	...	820	...	820	820	...	...	...	...	...	...	...	...	...	...	262 7 9	
General Supdt., Horse-Breeding Operations in India	...	...	...	...	...	3	495	165	...	165	...	...	...	...	...	...	...	...	...	...	197 1 0	One subject not yet printed.
Government of India, R. and A. Department	166	121	8	1	...	21	17,392	4,270	827	5,097	...	...	...	187	40	...	34	22,074	35	...	6,944 3 0	
,, ,, Foreign ,,	29	10	8	2	1	20	584	9	733	742	...	...	...	...	...	...	1	2	...	...	1,220 3 6	Four subjects not yet printed.
,, ,, Financial ,,	1	...	...	...	...	1	300	300	...	300	...	...	...	...	...	...	...	...	...	...	41 11 0	
,, ,, Home ,,	1	...	...	...	...	1	23	...	23	23	...	...	...	...	...	...	...	...	...	...	18 0 0	
,, ,, Military ,,	27	6	6	4	4	9	616	...	1,028	1,028	...	...	...	...	...	...	...	...	...	...	476 10 0	
,, ,, Public Works ,,	20	7	7	4	3	13	6,270	850	520	1,370	...	...	...	...	...	...	...	...	...	...	804 12 6	
,, of Bengal, Public Works ,,	1	...	...	...	...	2	52	20	12	32	...	...	...	...	...	...	...	...	...	...	54 4 6	
,, ,, Judicial ,,	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	420 4 9	
,, ,, Rev. and Genl. ,,	...	...	...	8	14	...	45,494	33,476	...	33,476	...	...	...	269	...	...	3	3	...	...	1,343 1 0	
,, ,, Financial ,,	...	...	...	...	...	...	1,212	909	...	909	...	...	...	6	...	...	...	...	...	...	15 12 0	
,, ,, Marine ,,	2	8	8	6	5	1	1,520	...	2,040	2,040	...	...	...	...	...	...	...	...	...	...	441 3 3	Four subjects not yet printed.
,, N.-W. P. and Oudh, P. W. D.	12	12	22	8	13	...	3,240	...	5,880	5,880	...	...	...	...	...	...	...	...	...	...	818 6 0	Three ditto ditto.
,, Punjab, Public Works Department	86	76	98	28	18	26	9,053	6,400	12,753	19,153	...	...	...	...	16	...	...	...	...	...	3,806 1 0	
,, ,, Revenue Department	1	...	...	...	...	1	550	...	550	550	...	...	...	...	...	...	...	...	...	...	102 9 0	
,, of Madras	...	...	...	...	...	...	...	...	...	...	...	...	...	66	...	...	...	...	...	...	125 1 6	
,, of Mysore	25	15	...	...	...	...	...	...	...	...	...	...	...	...	24	...	...	...	...	...	111 14 6	
,, Epigraphist, Madras	4	3	4	2	2	...	1,310	...	1,965	1,965	...	...	...	...	...	...	1	706	...	...	393 7 6	
Indian Museum	...	...	...	...	...	...	...	...	...	...	...	...	...	178	...	...	...	...	...	...	115 12 9	
Inspector-General of Artillery	9	...	...	...	...	1	1,000	...	9,000	9,000	...	...	...	...	...	...	...	...	...	...	216 9 0	
,, Ordnance	2	...	...	...	...	3	18	6	6	12	...	...	...	...	...	...	...	...	...	...	291 11 0	
,, Police, Calcutta	4	...	...	...	...	4	1,500	1,500	...	1,500	...	...	...	...	...	...	...	...	...	...	115 2 0	
Leprosy Commissioner	10	2	11	...	...	11	2,539	945	328	1,273	...	...	...	...	...	...	...	...	...	...	295 8 9	Two subjects not yet printed.
Meteorological Reporter, Government of India	45	...	...	4	8	40	62,715	8,300	58,250	66,550	...	...	...	...	...	...	...	...	...	...	2,704 15 6	Eleven ditto ditto.
,, ,, Bengal	4	...	...	1	...	5	18,249	16	18,225	18,241	...	...	...	...	...	...	...	...	...	...	279 0 6	
Municipal Board, Benares	5	20	20	5	5	...	500	...	500	500	...	...	...	...	...	...	...	...	...	...	391 0 0	
Natural History Society, Bombay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	96 0 0	
Officer Commanding Punjab Frontier Force	2	...	...	...	...	2	152	...	152	152	...	...	...	...	...	...	...	800	...	...	326 0 0	
,, ,, Sirhind District	2	2	2	1	1	1	200	...	200	200	...	...	...	...	...	...	...	...	...	...	121 0 6	
,, ,, Nerbudda District	1	5	5	3	3	1	295	...	295	295	...	...	...	...	...	...	...	...	...	...	188 7 0	
Photographic Society of India	5	6	1	3	3	...	2,060	...	2,060	2,060	...	...	...	...	...	...	...	...	...	...	474 15 6	
Port Commissioners, Calcutta	1	1	1	1	1	...	100	...	100	100	...	...	...	...	...	...	9	3,462	...	...	43 10 0	
Port Officer and Registrar of Wrecks	4	1	1	1	...	4	650	125	275	400	...	...	...	...	...	...	...	...	...	...	176 6 6	
Private Secretary to the Viceroy	...	...	...	...	1	...	85	...	85	85	...	...	...	...	...	...	...	...	...	...	22 9 3	
Carried over	1,332	1,074	960	418	371	360	306,490	86,746	268,279	355,025	...	...	...	748	286	...	54	30,699	35	...	53,103 6 9	

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE.

Statement of work done for other Departments, etc., during the year 1890-91—concluded.

Departments, etc.	Photo-Zincographic and Lithographic Printing.									Type Printing.			Silver and other Printing.			Heliogravure and Electrotyping.				Value.	Remarks.
	Sheets or subjects.	Negatives and transparencies.	Photo-transfer prints.	Zinc Plates transferred.	Zinc Plates printed.	Stones.	Pulls.	Number of Copies. Colored.	Uncolored.	Total.	Pages or items.	Pulls.	Copies.	Silver Prints.	Blue Prints.	Miscellaneous Prints.	Heliogravure Plates.	Heliogravure Prints.	Photo. Blocks.	Electrotypes.		
																					R a. p.	
Brought forward	1,332	1,074	960	418	371	360	306,490	86,746	268,279	355,025	...	...	...	748	286	...	54	30,699	35	...	53,103 6 9	
Private Secy. to Lieut.-Governor of N.-W. P. and Oudh	1	...	...	...	...	2	350	175	...	175	...	...	...	...	...	...	...	...	...	...	179 1 0	
President, Municipal Committee, Naini Tal	5	5	5	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	62 6 6	
Principal, Civil Engineering College, Seebpore	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	76	...	...	57 9 6	
,, Medical Store-keeper to Government	1	1	1	1	1	...	104	...	104	104	...	...	...	...	...	...	...	...	...	...	14 1 6	
Quarter-Master-General	58	58	57	38	63	24	12,071	1,820	13,119	14,939	...	...	...	...	1	...	...	...	...	...	3,327 4 3	Two subjects not yet printed.
Resident, Hyderabad Assigned Districts	...	...	...	...	...	1	20	...	20	20	...	...	...	...	...	...	...	...	...	...	1 14 0	
Sanitary Commissioner, Assam	...	...	4	2	2	...	500	...	250	250	...	...	...	...	...	...	...	...	...	...	89 8 0	
,, Bengal	6	...	...	2	2	7	4,946	3,060	1,274	4,334	...	...	...	...	...	...	...	...	...	...	463 6 3	
,, India	9	6	...	...	...	4	1,270	...	1,570	1,570	...	...	...	...	...	...	3	706	...	...	510 13 0	
,, Hyderabad Assigned Districts	2	1	1	...	...	1	200	...	200	200	...	...	...	...	...	...	...	...	...	...	19 13 0	
Secretary to Lady Dufferin's Fund	1	...	1	...	...	2	3,030	1,515	...	1,515	...	...	...	...	...	...	...	...	...	...	88 5 6	
Superintendent, Carriage and Wagons, B.B. and C. I. Ry	2	2	2	2	1	...	500	...	500	500	...	...	...	...	...	...	...	...	...	...	80 2 9	
,, Emigration, Calcutta	4	...	...	...	...	8	2,308	1,154	...	1,154	...	...	...	...	...	...	...	...	...	...	214 0 0	
,, Forest Surveys	1	...	...	...	...	5	50	10	...	10	...	...	...	...	...	...	...	...	...	...	20 0 0	
,, Government Printing, India	49	2	2	3	5	26	18,452	...	26,369	26,369	...	...	...	...	...	...	...	...	...	...	1,316 5 6	
,, Opium Agency	1	...	...	...	...	1	6	...	6	6	...	...	...	...	...	...	...	...	...	...	3 0 0	
,, Presidency Jail	3	...	...	1	1	3	1,000	...	1,000	1,000	...	...	...	...	...	...	...	...	...	...	73 14 9	
,, Stationery, Calcutta	13	...	...	...	...	13	9,600	...	9,600	9,600	...	...	...	...	...	...	...	...	...	...	604 4 0	
,, Telegraph Stores	46	3	3	...	...	6	3,000	...	11,500	11,500	...	...	...	...	...	...	...	...	...	...	442 11 6	
,, Zoological Gardens	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	400	...	...	120 0 0	
Special work done for Trade and Private Individuals	11	10	10	8	14	2	22,646	...	16,646	16,646	...	...	...	348	1	...	...	...	...	...	1,152 3 3	
Total	1,546	1,163	1,046	476	460	465	386,543	94,480	350,437	444,917	...	...	...	1,096	288	...	58	31,881	35	...	61,944 3 0	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE A.

Detail of issues to, and receipts from, Provinces and Departments during the financial year 1890–91.

Provinces and Departments.	RECEIPTS.	ISSUES.	DEBITS.	CREDITS.
	Value.	Value.	Value.	Value.
	₹	₹	₹	₹
Archæological Survey	...	70	70	
Assam	131	4,035	3,904	
Bengal, Civil	19,023	39,411	20,388	
,, Military	5,813	15,532	9,719	
Berar	...	555	555	
Bombay, Civil	50	3,030	2,980	
,, Military	61	1,095	1,034	
Burma	8,623	37,121	28,498	
Central India	1,325	2,665	1,340	
Central Provinces	...	6,800	6,800	
Forests	720	6,463	5,743	
Geological Survey and Museums	299	1,127	828	
Guaranteed Railways, E. I. Railway	...	284	284	
,, ,, Rajputana-Malwa Railway	...	158	158	
Land Revenue	691	3,252	2,561	
Law and Justice (Port Blair)	...	8	8	
Madras, Civil	1,581	17,305	15,724	
,, Military	3,053	1,930	...	1,123
Marine	726	1,085	359	
Medical	...	41	41	
Meteorological	268	1,913	1,645	
Mint	757	56	...	701
Military Works	339	7,399	7,060	
N.-W. Provinces and Oudh	11,423	10,383	...	1,040
Native States, Jaipur	1,097	1,006	...	91
,, ,, Ulwar	...	124	124	
P. W. D., N.-W. State Railway	860	2,526	1,666	
P. W. D., Coorg	...	270	270	
P. W. D., Baluchistan Railway Branch	957	22,458	21,501	
P. W. D., Baluchistan Ordinary Branch	149	1,520	1,371	
P. W. D., Hyderabad	...	5,680	5,680	
P. W. D., Rajputana and Central India	...	267	267	
P. W. D., Sind-Pishin State Railway	...	10	10	
Perso-Afghan Frontier (Khorassan)	...	829	829	
Political	...	372	372	
Post Office	...	4	4	
Punjab	7,625	26,252	18,627	
Secretariats, Government of India	1,557	8,660	7,103	
Survey of India	17,422	52,541	35,119	
Telegraph	116	585	469	
TOTAL	84,666	2,84,822	2,03,111	2,955
NET DEBIT	...	...	2,00,156	

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B.

Instruments, etc., purchased in the local market during 1890-91.

Instruments.	Number.	Value. R	Value. a.
Barometers, aneroid, large	9	634	1
" " pocket	8	481	14
" " Watkins'	5	569	10
Boards, drawing, deal, large	2	24	0
Callipers, micrometer, small, parallel jaw	1	258	12
Clinometers, Watkins' pattern	12	226	8
Chain, measuring, iron, 30 feet	16	64	0
" " 66 "	50	256	0
" " 100 "	55	495	0
Compasses, beam, plain, 2 "	1	31	8
" " 3 "	1	21	11
" " with adjustment, 2 feet	4	144	0
" " " " 2½ "	6	224	4
" bow divider, electrum spring	2	4	0
" bow pens " "	6	62	4
" bow pencils, " " single jointed	1	3	8
" " " " spring	1	2	0
" bow, sets	1	5	2
" drawing, common, brass, 5-inch	966	1,025	12
" " " " 6 "	2	2	9
" " hair, " 5 "	1	3	4
" " common, electrum, 5-inch	2	2	9
" " " " 6 "	1	2	8
" " hair " 5 "	28	105	0
" magnetic, pocket, in brass cases	19	222	12
" " " " electrum, cases	19	363	0
" prismatic, card, 2½-inch	1	25	0
" " S. R., 2½ "	1	47	0
" " " 5 " and 6-inch	3	343	8
" " " 4½ "	1	94	0
" proportional, brass, 6-inch	18	204	8
" " electrum, 6 "	7	142	14
" " " 9 "	10	347	10
" triangular	2	94	8
Curves, French, large, set	1	4	0
" railway or circular, small, set	1	12	8
" " " wooden, sets, large and small	4	179	5
Declinometers	7	123	13
Glasses, binocular, large	1	27	9
" " small	5	201	11
" copying or tracing	13	208	0
Girder testers	2	100	0
Glasses, time	2	9	0
Hydrometers with brass floats	80	3,182	5
" " glass "	20	324	12
Hygrometers, Masons'	1	9	14
Ghât tracers	16	770	15
Instruments, drawing, mathematical, electrum, 1st sort	12	794	4
" " " " 2nd "	3	85	2
" " " " 3rd "	28	515	15
" " " in fish skin cases	3	112	0
Lenses, reading, ½-inch and 1-inch	100	50	0
" " 2½ "	6	11	13
" " 3 " and 3½-inch	12	32	4
" " 4 "	6	21	6
Levels, field service	5	100	0
" reflecting, Abney's	1	23	10
" reversible, 12-inch	2	441	0
Machine, map printing, Ordnance pattern	6	255	0
Carried over	1,599	14,130	10

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B—*continued.*

Instruments, etc., purchased in the local market.

	Number.	Value.
		£ a.
Instruments—continued.		
Brought forward	1,599	14,130 10
Magnets, horse-shoe, 3-inch	6	2 4
" " " 6 "	5	7 8
Pens, drawing, common, ivory handles	226	407 8
Pins for maps, brass	1,649	87 9
" " electrum	2,052	158 5
Plane-tables, deal	16	153 8
Planimeters, electrum	2	87 8
Protractors, circular, cardboard, 5-inch	16	4 0
" plain, circular, brass, 6 "	1	7 14
" " " " 9 "	1	14 10
" with adjustment, semi-circular, brass, 6-inch	2	63 6
" rectangular electrum, 6-inch	15	108 9
" " ivory, 6-inch	41	145 7
" " woooden, 6-inch	14	21 8
Pins for chains, common pattern	3 860	289 6
Rules, carpenters', boxwood, 2 feet, 2 fold	2	2 4
" " " 2 " 4 "	50	46 1
" flat, ebonite, 6-inch	1	0 14
" " " 1 "	265	174 2
" " " 1½ "	1	1 8
" parallel, bar, wooden, 6-inch	51	38 0
" " " " 12 "	1	1 0
" " " " 18 "	1	1 8
" " on rollers, brass, 12-inch	10	141 15
" " " " 18 "	1	23 10
" " " electrum, 12-inch	1	23 10
" " " " 18 "	1	31 8
" sight, wooden	275	825 0
Scales, architects', boxwood, sets	17	246 14
" " " single	60	168 12
" " ivory, sets	1	47 4
" " " single	3	47 7
" diagonal, wooden	1,700	587 8
" engineering, cardboard, single	84	89 4
" Marquois, sets, wooden	8	44 0
" offsets, single, ivory and slips	1,632	408 0
" " " wooden	376	148 6
" plotting, sets, ebonite	5	101 4
" " " wooden	1	14 7
" " single, "	342	496 1
Sectioner, dead beat, Macginniss's	3	18 0
Sheets, celluloid	1,000	187 8
Slopes and batters, ebonite, single	14	12 4
Squares, optical	356	2,314 0
" sets, ebonite, sets	12	88 14
" " " single	38	37 0
" " wooden "	12	3 5
Sun-dials	4	80 0
Stands for levels, 12-inch	2	90 0
" " prismatic compasses	6	89 3
" " plane-tables, survey pattern	533	3,884 0
Stencil plates	46	67 5
T. squares, wooden, of sizes	6	34 8
Tapes, measuring, metallic, 25 feet and 33 feet	84	263 13
" " " 50 "	60	255 4
" " " 66 "	1	3 15
" " " 24 "	13	48 12
" " " 100 "	75	542 14
Carried over	15,060	27,420 4

MATHEMATICAL INSTRUMENT OFFICE.

TABLE B—*concluded.*

Instruments, etc., purchased in the local market.

	Number.	Value.
		£ a.
Instruments—concluded.		
Brought forward	15,060	27,420 4
Tapes, measuring, steel, pocket, and others	62	860 10
Thermometers, spare, for hypsometers	12	99 12
„ clinical	12	60 15
„ maximum and minimum on same board, 9-inch	1	16 0
„ spare, for Syke's hydrometers	36	64 14
Watches, common	6	69 0
„ stop	2	150 0
Umbrellas, surveying	47	809 12
TOTAL	16,837	29,551 3
Books.		
Hints to Travellers	10	50 0
Manual of Surveying	2	24 0
Nautical Almanacs	179	270 4
Practical Physics	1	4 4
Tables for Barometrical Height, Mackesy	24	48 0
„ for Hydrometers, Casellas'	13	41 0
„ Log., Chambers'	24	66 0
Instructions for the use of Edmondson's Arithmometers	6	2 10
Tables, Log., Shortredes', with sines and tangents	25	500 0
Bruhn's Manual of Logarithms	16	57 9
Physical Optics	1	4 3
TOTAL	301	1,067 14
Sundries.		
Box for drawing instruments	1	2 8
Cards for marine compasses, mounted	1	9 0
Cases, leather	7	21 8
Canvas bags, waterproof lined	134	588 10
Glass ink bottles	24	3 2
„ jars for hydrometers	332	282 12
„ bottles for hygrometers	10	5 0
Havresacks	10	13 2
Horns, centre	24	4 0
Numbers for chain, iron, sets	2,000	562 8
Pencils, lead, for instruments	23	22 14
Telescopes for Watkins' range-finder	6	44 10
Trunks, mule, leather	6	87 0
Boxes for standard yard	62	62 0
Upper and lower cases for keeping type	2	10 0
Green umbrella covers	49	102 10
Rope, manilla	1,050	10 8
Water-gauge glasses	12	3 0
India-rubber rings	24	1 8
Screen for office	1	30 0
Opal glass reflector for Fortins' backboards	12	9 12
Excise ink bottles	12	1 12
Steel shots, $\frac{3}{10}$-inch	50	3 14
Brushes, stencils, medium size	21	7 3
Knives for instrument boxes	51	42 10
TOTAL	3,924	1,931 7
TOTAL OF BOOKS	301	1 067 14
TOTAL OF INSTRUMENTS	16,837	29,551 3
SUM TOTAL	21,062	32,550 8

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C.

Instruments, etc., manufactured in the Mathematical Instrument Office during 1890-91.

	Number.	Value.
		£ a.
Instruments.		
Boards, drawing, deal, large	27	320 0
,, ,, ,, small	4	15 0
Chains, measuring, iron, 33 feet	7	15 12
,, ,, ,, 50 ,,	1	3 0
,, ,, ,, 66 ,,	1,087	3,657 0
,, ,, ,, 100 ,,	53	455 8
,, ,, steel	18	156 0
,, ,, other sizes and sorts	4	23 0
Clinometers, with hill shading scales and plummets	29	73 0
,, survey pattern	18	540 0
Combs, acre, cardboard	4,611	1,729 2
Compasses, magnetic, for plane-tables, 5-inch needles	130	1,585 0
,, ,, ,, ,, 6 ,, ,,	191	2,657 0
Glasses, copying or tracing	17	707 0
Girder testers	4	200 0
Hold-alls	36	633 0
Horizons, dark glass, plain	1	45 0
Level reflecting, Abney's	3	75 0
Machines, map printing, Ordnance pattern	6	315 0
Plane-tables, deal	397	2,865 8
,, ,, ,, military pattern	30	120 0
Pluviometers, Symon's pattern	200	1,606 0
Protractors, circular, cardboard, 12-inch	96	120 0
,, ,, ,, ,, 5 ,,	306	76 8
Pins for chains, common pattern	1,900	116 8
,, ,, Revenue Survey pattern	180	22 8
Rods, measuring, wooden	200	365 12
Rule, flat, ebonite, 1 foot	2	1 8
,, ,, wooden, 1 ,,	200	37 8
,, parallel on rollers, brass, 18-inch	12	420 0
,, sight, wooden	37	341 0
,, ,, brass, military	35	594 0
Scales, Bengali, metal	1	4 0
,, diagonal, cardboard	3,359	1,220 2
,, engineering, cardboard, single	1,295	249 1
,, offsets, sets, metal	1	6 0
,, ,, ,, wooden	40	7 8
,, ,, single, cardboard	1,512	203 6
,, ,, ,, ivory and slips	125	46 14
,, ,, ,, wooden	402	109 12
,, plotting, single, wooden	3	4 2
Staves, cross or offsets	24	120 0
,, for omnimeters	18	450 0
,, ,, subtense theodolites and compasses	9	225 0
,, levelling, telescopic, other pattern	1	20 0
Stamps for conventional signs and type-holders	12	80 0
Stands for plane-tables, survey pattern	44	734 0
Stencil plates	155	222 14
Yard, standard	251	1,255 0
TOTAL	17,100	24,848 13
Sundries.		
Boxes and cases, block tin and tin	5	15 0
,, deal-wood	2	5 0
Cases, leather	1	2
Carried over	8	22 4

MATHEMATICAL INSTRUMENT OFFICE.

TABLE C—*concluded.*

Instruments, etc., manufactured in the Mathematical Instrument Office during 1890-91.

	Number.	Value. R	Value. a.
Sundries—continued.			
Brought forward	8	22	4
Canvas bag, waterproof lined	8	35	8
Gauges writing	42	84	0
Glasses for pluviometers	164	395	8
Havresacks	7	13	4
Plummets, brass	54	137	0
Clamping screws for plane-tables	5	12	8
Squares, acre, horn	995	186	9
Traverse indicators	31	77	8
Water-gauge glasses	12	4	8
Packing rings for glasses	24	2	0
Cabinet stands for standard yard	2	60	0
Box, spare	1	2	8
Table	1	32	0
Steel punch	1	3	0
Seismoscope	1	32	0
Brass tube	1	3	8
Blanks for type	12	2	4
Screw-drivers	4	6	0
Talc square	1	0	3
Brass painter	1	2	8
Talc square, Bigah	200	28	0
Polariscope, circle, with stand	1	50	0
Box for stencil plates	1	2	0
Component parts of subtense staves	sets 4	80	0
Tin cases for plans	4	6	0
Boxes for scales	10	10	0
Pins for levels	16	3	0
Box for sight rules	1	1	0
Backboards for barometers	12	90	0
Zinc tickets for *khalásis*	166	7	12
Box for scale	1	1	0
Newar straps for boxes	2	3	0
Tin tube	1	0	12
Clasp for telescope	1	16	0
Camera lucida for telescope	1	10	0
Box, teakwood, for rule sight	1	1	8
Box, dealwood, with hinges and hasps	1	3	0
Surveyors' table, deal	1	20	0
Covers for umbrellas	3	6	0
Boxes for rule sight	2	2	0
Instrument for measuring Barograph scale	1	50	0
Zinc bottle for 5-inch Rain-gauge	1	2	0
Tin tube	2	3	0
Height Indicators	50	22	8
	50	25	0
Scales for Tide gauges	2	36	0
Wooden handles for rubber stamps	55	16	0
Scale attachment to Theodolite	1	107	6
Bubble spirit, 2-inch, mounted	1	3	8
Scale for testing Rain-gauge	2	11	0
TOTAL	1,969	1,731	14
TOTAL OF INSTRUMENTS	17,100	24,848	13
SUM TOTAL	19 069	26,580	11

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D.

List of principal Instruments repaired in Workshop during the financial year 1890-91.

	Number.
Anemometers	27
Arithmometer	1
Bar lengthening	1
Barometers, of sorts	71
Board, drawing	1
Cases, sketching, leather	2
Chains, of sorts	48
Chronographs	5
Chronometers, of sorts	3
Chrono-micrometers	2
Circular calculating machine, Edmondson's	2
Clinometers, of sorts	20
Clocks, of sorts	3
Combs, acre	2
Compasses, bow dividers, spring, of sorts	4
„ „ pen, of sorts	52
„ „ pencil, of sorts	6
„ „ set	1
„ beam	3
„ drawing, of sorts	194
„ marine	9
„ magnetic, pocket	8
„ pillar	1
„ "Pelorus"	1
„ prismatic, of sorts	75
„ proportional	4
„ rectangular, of sorts	47
„ surveying, of sorts	64
Ghât tracer, with stand	1
Glasses, binocular	36
„ tracing	2
Hand-printing presses	8
Heliographs	44
Heliotropes	4
Hold-alls, leather	7
Hydrometers	117
Hygrometers	2
Instruments, drawing, mathematical, of sorts	45
Lamps, bull's-eye	1
Lenses, reading, of sorts	8
Levels, of sorts	89
„ reflecting	2
„ spirit	9
Machines, map printing, of sorts	4
Magnet bar	1
Microscopes	12
Pedometers	3
Pens, drawing, of sorts	115
Pencil legs, of sorts	3
Pentagraphs, of sorts	5
Pins for chains	230
Plane-tables, of sorts	4
Planimeters, of sorts	11
Pointers, station	2
Protractors, of sorts	9
Quadrant, gunners'	8
Quintant sounding	12
Rain-gauge, of sorts	25
Range-finders, of sorts	52
Recorders	2
Rules, of sorts	24
„ sight, for plane-tables, of sorts	48
Carried over	1,602

MATHEMATICAL INSTRUMENT OFFICE.

TABLE D—*concluded.*

List of principal Instruments repaired in Workshop during the financial year 1890-91.

	Number.
Brought forward	1,602
Scales, of sorts	3
Scotts' telescopic sights	10
Sextants, of sorts	6
Squares, optical	74
Stands of compasses, of sorts	33
,, heliographs	21
,, levels, of sorts	51
,, plane-tables	3
,, range-finders	5
,, theodolites	54
,, telescope	1
Station pointer	1
Staves, levelling, of sorts	79
Tapes, of sorts	270
Telescopes, of sorts	58
Theodolites, of sorts	120
Thermometers, of sorts	38
,, for hydrometers	22
,, for hygrometers	18
Tide-gauge, measuring apparatus	1
Watches, of sorts	3
TOTAL OF PRINCIPAL INSTRUMENTS REPAIRED	2,473
MINOR INSTRUMENTS REPAIRED	1,092
TOTAL OF ALL INSTRUMENTS REPAIRED	3,565

Profit and Loss account of the Workshop for the financial year 1890-91.

DEBITS.	R	a.	CREDITS.	R	a.
Workshop Establishment, less proportion debitable to the store branch for cleaning and adjusting serviceable instruments	36,767	3	By repairs for public officers	17,145	9
One-third of office establishment	2,416	13	,, ,, for stock	22,770	6
Pay of Material Store-keeper for the whole year	780	0			
Workshop contingencies as distinguished from materials purchased	4,034	5	,, manufactures for stock—		
			Instruments	26,400	11
			Packing cases	1,412	2
Value of materials—					
For special work	26,815	13	Manufactures of materials	2,994	0
,, general workshop use					
,, manufacture of packing cases			Work on payment	1,346	3
Paid for repairs	11	6			
Wear and tear of plant	1,414	10	Loss	8,021	10
Half of rent at R600 per mensem	3,600	0			
Printing and stationery	576	7			
Four per cent. on value of tools and plant amounting to R91,849	3,674	0			
TOTAL	80,090	9	TOTAL	80,090	9

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Extract from the Narrative Report of MR. J. ECCLES, M.A., *in charge Computing Party, Season 1890-91.*

Lieutenant J. M. Burn, R.E., was appointed to do duty in this office on 10th May 1891, and was transferred on 30th September 1891 to No. 24 Party. Three temporary computers resigned during the year, and their places were filled by the appointment of new hands. One pressman for the Printing Section was appointed to work the large press received from Calcutta

The cost of the Computing Section under its various class-heads, and the percentages hereof with those of the two prior years, are given in the following statement :—

Class.	Cost in Rupees.	Percentage of Cost.		
	1890-91.	1890-91.	1889-90.	1888-89.
1. Records, Library	1,232	3	4	4
2. Accounts, returns, correspondence	2,226	5	5	3
3. Supply of data, &c.	475	1	2	4
4. Computations	10,176			
5. Preparation of press copy	13,880	74	71	69
6. Examination of press proofs	8,176			
7. Ditto of charts	1,936	4	1	1
8. Protection of stations	434	1	2	2
9. Miscellaneous	3,844	9	11	13
10. Meteorology and general science	658	2	2	3
11. Extra-departmental work	325	1	2	1
	43,362	100	100	100

It will be noticed that the percentages for classes 4, 5 and 6 contrast very favourably with those for the two preceding years, showing thereby that the working power of this section has been increased in its primary duties, that is, in the final reduction and publication of the results of the operations of the trigonometrical survey.

The following is an account of the work done under the various classes shown in the foregoing table :—

CLASS 1 ; RECORDS, LIBRARY, ETC.—The records have received the same care and attention as heretofore, and during the year five instalments have been received from field parties. There is nothing to add to the statement in last report regarding the work in connection with the Library, except that three copies of the catalogue have been kept up to date, each new work or periodical being entered by hand.

CLASS 2 ; ACCOUNTS, RETURNS, AND CORRESPONDENCE.—Under this head are included indents, estimates, monthly detailed and abstract progress reports, stock returns of ordnance stores, the compilation of data for the annual report, and various other items.

CLASS 3 ; SUPPLY OF DATA.—Requisitions from officers for data of various kinds have been complied with. In this class is also included the work in the despatch of maps, charts, books and forms.

CLASS 4 ; COMPUTATIONS.—These are given below in detail, but the computers' time has chiefly been taken up with the final reduction of the secondary work of the Southern Trigon, including Colonel Lambton's triangulation. The calculations were mostly of an intricate nature on account of the entanglement in very many places between the new and the old work, and it became a matter of considerable anxiety at one time to provide work for the Printing Section, as no press copy could be got ready without first completing the reduction; but by sub-dividing each section, and by judicious arrangement, this difficulty was obviated. The progress of the work is as follows :—

(1) The Mangalore Meridional series, finished.
(2) The South-East Coast series, finished.
(3) The Bombay Longitudinal series, finished.
(4) The Madras Meridional and Coast series, finished.
(5) The Madras Longitudinal series } about three-fourths completed.
(6) The Great Arc series . . }

A small catalogue, showing star-places, as deduced from the Latitude and Longitude observations of this Department, is in hand ; two computers have been engaged on this work for four months.

The following help was afforded to field parties :—

Two computers were lent for three weeks to the Astronomical parties for the reduction of latitude observations of season 1890-91. Two computers were engaged for one month in preparing data for the survey officer who accompanied the Hazara Field Force. Two computers were engaged for one month in certain calculations in connection with Mr. Wainright's triangulation of season 1890-91 in Baluchistan, and that executed previously by Mr. Claudius.

Spirit-levelled heights for pamphlet No. 5, Bombay Presidency, and for No. 6, Madras Presidency, were revised.

The remaining work under this class was of a miscellaneous character.

CLASS 5; PREPARATION OF PRESS COPY.—This consists in abstracting and compiling the final results of the various calculations in a suitable form for publication: the copy so compiled is compared twice, both against the original field records and the final calculations before being sent to the press. The details of the work are as follows:—

(*a*) *South-West Quadrilateral.*—The descriptions of the principal stations of the Singi Meridional series were finally revised for the press, thus completing the remaining portion of Part II of Professional Volume XIV. The secondary triangulation belonging to the Quadrilateral could not be taken in hand on account of similar work of the Southern Trigon, which was urgently required to give work to the Printing Section.

(*b*) *Southern Trigon.*—Very considerable progress has been made with the compilation and comparison of the several tabular statements to be embodied in the Synoptical volumes. All those appertaining to the Mangalore Meridional and South-East Coast series have been entirely completed and passed for the press, and those for the Bombay Longitudinal, Madras Longitudinal and Madras Meridional and Coast series are well advanced. There only remains the Great Arc series, which cannot be taken in hand at present, the calculations being still incomplete.

(*c*) Letter-press for the preliminary chart of the Mandalay Meridional series, and for charts Nos. 56, 57, and 58 of the Burma Coast Triangulation, season 1889-90, has been revised and completed.

(*d*) The pamphlets of spirit-levelled heights, No. 5, Bombay Presidency and No. 6, Madras Presidency, were passed through the press.

(*e*) *Hand-Books of the Trigonometrical and Topographical Branches.*—The remaining portions of these two books were prepared, revised, and passed through the press.

(*f*) *Synoptical Volume XXII (Preliminary Issue).*—The co-ordinate list, pages 73 to 121, was revised: the preface, table of contents, errata, etc., were prepared and passed for the press.

(*g*) *Electro-Telegraphic Longitude.*—Two hundred and twenty pages containing observations and results of seasons 1885-86, 1887-88, and 1889-90 were examined and passed for the press.

(*h*) *Tidal Volume.*—A few chapters of the introduction have been compiled.

(*i*) *Burma Coast series.*—The alphabetical and numerical lists containing 142 principal stations have been prepared, and the observed angles at 20 stations arranged and numbered for printing: this had to be taken in hand to feed the presses which were running short of work.

CLASS 6; EXAMINATION OF PRESS PROOFS.—This consists in passing proofs, all requiring the utmost care in examination and comparison in the three stages of *first*, *second*, and *form* proof. As most of the matter printed is numerical or depends on numerical data, the examination can only be made by men who have been specially trained to this branch of the work.

The following works have been completed during the year:—

(1) Professional Volume XIV.
(2) Synoptical Volume XXII.
(3) ,, ,, XXIII.
(4) ,, ,, XXIV.
(5) Hand-book of the Trigonometrical Branch.
(6) ,, ,, Topographical Branch.
(7) Pamphlet of Spirit-levelled heights, No. 5, Bombay Presidency.
(8) ,, ,, ,, No. 6, Madras Presidency.
(9) Two exploration reports (reprint).

Nos. 1, 5, 6, 7, 8, and one of 9 have been bound and issued, and the others are in the hands of the binder, and will shortly be ready for issue.

CLASS 7; EXAMINATION OF CHARTS.—The following charts were examined and passed for the press:—

(1) Preliminary chart, Mandalay Meridional series
(2) Three preliminary charts of Bombay Coast Triangulation
} Season 1889-90.
(3) Final charts for Synoptical Volumes XXII, XXIII, and XXIV.
(4) Two Level charts for Pamphlets of spirit-levelled heights.

In addition four rough working charts for Synoptical volumes of the Bombay and Madras Longitudinal series were prepared, without which the compilation of the tabular details of these volumes would have been very materially delayed.

CLASS 8; PROTECTION OF STATIONS.—The usual professional aid in connection with the protection of survey stations has been rendered by the Computing Section to the office of the Deputy Surveyor General. During the year 416 stations have been repaired by District Officers at a cost of ₹1,448-14-6. Twenty-eight districts out of 334 from which reports are due failed to submit them.

CLASS 9; MISCELLANEOUS.—In this class are included various duties which cannot fairly be assigned to any of the other classes, such as the following:—

(*a*) the taking and reducing of time observations at Mussooree and giving the signal for the 12 o'clock gun;

(*b*) the preparation of examination papers for the Senior and Junior Divisions of the Survey of India Department, and the examination of 33 sets of such papers, one being for the Senior Division;

(*c*) the examination and despatch of printed papers to the Survey of India Office for safe custody, and of printed pages of Professional and Synoptical volumes to Roorkee and Calcutta for binding, etc., etc.

CLASS 10; METEOROLOGY AND GENERAL SCIENCE.—A complete set of meteorological observations was taken daily throughout the year, and monthly abstracts prepared. The results are given in the following statements.

CLASS 11; EXTRA-DEPARTMENTAL WORK.—Two computers were engaged for two months for the Quarter Master General's Department in reducing astronomical, barometrical, and hypsometrical observations taken in Persia and elsewhere.

MEAN MONTHLY READINGS OF EARTH THERMOMETERS.

Depth in feet of Thermometer bulbs below surface of ground.	YEAR.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
25·6	1890-91	77·42	77·26	77·04	76·68	76·08	75·42	74·70	74·26	74·16	74·25	74·70	75·47
	Mean 1881—90	76·73	76·83	76·60	75·83	75·25	74·66	74·19	74·00	73·99	74·33	75·40	76·51
12·8	1890-91	79·96	78·81	76·91	74·72	72·71	71·05	70·72	72·19	74·40	76·36	77·84	78·72
	Mean 1881—90	79·39	77·83	75·32	72·59	71·00	70·54	71·40	73·20	75·24	77·10	79·07	79·68
6·4	1890-91	79·58	75·87	71·73	68·10	65·61	65·60	69·38	75·33	79·21	81·56	81·03	80·78
	Mean 1881—90	79·72	75·60	70·86	66·97	65·41	67·44	71·74	76·70	80·06	81·11	81·36	81·24
3·2	1890-91	77·47	70·97	65·60	62·13	59·96	63·35	72·61	80·08	84·13	84·36	81·62	81·27
	Mean 1881—90	78·28	71·66	65·43	61·81	61·35	67·16	75·42	81·55	84·62	83·17	82·16	81·69
1·1	1890-91	74·91	66·71	59·28	56·82	55·48	61·88	75·40	83·59	88·23	85·51	81·63	80·92
	Mean 1881—90	76·31	67·52	60·32	57·48	58·77	68·42	79·10	85·49	88·08	83·94	82·59	81·81
Thermometer in shade.	1890-91	80·17	73·10	67·04	64·70	62·79	72·11	88·53	92·81	94·90	85·46	79·89	80·50
	Mean 1881—90	81·19	73·91	68·74	64·45	68·07	79·28	89·89	93·37	90·75	82·21	80·90	82·79

Mean velocity in miles of the Winds which blew at Dehra Dun during the twelve months of 1890-91 for each hour of the day.

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Mean.
0 to 1 . .	0·58	1·73	0·50	0·58	0·61	1·42	1·72	1·29	1·83	0·66	0·71	0·80	1·04
1 „ 2 . .	0·42	1·47	0·47	0·81	0·71	1·32	1·66	1·29	1·63	0·90	0·43	0·77	0·99
2 „ 3 . .	0·45	1·13	0·50	0·71	0·39	1·52	1·31	1·03	1·63	0·72	0·57	0·83	0·90
3 „ 4 . .	0·26	0·77	0·67	0·61	0·57	1·26	1·55	0·94	1·47	1·07	0·46	0·53	0·85
4 „ 5 . .	0·16	0·97	0·77	1·16	0·54	1·19	1·45	0·71	1·00	1·03	0·43	0·53	0·83
5 „ 6 . .	0·13	0·97	0·53	0·68	0·54	1·29	0·90	0·81	0·60	0·86	0·57	0·57	0·70
6 „ 7 . .	0·23	0·43	0·57	0·77	0·89	1·23	1·00	0·87	0·57	0·66	0·68	0·67	0·71
7 „ 8 . .	0·19	0·43	0·60	0·84	0·86	1·16	1·07	0·90	0·77	0·69	1·04	0·43	0·75
8 „ 9 . .	0·07	0·33	0·40	0·68	0·86	1·42	1·27	1·23	0·87	1·14	1·04	1·03	0·86
9 „ 10 . .	0·10	0·77	0·73	0·87	1·71	1·94	1·77	1·97	1·37	1·52	1·54	1·37	1·31
10 „ 11 . .	0·52	1·28	0·67	1·42	2·29	2·39	2·23	2·80	1·90	1·73	1·55	1·97	1·73
11 „ 12 . .	0·71	1·79	1·30	1·65	2·32	3·23	2·63	3·30	2·53	1·97	1·86	1·83	2·09
12 „ 13 . .	0·81	1·47	1·55	1·74	2·36	3·68	3·17	3·30	2·73	2·03	2·32	2·10	2·27
13 „ 14 . .	0·90	1·90	1·52	1·77	3·70	4·26	3·72	4·40	3·33	2·76	2·64	2·21	2·76
14 „ 15 . .	0·74	2·00	1·83	2·39	4·14	3·77	3·76	4·20	3·80	2·90	2·64	2·21	2·87
15 „ 16 . .	0·77	1·57	1·24	2·03	3·54	3·90	3·93	4·10	3·57	2·41	2·18	1·86	2·59
16 „ 17 . .	0·32	0·50	0·53	1·90	2·54	4·42	3·62	4·00	3·13	1·90	2·46	1·69	2·25
17 „ 18 . .	0·03	0·17	0·37	0·68	1·21	2·48	3·24	3·84	2·73	1·31	1·43	1·14	1·55
18 „ 19 . .	0·07	0·67	0·53	0·55	1·07	1·42	1·21	2·55	1·83	1·10	0·71	0·93	1·05
19 „ 20 . .	0·81	1·43	0·90	0·48	1·18	1·07	1·52	2·16	0·73	0·76	0·39	1·31	1·06
20 „ 21 . .	0·48	2·07	0·87	0·71	0·89	1·52	1·83	2·29	0·93	0·76	0·57	0·90	1·15
21 „ 22 . .	0·61	2·13	0·90	0·68	0·96	1·74	1·86	2·26	1·23	0·76	0·75	0·72	1·22
22 „ 23 . .	0·61	2·13	0·93	0·61	1·07	1·71	1·66	2·00	1·87	0·66	0·79	0·86	1·24
23 „ 24 . .	0·77	1·87	0·83	0·68	1·04	1·81	1·72	1·52	1·63	0·76	0·68	0·93	1·19
Sums . . .	10·74	29·98	19·71	25·00	35·99	51·15	49·80	53·76	43·68	31·06	28·44	28·19	...
Average . .	0·45	1·25	0·82	1·04	1·50	2·13	2·08	2·24	1·82	1·29	1·19	1·17	...

Monthly Meteorological Results of Observations taken at the Office of the Trigonometrical Branch, Survey of India, Dehra Dun.

Year and Month.	Barometer reduced to 32° Fahrenheit.						Hygrometer.		Thermometer.				Rain.		Wind.	Cloud.	
	At 10 A.M.			At 4 P.M.			At 10 A.M.	At 4 P.M.	Dry Bulb.			Wet Bulb.					
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean humidity.	Monthly mean humidity.	Maximum in air.	Minimum in air.	Monthly mean in air.	Minimum.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 10 A.M.	At 4 P.M.
1890.																	
October	27·810	27·543	27·703	27·736	27·490	27·618	60	48	85·6	52·7	69·8	49·0	3	0·34	Calm	1	1
November	·905	·717	·818	·813	·658	·732	54	42	78·9	46·2	62·0	41·9	*Nil*	*Nil*	,,	2	3
December	·917	·717	·795	·888	·630	·712	67	50	76·3	40·8	56·8	38·8	5	1·64	,,	4	5
1891.																	
anuary	·887	·634	·797	·816	·618	·718	74	52	74·2	39·7	55·4	40·2	6	3·06	,,	4	5
February	·996	·555	·760	·914	·455	·694	61	44	74·5	35·4	53·3	33·9	6	2·37	,,	5	6
March	·769	·562	·693	·737	·425	·612	48	38	83·3	46 6	61·7	43·1	6	1·68	W	3	5
April	·717	·532	·609	·631	·387	·520	33	23	95·3	56·7	75·4	51·1	2	0·25	WNW	4	4
May	·651	·358	·525	·616	·276	·437	32	24	100·0	60·3	80·6	56·0	4	1·30	,,	2	4
June	·518	·271	·389	·405	·187	·308	42	33	103·1	67·6	84·3	57·1	4	3·69	,,	2	2
July	·477	·203	·346	·412	·113	·264	73	67	99·7	67·1	80·3	61·3	19	13·08	SSE	6	6
August	·578	·278	·455	·494	·232	·379	83	84	89·8	68·5	75·8	68·3	23	18·46	,,	8	8
September	·678	·443	·564	·572	·366	·473	80	80	87·2	67·1	75·6	65 8	14	7·45	,,	7	8

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

TYPE-PRINTING SECTION.—With the exception of a trifling amount of work done for other departments, the energies of this section have been entirely devoted to the publication of the records of this branch of the Survey Department and work connected with the office.

For many years the forms for use with the Tidal and Levelling Party were procured elsewhere, but now a portion of them are printed in this office, and this has thrown a good deal of extra work on the Type section. In order to increase the press power of the branch, a press has been transferred from the Calcutta Office, and in the hands of a suitable pressman is now found quite equal to meet the extra demand.

Statement of Departmental work done during the year 1890-91.

SPECIFICATION OF PRINT.	Number of pages.	Total number of pulls.	Number of copies.	Value.
				R
Professional Volumes	479	62,680	510	7,089
Synoptical	252	26,105	360	3,600
Pamphlets of spirit-levelled heights	77	5,520	310	846
Letter-press for charts, map headings and foot-notes	78	1,510	...	285
Hand-books for the Trigonometrical and Topographical Branches	313	8,745	154	3,189
Forms	239	60,296	...	2,007
Exploration Reports (reprints)	128	3,180	100	1,390
Extra-Departmental	32	1,302	...	103
TOTAL	1,598*	169,338	...	18,509

* Equal to 2,165 pages of standard (foolscap) size.

The usual table showing the work annually performed by this section during the past five years is given below, the unit (a page of foolscap) being the same throughout.

	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.
Pages composed	1,516	1,994	1,989	1,998	2,165

An analysis of the pages composed is as follows :—

		PAGES
PROFESSIONAL VOLUMES	Bombay Longitudinal Series	6
	South-East Coast Series	6
	Introductory chapters	106
	Singi Meridional Series	25
	Kattywar Meridional Series	89
	Abu Meridional Series	9
	Gujarat Meridional Series	18
	Cutch Coast Series	92
	Longitude operations	415
	Burma Coast Series	39
	TOTAL	805
SYNOPTICAL VOLUMES	South Konkan Coast Series	25
	Mangalore Meridional Series	184
	South-East Coast Series	54
	Madras Longitudinal Series	28
	Assam Valley Series	112
	TOTAL	403
MISCELLANEOUS	Exploration reports (reprint)	170
	Hand-books for Trigonometrical and Topographical Branches	313
	Spirit-levelled Heights	76
	Letter-press for Charts, map headings and foot-notes	33
	Forms, Orders, Memoranda, etc.	333
	Extra-Departmental	32
	TOTAL	957

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

PHOTO-ZINCOGRAPHIC SECTION.—This section has been employed in printing maps charts, diagrams, etc., both to illustrate the volumes published by the office and for general use ; also in printing from zinc the departmental professional forms in which mathematical formulæ are largely employed : it has also executed a large amount of extra-departmental work, as will be seen on reference to one of the following tables ; about one-third the work done has been for other departments.

The following statements exhibit the value and out-turn of work done in this section :—

Statement shewing the Amount and Value of work done for other Departments, etc., during the year 1890-91.

DEPARTMENTS, ETC.	PHOTO-ZINCOGRAPHIC PRINTING.								Value.	REMARKS.
	Sheets or sections or subjects.	Negatives.	Photo-transfer Prints.	Zinc Plates.	Silver Prints.	Blue Prints.	Pulls.	Copies.		
									R. a.	
Foreign Department . .	1	7	7	1	...	...	60	60	88 14	
Forest ditto . .	63	269	263	57	100	460	3,413	3,421	3,696 1	
Military ditto . .	5	16	22	3	...	...	652	252	315 2	
Quarter Master General .	6	15	35	6	...	...	935	335	416 0	
Miscellaneous . . .	2	6	6	2	...	...	...	...	67 3	
Cash sale	...	...	...	...	...	...	...	...	459 0	
TOTAL . .	77	313	333	69	100	460	5,060	4,068	5,042 4	

Statement of Departmental Work done during the year 1890-91.

Specification of Plate or Print.	Photo-zincographic Printing.											Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Negatives.	Photo-transfer prints.	Zinc plates.	Silver prints.	Blue prints.	Pulls.	Copies.	Value.	
												₹	
Abstract of horizontal angles and approximate azimuths, etc. (Colonel Tanner's)	F.	...	½ Im.	1	...	...	...	...	...	206	206	25 12	
Arabia and Persia, Map of Part of Nos. 1 and 2	* F.	32	D. E.	2	...	...	...	...	...	150	150	36 12	
Assam Valley Triangulation, Index to Degree Sheets	F.	16	½ D. E.	1	4	4	1	...	...	110	110	59 4	For Synoptical Volume XXII.
Burma Coast, Preliminary Chart, Nos. 56, 57 and 58	F.	2	D. E.	3	20	20	3	...	...	186	186	272 4	
Central Provinces Survey, Sheets Nos. 12 S.E./2, S.E./4; 13 N.E./2; 19 N.E./1, N.E./2, N.E./3, N.E./4, N.W./4, S.E./2, S.E./4, S.E./1 & 2, S.W./1, S.W./2, S.W./3; 20 N.W./1, N.W./3; 19 S.E./3 and 20 N.E./1 (in one); 19 S.W./4 and 20 N.W./2 (in one); 26 N.W./3, S.W./1 & 2, and S.W./3 & 4.	F.	¼	D. E.	21	118	130	21	...	...	3,156	3,156	2,057 15	
Chart showing the Triangulation between Ibrahimabad and Kushan for the purpose of fixing the longitude of Kushan	F.	25	⅛ D. E.	1	...	...	...	...	..	162	324	17 14	For Hand-book, Topographical Branch.
Clinometer, Height Indicator (Captain Wahab's)	* F.	...	⅛ D. E.	1	...	...	...	...	...	26	156	8 10	
Curve showing the Graduation of Errors of T. and S's 12″ Theodolite No. 1	F.	...	⅛ D. E.	1	1	...	...	...	...	...	...	5 11	
Dehra Dun and Siwaliks Survey, Index map	* F.	4	½ D. E.	1	2	4	1	...	...	30	60	40 2	
Eastern Frontier Series, Preliminary Chart, 1866-67 (in two parts)	* I.	4	D. E.	2	12	...	...	...	...	...	...	68 7	
Forms for Departmental use (Miscellaneous)	F.	...	...	21	14	63	17	...	...	2,475	2,324	736 1	
Do. do. do. (Professional)	F. & I.	...	...	24	7	132	29	...	...	10,181	11,043	1,986 6	
Gujarat Survey, Sheets Nos. 6, 11, 12, 13, 16, 25, 29, 30, 33, 34, 49, 49 (portions of Sections 2, 4 and 5) and 76	* F. & I.	1	D. E. and 1/16 D. E.	15	43	99	11	12	...	686	698	935 5	
Hazara Expedition, 1891 (Preliminary issue)	* F.	½	D. E.	1	4	4	1	...	...	182	182	86 13	
Hundes or Narikhorsun and Monyul (in two parts)	* F.	⅛	D. E.	2	9	18	2	...	...	100	50	165 14	
Jaunsar and Bawar Survey, Sheets Nos. I, II, III and IV	* F.	¼	D. E.	4	18	18	3	...	...	240	240	267 9	
Karwar Port, Diagram	I.	½	¼ D. E.	1	1	2	1	...	...	4	8	16 7	For Professional Volume.
Do., Map (portion of)	I.	⅛	⅛ D. E.	1	1	4	1	...	...	2	8	31 8	
Do., Tidal Curves at	I.	...	⅛ D. E.	1	1	1	1	...	...	12	12	13 11	
Kattywar Survey, Sheets Nos. 8, and 2nd Edition of 10, 11, and 20	* F.	1	D. E.	4	19	37	4	...	...	252	252	355 4	
Khánpisura Meridional Series, Rough Chart	F.	4	D. E.	4	25	25	4	...	...	88	44	311 10	
Kohat Topographical Survey, Triangulation Chart, 1880—83	* F.	4	D. E.	1	6	6	1	...	...	30	30	75 7	
Kumaun and Garhwál Survey, Sheets Nos. 1, 2, 7, 9, 17, 18 and 24	* F. & I.	1	D. E.	8	18	30	5	...	...	403	403	353 15	

Lhasa, Plan of, by A—K	* F.	4	¾ D. E.	1	6	6	1	...	...	105	105	81 5	For reprint of Exploration Report.
Mandalay Series, 1889-90, Preliminary Chart of principal Triangulation	F.	4	D. E.	1	6	6	1	...	...	60	60	83 11	
Mandalay Series, 1889-91, Preliminary Chart of principal Triangulation	F.	4	D. E.	1	8	8	1	...	...	60	60	104 2	
Mangalore Meridional Series, Final Chart (in two parts)	F. & I.	32	D. E.	2	16	24	4	...	...	366	366	273 10	For Synoptical Volume XXIV.
Mirzapur Survey, Sheet No. 185 S.E.	F.	½	D. E.	1	6	6	1	...	...	150	150	99 7	
Mussooree and Landour, Guide Map	* I.	⅛	D. E	1	...	8	1	...	...	...	...	42 0	
N. E. Quadrilateral of the G. T. S. of India, Diagram	F.	16	⅛ D. E.	2	2	6	2	...	...	241	482	69 14	For Synoptical Volumes.
N. E. T. Frontier, Sheets Nos. 6, 7, 7 N.W.^{1} $\frac{N.W.}{1}$, and part of 6 $\frac{S.W.}{3}$ (in one), and $\frac{N.W.}{3}$	* F. & I.	¼, ½, 2&8	D. E.	6	1	38	5	...	...	270	270	276 15	
Punjab Survey, Sheets Nos. 246 (N.E.) 1, (N.E.) 2 (N.E.) 3, (N.E.) 4, (N.W.) 4, (S.E.) 1; 285 (N.W.) 1, (N.W.) 2, (N.W.) 3; 310 (N.E.) 1 and 2.(N.E.) 2, (N.E.) 4, (S.E.)4; 332 (N.W.) 1, (N.W.) 2, (N.W.) 3, (N.W.) 4, (S.W.) 1 and (S.W.) 3	F. & I.	¼, ½ & 1	¼, 1/16, and D.E.	26	117	152	16	27	...	342	423	1,344 9	
Singi Meridional Series, Rough Chart	F.	...	⅛ D.E.	1	3	18	...	...	...	...	6	27 14	
Skeleton Chart of the Principal Chains of Triangles west of the meridian of 92°, Diagram	F.	...	⅛ D. E.	1	1	2	1	...	...	260	520	48 10	For Professional Volume XIV.
Specimen of Hill shading	F.	...	1/16 D. E.	1	1	2	1	...	...	30	60	14 0	For examination of candidates for Junior Division.
Spirit-levelling Operations, No. 6 Madras Presidency and No. 5 Bombay Presidency	F.	16	¼ D. E.	2	4	8	2	...	...	329	658	109 6	For Pamphlets of Spirit-levelled heights.
S. Trigon. of the G. T. S. of India, Diagram	F.	...	⅛ D. E.	1	1	8	2	...	...	620	2,480	138 15	For Synoptical Volumes.
S. W. Asia, Sheet No. 72	* F.	8	D. E.	1	...	...	...	...	...	75	75	18 6	
S. W. Quadrilateral of the G. T. S. of India, Reduction Chart of principal Triangulation	F.	24	D. E.	1	9	18	2	...	...	515	515	210 6	For Professional Volume XIV.
Tibet, Revised map (Mr. Paul's)	* F.	16	⅜ D. E.	1	...	...	...	...	...	20	10	7 0	
Trans-Himalayan exploration map No. 11, by Mullah, 1876	* F.	12	½ D. E.	1	...	...	...	...	...	52	52	7 8	
Do. do. No. 15, by A—K, Nos. 1 to 3 (revised)	* F.	16	D. E.	1	18	18	3	...	...	315	315	252 0	For Reprints of Exploration Reports.
Do. do. do. Index	* F.	...	D. E.	1	6	6	1	...	...	105	105	84 0	
Turkistan, map, Nos. 1, 2, 3 and 4 (6th edition)	* F.	32	D. E.	4	...	28	4	...	...	240	240	216 0	
Do. do. Index	* F.	...	⅛ D. E.	1	...	2	1	...	...	15	30	9 8	
Other maps, for office use, Surveyor General's Office, etc.	F. & I.	...	...	47	114	172	34	...	3	5,376	2,660	2,684 1	
COPIES OF MAPS OF OTHER DEPARTMENTS TAKEN FOR DEPARTMENTAL USE, 1890-91.													
Anglo-Siamese Boundary Commission, 1890-90 (Preliminary Map)	F.	12	D. E.	..	...	...	...	...	...	...	...	17 12	
Berar Forest Survey, Sheets Nos. 13 N. E., $\frac{N.E.}{1}$, $\frac{N.E.}{2}$, S. E.; 14 N. E., $\frac{N.W.}{3}$; 13 S. W. and 14 N. W. (in one); 19 $\frac{N.E.}{1}$, $\frac{N.E.}{2}$, $\frac{N.W.}{2}$, $\frac{N.W.}{3}$, $\frac{S.W.}{1}$, $\frac{S.W.}{3}$, N. W. and S. W. (in one); 20 $\frac{N.W.}{2}$; 20A N. W.; 26 $\frac{N.W.}{1}$, $\frac{N.W.}{3}$ and $\frac{S.W.}{1}$	F.	½ & ¼	D. E. & D. E.	23	14	81	19	...	490	345	345	110 6	

Statement of Departmental Work done during the year 1890-91—contd.

Specification of Plate or Print.	Photo-zincographic Printing.											Remarks.
	Progress made.	Scale of map.	Size of each sheet.	Sheets or subjects.	Negatives.	Photo-transfer prints.	Zinc plates.	Silver prints.	Blue prints.	Pulls.	Copies.	Value.	
												R a.	
Burma Forest Survey, eight circles	F.	1	½ D. E., ¼ D. E., ⅛ D.E.	8	4	4	1	...	...	160	160	23 6	
Burma (Upper), Kindat; Taungawin with parts of Mingin, Kani and Se-Yaw-Gyaung; and Yu Reserves	F.	1	D. E.	3	18	18	3	...	...	45	45	15 12	Copies retained for office record, of maps, etc., requisitioned for by other departments, the cost of press pulls and stationery being all that is here charged to the Survey Department; the numbers in columns 5 to 8 therefore stand excluded from the totals.
Burma (Upper), Map of the Sariskta, Nankwita and Nanbyen forests, Kaulia range, Yeu and Wuntho Districts	F.	1	D. E.	...	...	...	...	...	...	15	15	6 6	
Central Provinces, Index to the Forest Survey, District Bhandara	F.	8	½ D. E.	...	...	...	...	...	...	...	...	3 14	
Chamba State, Leased Forests	F.	½ & 2	½ D. E. & D. E.	3	1	10	2	...	...	55	35	13 7	
Chota Nagpore Forest Survey, Sheets Nos. 125 S. E./1 & 3, S. E./2 & 4; 126 N. E./1, N. E./2, N. E./3, N. E./4, N. W./2, N. W./4, S. E./1, S. E./2; 127 S. W./4 and 157 N. W./3	F.	¼	D. E.	13	12	37	6	...	...	195	195	82 14	
Jaunsar Division, Korwa Forest, Bamtar Khat	F.	1/12	½ D. E.	...	...	...	...	...	...	...	...	4 3	
Kheri and Pilibhit, Map of the Reserved Forests	F.	4	¼ D. E.	...	...	...	...	...	...	...	...	2 12	
Naini Tal, Geological map	F.	¼	¼ D. E.	...	...	...	...	...	...	...	...	1 14	
Punjab Forest Survey, Bushahr State, Sheet No. 332 N. W./3	F.	¼	D. E.	1	...	...	...	...	...	...	...	6 6	
Other maps	F.	...	...	6	15	17	3	...	...	395	265	67 2	
Total	...	...	...	226	642	1,133	189	39	493	29,437	30,344	14,487 14	

* Additional prints of previous publications; Im. represents Imperial; D. E. represents double elephant; F. represents finished; I. represents in press.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

SOLAR PHOTOGRAPHIC SECTION.—This section has no real connection with the work of this office; but was established at Dehra as a matter of convenience, so that it might be under suitable supervision without expense to Government.

In addition to the ordinary daily routine of photographing the sun, some photographs were obtained of the passage of Mercury across the sun's disc on the morning of 10th May, so timed as to secure the planet at the moment of internal contact at egress.

Table of working facts for the year 1890-91.

1890-91.	NUMBER OF DAYS.				NUMBER OF NEGATIVES.										NUMBER OF WORKING DAYS WHEN SOLAR PHENOMENA WERE	
					Solar Phenomena.								Total.			
					Spots and Faculæ.		Spots only.		Faculæ only.		None.					
	When negatives were taken.	Failures: From bad weather.	Failures: From various causes.	Total.	8″	12″	8″	12″	8″	12″	8″	12″	8″	12″	Visible.	Absent.
October	31	...	...	31	33	...	...	...	24	...	...	...	57	...	31	...
November	26	4	...	30	23	...	...	...	18	...	5	...	46	...	23	3
December	26	5	...	31	30	...	...	...	14	...	...	...	44	...	26	...
January	24	7	...	31	23	...	...	...	20	...	...	...	43	...	24	...
February	20	8	...	28	28	4	...	...	9	...	...	...	37	4	20	...
March	27	4	...	31	37	...	...	...	9	...	...	...	46	...	27	...
April	28	2	...	30	49	...	...	...	...	...	...	...	49	...	28	...
May	30	1	...	31	55	7	...	...	...	...	...	...	55	7	30	...
June	30	...	...	30	54	...	...	...	...	...	...	...	54	...	30	...
July	22	9	...	31	35	...	...	...	...	...	...	...	35	...	22	...
August	18	13	...	31	26	...	...	...	2	...	...	...	28	...	18	...
September	21	9	...	30	33	...	...	...	...	...	...	...	33	...	21	...
TOTAL	303	62	...	365	426	11	...	...	96	...	5	...	527	11	300	3

Seven hundred and thirty-four silver prints of the 8-inch, and twelve of the 12-inch pictures were prepared, and weekly despatches of both silver prints and negatives made as usual to the India Office.

Table contrasting visibility of sun at Dehra Dun and Greenwich.

YEAR.	AT DEHRA DUN.			AT GREENWICH.		REMARKS.
	Number of days on which negatives were taken.	Percentage of days on which negatives showed features.	Number of days when sun was invisible.	Year.	Number of days on which negatives were taken.	
1880-81*	307	96	55	1880	156	* From 1st October to 30th September following.
1881-82	328	100	37	1881	181	
1882-83	318	100	47	1882	221	
1883-84	285	100	78	1883	215	
1884-85	284	100	81	1884	154	
1885-86	290	100	75	1885	206	
1886-87	302	98	61	1886	199	
1887-88	328	91	38	1887	188	
1888-89	315	71	50	1887-88	205	† Year ending 10th May 1889. Obtained from Report to the Board of Visitors.
1889-90	320	78	45	1888-89†	182	
1890-91	303	99	62	1889-90	Not obtainable.	
Means	307	...	57	...	191	

DRAWING SECTION.—The details of the work done in this section are given in the tables which follow:—

Statement showing the value of work done for other Departments, etc., during the year 1890-91.

Departments, etc.	Value.
	R a.
Quarter Master General's Department	132 0
Forest Survey Office	78 8
Director, Geological Survey of India	30 8
Deputy Commissioner, Simla	4 0
TOTAL	245 0

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

DRAWING SECTION.

Statement showing work performed during the year 1890-91.

Title.	Number of Sheets.	Scale.	Remarks.
		In. M.	
General Maps.			
Exploration map	2	1 = 16	Final press order given.
Ditto	1	1 = 32	Corrected. Final press order given.
Expedition Survey map	1	1 = 2	Ditto. Ditto.
Ditto	1	2 = 1	Ditto. Ditto.
Miranzai Expedition Survey map, April-May 1891	1	1 = 1	Completed. Ditto.
Standard Maps.			
North-Western trans-Frontier series—			
One map (3rd Edition)	1	1 = 4	Final press order given.
Three maps	3	1 = 4	Completed. In press.
Kumaun and Garhwal Survey Sheet No. 17	1	1 = 1	Corrections made for reprints. Final press order given.
Central India and Rajputana Topographical Survey, Sheet No. 260 (2nd Edition)	1	1 = 1	In hand.
Gujarat Survey, Sheet No. 10	4	2 = 1	Corrected for reprints. In hand.
Ditto No. 29	4	2 = 1	Ditto. Final press order given.
Punjab Survey, Sheets	12	4 = 1	Corrected the preliminary edition. Final press order given.
Ditto	4	4 = 1	Corrected for reduction to ½ scale. In press.
Central Provinces Survey, Sheets	15	4 = 1	Corrected and completed. Final press order given.
Index Maps.			
For Annual Administration Report	4	Various	Corrected to date and sent to press.
Degree Sheets of Assam Valley Triangulation	1	1 = 16	Prepared on a copy of the map of Assam for Synoptical Volume. Preliminary issue. Final press order given.
Spirit-Levelling Operations in Bombay Presidency	1	1 = 16	Corrected. Drawn on double the scale for reduction to one-half for Pamphlet No. 5, Bombay Presidency. Final press order given.
Spirit-Levelling Operations in Madras Presidency	1	1 = 16	Corrected. Drawn on double the scale for reduction to one-half for Pamphlet No. 6, Madras Presidency Final press order given.
Final Reduction Chart, South West Quadrilateral	1	1 = 12	For reduction to one-half scale for Professional Volume. Final press order given.
Miscellaneous Maps.			
Diagram of N. E. Quadrilateral showing Assam Valley	1	...	For Synoptical Volume. Preliminary issue. Final press order given.
Diagram of the Southern Trigon.	1	...	For Professional Volume. Final press order given.
Map of Karwar Port	1	1 = ½	Ditto ditto ditto.
Diagram showing Tidal Curves at Karwar	1	...	Ditto ditto ditto.
Nepal Boundary Survey, Sheets Nos. 1, 2, 3 and 4 (Mechi River)	4	4 = 1	Corrected for reprints.
Forms—Professional	12	...	Prepared and final press order given.
Charts.			
Hazara Branch Series, by Lieutenant Robinson	1	1 = 4	Prepared tracings for Captain Wahab, R.E.
Triangulation of Hazara Field Force, 1888	1	1 = 4	Prepared tracings for Captain Wahab, R.E.
Final Triangulation, Mangalore Meridional Series	2	1 = 4	For reduction to one-half, for Synoptical Volume. Final press order given.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

DRAWING SECTION.

Statement showing work performed during the year 1890-91—continued.

Title.	Number of Sheets.	Scale.	Remarks.
Charts—contd.		In. M.	
Final Triangulation, Madras Longitudinal Series, South-East Coast Series, Madras Meridional and Coast Series, Great Arc Meridional Series, Section 8° to 18°, and Bombay Longitudinal Series	13	1 = ½&4	For reduction to one-half, for Synoptical Volume. In hand.
Triangulation, Khánpisura Meridional Series	2	1 = 4	Rough Charts, for use of the Computing office. Final press order given.
Triangulation, Burma Coast (for fixing of Beacons for the Marine Survey), Nos. 56, 57 and 58	3	1 = 2	Preliminary charts; corrections made. Final press order given.
Triangulation, Mandalay Merl. Series, Season 1889-90	1	1 = 4	Ditto ditto ditto.
Level Sheets Nos. 1 (3rd Edition), 67, 74, 88, 89 and 97	6	1 = 2	In hand.
Maps coloured	3,740	...	

Maps examined.

	Number of Sheets.
General maps	4
District maps (portions of)	10
Original standard maps	29
Trans-Frontier maps	5
Index maps	4
Miscellaneous maps	6
Tracing of original maps	11
Charts	11
Photo-zincographic proofs of standard sheets and various other maps	238
TOTAL .	318

N.B.—In addition to the above, much miscellaneous work has been done, such as assisting in Photographic office; completing for press original maps of Central Provinces survey, Punjab survey and forest survey in respect to headings, foot-notes, etc.; putting in boundaries of districts on charts for use of the Computing office; supplying tracings of margins of Gujarat sheets to Gujarat Party; pantographing and transliterating three Russian maps for office use, and preparing a specimen of hill-shading for examination purposes.

Statement of work done for other Departments, etc., during the year 1890-91.

Title.	Number of Sheets.	Scale.	Remarks.
		In. M.	
General Maps.			
Map showing concentration of troops in Manipur in April 1891 . . .	1	1 = 16	Additions and corrections made to Map of Assam Province, for Quarter Master General. In press.
Standard Maps.			
Forest Surveys	38	Various	Completed headings and foot-notes, references, etc., and final press order given, for Forest Survey Branch.
North-Eastern Trans-Frontier, Sheet No. 21	2	1 = 8	Inserted points for Quarter Master General.
Miscellaneous.			
Colonel Tremenheere's Levels in Sind .	1	1 = 4	Prepared a tracing for Director, Geological Survey of India.
Jaunsar Bawar Survey . . .	7	1 = 2	Examined the tracings for Deputy Commissioner, Simla.
Maps coloured	485	Various.	

G. I. C. P. O.—No. 21 S. G.—11-4-92.—450.

1892.

File No. 109.

GOVERNMENT OF INDIA.

SERIAL No. 2.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

No. $\frac{1156\text{-}69}{109}$.

Dated Simla, the 11th June 1892.

SUBJECT.

Review of the General Report on the operations of the Survey of India Department for 1890-91.

C. C. Press, Simla.—No. 262 R. & A. D.—17-6-92.—725.

officials. This course may be successfully adopted for a short time, so long as the instructions of the survey officials are remembered; but sooner or later the accuracy of the traverse or skeleton survey prepared by new or inefficiently supervised workmen becomes impaired, and the maps are rendered more or less useless for inclusion in any cartographical series of recognized accuracy. The reduction of rates which has now been attained by the Survey Department has removed the objection of expense, which formerly stood in the way of the acceptance by some Provincial authorities of its aid in cadastral surveys, and the Government of India see no reason why any departure from the canon laid down should in future be justified. The matter is of great importance in connection with the maintenance of the topographical maps of the country, which can always be corrected at an insignificant cost if the cadastral maps maintained by local agency are based upon the same series of survey stations, but not otherwise. It becomes, therefore, the duty of the Surveyor General to bring to the notice of the Government of India any material breach of the canon laid down in 1882 in order that unnecessary expenditure may not be incurred in maintaining the cartographical series of maps in the Imperial office. His Excellency the Governor General in Council has, however, reason to be satisfied that at present the continuous efforts of the Department to reduce the acreage rates of all classes of survey are fully recognized by Provincial Governments, and that it is to this circumstance that the expansion of the programme which has been entrusted to the Survey Department, and which has resulted in the maintenance of the Imperial Survey establishments at a fuller strength than could at one time be anticipated, is greatly due.

6. The most important example of the now recognized utility of the Imperial Survey Department in provincial surveys is its present employment upon all cadastral and field-surveys in Bengal, in which province all such surveys had in previous times been executed by provincial establishments. It was essential that on this occasion the survey should be executed by the cheapest agency compatible with correct results. Colonel Sandeman, whose valuable work in bringing about the most economical amalgamation of scientific and local agencies that has as yet been effected was acknowledged by the Surveyor General and the Government of India in connection with the report for 1889-90, has been selected to take charge of all cadastral surveys in Bengal—a work which, in view of the forthcoming field-survey of Behar, is of no little magnitude. It is creditable to the Imperial Survey Department that this result has been secured by the persistent endeavours of its officers to reduce the acreage cost of survey to rates which justified the Provincial Government in accepting their control over the local surveys.

7. The same position has been obtained in Burma. There, however, the local officers were at first less capable of being utilized than in Bengal or Northern India, and the cadastral surveys had perforce to be conducted entirely by professional agency. It is satisfactory that during the last year material progress has been made in training Burman surveyors, and that a prospect is now held out of a gradual reduction in cadastral rates. Care, however, will have to be taken that the new local agency is not made too independent of the professional department, and that ultimate expenditure is not caused by a neglect of the canon to which reference has been made in paragraph 5. The same caution must be applied also to Assam.

8. The relations between the survey officials and the Provincial Governments have throughout the year been on a satisfactory footing, and the Government of India are glad to observe that the more frequent tours of the inspecting officers have tended to secure the result, which was anticipated, of removing such local difficulties as had hindered progress in consequence of insufficient personal communication between the Provincial authorities and the responsible officers of the Survey Department. The establishment of a thorough understanding between the Imperial Survey Department and the authorities in the Province where it is at work has, under the present system of financial decentralization, become one of the most important duties of the more responsible officers of the Department. No effort should be spared to secure this result.

9. The outturn of work has increased in every branch of the head-quarters offices, and it is satisfactory to notice that the demand for maps is steadily increasing. The total number issued in 1890-91 was 208,848, valued at Rs. 1,45,245. This number is four times greater than it was ten years ago. The Mathematical Instrument Department also did good work during the year. The value of the instruments issued amounted to Rs. 2,88,337, or Rs. 17,879 more than in the previous year.

10. The demands from the public for heliogravures are increasing, and the introduction of the photo-block process in half tones is satisfactory. The success with which Colonel Waterhouse has kept the photo-lithographic printing of the Department abreast with, and in some directions ahead of, European improvements is a subject for congratulation.

11. At the Dehra Office material progress has been made towards the reduction and publication of the trigonometrical records of past years, a work which it is important to bring to an early close in view of the Dehra buildings being required for other imperial purposes. Solar photography, which was started in 1877 at the request of the Industry, Science and Art Department, has been continued as usual, photographs of the sun having been taken throughout the year on all days that the sun was visible, and the negatives sent to the Solar Physics Committee at South Kensington. The results are included in the yearly volumes of Greenwich observations. But it is probable that a new observatory for the purpose of heliographic observations will be shortly established under a clearer atmosphere in the Madras Presidency, and the Dehra series will then cease.

12. The Department has been maintained in an efficient manner throughout the year, and the Government of India acknowledge the services rendered by the Surveyor General and the other officers of the Department.

ORDER.—Ordered, that the above Resolution be forwarded to the Surveyor General of India, to the Inspector General of Forests, to the Local Governments and Administrations noted on the margin, and to the Foreign, Military, and Public Works Departments.

Madras.	Punjab.
Bombay.	Central Provinces.
Bengal.	Burma.
North Western Provinces and Oudh.	Assam.
	Coorg.

Ordered also, that the Resolution be published in the Supplement to the *Gazette of India*.

[True Extract.]

E. C. BUCK,

Secretary to the Government of India.