GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India Department

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1891-92.

PREPARED UNDER THE DIRECTION OF

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

SURVEYOR-GENERAL OF INDIA.

CALCUTTA:

OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.

1893.

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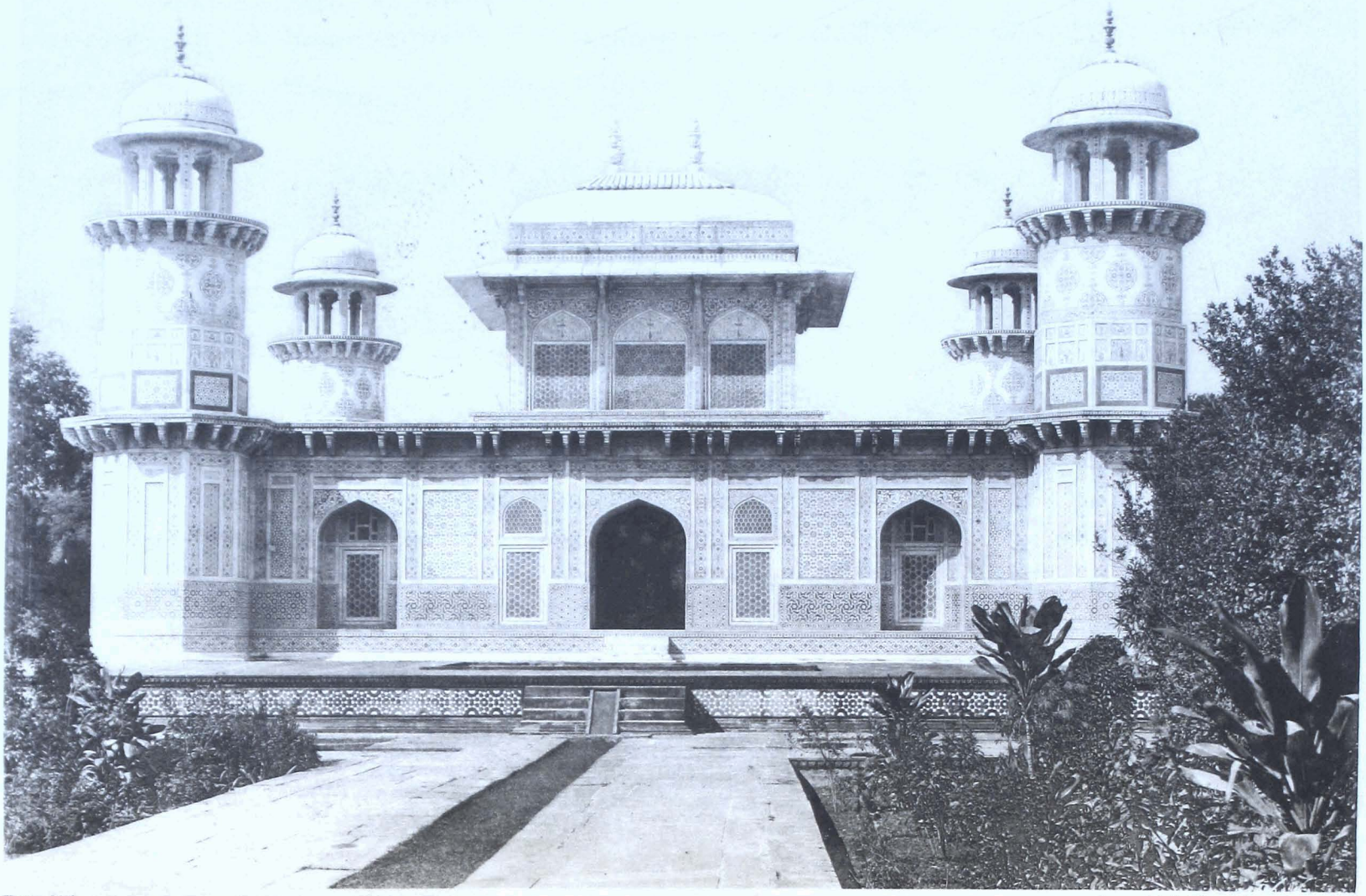

Photo-etching.

Survey of India Offices, Calcutta, January 1893.

TOMB OF ITMAD-UD-DAULA, AGRA.

Enlarged from a negative by Col. J. Waterhouse.

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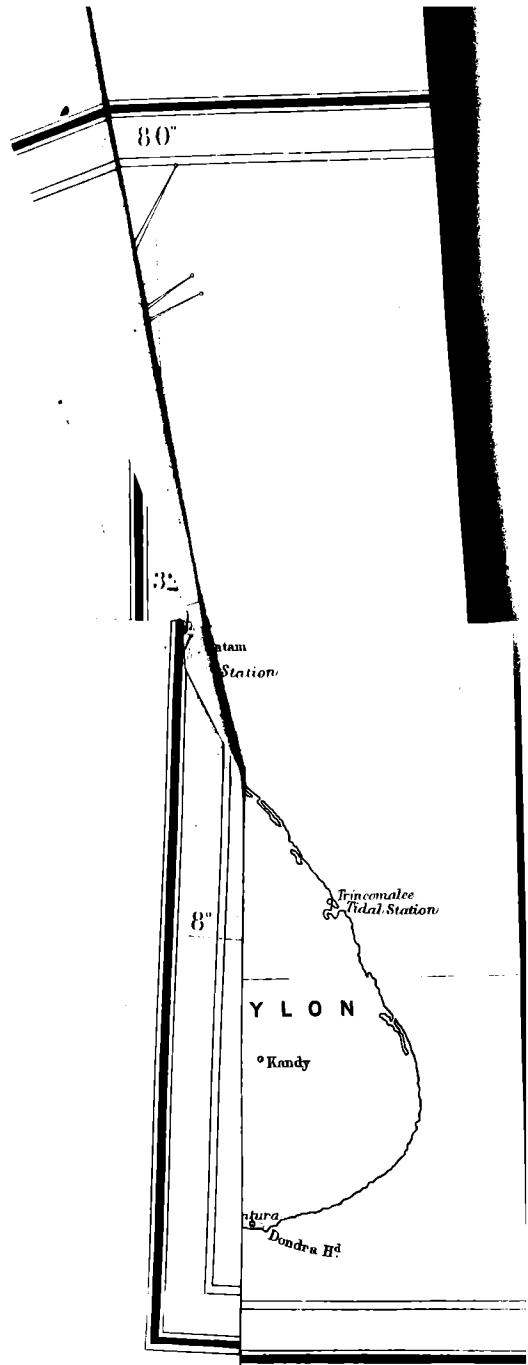


OF COL. J. T. WALKER, R. E., F. R. S. &

Published

GENERAL REPORT

ON THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1891-92.

PART I.

SUMMARY.

ADMINISTRATION.

1. The operations of the Department that are now reported on are for the survey year ending 30th September 1892.

2. The general administration of the Department and the superintendence of the Topographical Branch remained in the hands of Colonel H. R. Thuillier, R.E., during the year, except for a period of three months while absent on privilege leave, when Colonel G. Strahan, R.E., officiated as Surveyor-General in addition to his other duties. The supervision of the Revenue Branch has been carried on, as before, by Lieutenant-Colonel C. Strahan, R.E, and that of the Trigonometrical Branch by Colonel G. Strahan, R.E. In view of the forthcoming survey and preparation of record of rights in Bihar which have been entrusted to the Survey Department, together with the operations in Orissa and elsewhere in Bengal now in progress, it was considered that such extensive operations should, in the interests of economy and administrative efficiency, be placed under the superintendence of an officer experienced in cadastral-cum-settlement surveys, whose time would be wholly at the command of the Bengal Government. The appointment of Director of Bengal Surveys was therefore created for a term of five years from 1st April 1892, and Lieutenant-Colonel Sandeman was selected for the post and assumed the administrative charge of all cadastral surveys in Bengal from that date. Lieutenant-Colonel Sandeman, however, obtained furlough for six months from the 18th April, 1892, and the superintendence of these parties remained in the hands of the Deputy Surveyor-General in charge of Revenue Surveys during this period.

Inspection tours of the Administrative Officers.

3. The Surveyor-General left Calcutta on the 7th April, 1892, for Madras and returned on the 29th idem, during which time he inspected at Bangalore the office of No. 19 Party, which is employed on forest surveys in the Madras Presidency, and conferred with the Forest Member of the Board of Revenue and the Conservator regarding the operations being carried out in the Madras Presidency. On the 5th May the Surveyor-General proceeded to Simla under the orders of the Government of India, to be in personal communication with them. While at Simla, he inspected the Survey offices located there, *viz.*, the Drawing Office and No. 18 Party. He returned to Calcutta on the 20th July, and proceeded on leave on the 2nd August.

The Officiating Surveyor-General left Calcutta on the 18th August, 1892, on tour to Bangalore and Poona. At Bangalore he inspected the offices of Nos. 11 and 21 Parties and the Mergui detachment, and at Poona those of Nos. 10, 17 and 25 Parties. He returned to Calcutta on the 4th September, and

proceeded to Mussoorie on the 22nd, where he inspected the office of the Aden detachment.

4. The Deputy Surveyor-General, in charge Trigonometrical Branch, proceeded to Simla in October 1892, and inspected the office of No. 18 Party. The recess offices of the other parties under his immediate superintendence were located at his head-quarters and were duly inspected from time to time, *viz.*, those of Nos. 14, 22, 23 and 24 Parties.

5. On the 3rd December, 1891, the Deputy Surveyor-General, Revenue Branch, left Calcutta to inspect No. 2 Party at Chittagong, returning on the 8th idem; whilst at Chittagong he conferred with the Settlement Officer regarding arrangements for the demarcation and survey of the *thanas* of Chakiria, Mashkhal and Teknaf, and on other matters connected with the prosecution of the survey, such as the attendance of the landholders, the neglect of which had caused much delay in some cases. On the 12th January, 1892, he visited Muzaffarpur and inspected the Bihar traverse detachment whilst at work in the field; he also conferred with the Collector on the subject of supplies to the sub-surveyors, there being a scarcity in the district, and on the proper procedure to ensure the attendance of the *zamindars*. On the 26th June, Lieutenant-Colonel C. Strahan proceeded to the Central Provinces, where he inspected the recess office of No. 9 Party at Kampti. On the 2nd July he again went to Muzaffarpur and visited the office of the Bihar traverse detachment; the survey schools for *patwaris* at Muzaffarpur and Motihari were also inspected. On the 9th July, a conference was held with the Commissioner of Patna at Bankipore, at which Mr. McNaughten, the Secretary to the Planters' Association, was present, when the difficulties connected with the employment of *patwaris* as field surveyors, in those parts where the lands of a village were the property of several *zamindars*, were discussed. On 13th August, Lieutenant-Colonel C. Strahan left Calcutta for Burma, returning on the 3rd September: during this time he thoroughly inspected the offices of Nos. 3, 7, 12, and 20 Parties. He also conferred with the Chief Commissioner, the Financial Commissioner, and the Director of Land Records on the subject of the progress of the surveys generally and the programme for 1892-93 for each party. From the 10th to the 21st September he was occupied in proceeding to Assam and inspecting the office of No. 6 Party at Shillong, where also he conferred with the Chief Commissioner and the Acting Director of Land Records, after which he again visited Muzaffarpur. During October he inspected the detachment of No. 5 Party (Garhwal) at Naini Tal, and consulted with the Secretary to the Board of Revenue on the future work required in Garhwal.

6. Prior to Lieutenant-Colonel Sandeman's appointment as Director, Bengal Surveys, he was placed on special duty from the 27th January, 1892, for the purpose of making suitable arrangements for the commencement of the Bihar cadastral survey and for the prosecution of the other surveys in Bengal.

Lieutenant-Colonel Sandeman left Calcutta on the 23rd January, 1892, for Cuttack, where he was joined by the Director of Land Records; a plan of future procedure for the survey of Orissa was then definitely decided on, and this, with some modification, received the sanction of His Honor the Lieutenant-Governor when he inspected the survey and settlement offices there in February. Colonel Sandeman returned to Calcutta on the 8th March, and on the 10th idem proceeded to Chittagong to inspect the party working in that district, returning to Calcutta on the 22nd idem. On the 27th March he proceeded to Bankipore and thence to Muzaffarpur, where a meeting was held under the presidency of the Commissioner of the division, at which the Maharaja of Darbhanga and the principal *zamindars* and planters of Tirhut were present, to consider Colonel Sandeman's plan of carrying out the survey operations by the agency of *patwaris* specially trained for the purpose. In accordance with the decision then arrived at, measures were taken for the instruction of a selected number of *patwaris* during the recess season of 1892.

On the 30th March, Colonel Sandeman proceeded to Darbhanga and inspected the maps and papers of the Maharaja's estate. On the 1st April he went to Raniganj, and discussed with the officer in charge the progress of the detachment working in the Burdwan Raj estates. The Director then proceeded *vid* Calcutta to Jalpaiguri, where he arrived on the 6th April and inspected No. 4 Party, giving the officer in charge orders regarding the preliminary

arrangements to be made for the conduct of the Bihar operations of the future which that party was to undertake. Colonel Sandeman returned to Calcutta on the 8th April, and proceeded on furlough on the 15th idem.

FIELD PARTIES.

7. Field operations have been carried on during the year under report by 21 parties and 6 small detachments. Of these, one party was employed on trigonometrical surveys; three parties and two detachments on topographical surveys; four parties on forest surveys; seven parties (one of which was of double strength) and two detachments on cadastral surveys; one party and one detachment on traverse surveys; three parties on scientific operations; and two parties and one detachment on geographical surveys. The following tabular statement shows collectively the whole of these operations, grouped according to the scope and nature of the work on which the parties were severally employed:—

Statement of Survey Operations and Parties.

No. of Party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
	Trigonometrical Survey				
24	Burma . . .	15	Lieutenant C. F. Close, R.E.	.....	D. S. G., Trig.
	Topographical Surveys.				
10	Bombay . . .	16	Major J. R. Hobday, S.C. Lieutenant-Colonel J. Hill, R.E.	2″ = 1 mile for reduction to half scale.	Ditto, Rev.
15	Baluchistan . . .	18	Colonel T. H. Holdich, R.E.	2″ = 1 mile, $\frac{1}{2}$″ = 1 mile and $\frac{1}{4}$″ = 1 mile for reproduction.	Ditto, Topo.
18	Himalayas . . .	20	Major St. G. C. Gore, R.E. Captain J. M. Fleming, S.C. Captain W. J. Bythell, R.E.	4″ = 1 mile for reproduction and reduction to half scale and 2″ = 1 mile for reproduction.	Ditto, Trig.
Det.	Mergui . . .	22	Mr. A. J. Gibson . .	1″ = 1 mile for reproduction.	Ditto, Rev.
Det.	Aden	24	Captain R. A. Wahab, R.E.	$\frac{1}{2}$″ = 1 mile for reproduction.	Ditto, Topo.
	Forest Surveys.				
14	Central Provinces . .	26	Colonel J. R. Wilmer, S.C.	4″ = 1 mile for reproduction.	Ditto, Trig.
17	Bombay . . .	27	Colonel H. S. Hutchinson, S.C.	16″ = 1 mile, 8″ = 1 mile and 4″ = 1 mile for reproduction.	Ditto, Topo.
19	Madras . . .	29	Lieutenant-Colonel J. R. McCullagh, R.E.	4″ = 1 mile for reproduction.	Ditto, ditto.
20	Lower Burma . .	31	Mr. A. D'Souza . . . Captain J. M. Fleming, S.C.	4″ = 1 mile and 2″ = 1 mile for reproduction.	Ditto, ditto.
	Cadastral Surveys.				
2	Eastern Bengal . .	33	Mr. F. Grant . . . ,, W. J. O'Sullivan.	16″ = 1 mile and 2″ = 1 mile for reproduction.	Director, Bengal Surveys.
3	Upper Burma . .	37	Mr. G. B. Scott . . . ,, B. G. Gilbert-Cooper.	16″ = 1 mile and 1″ = 1 mile for reproduction.	D. S. G., Rev.
4	Western Duars . .	40	Captain G. B. Hodgson, S.C.	16″ = 1 mile, 4″ = 1 mile and 2″ = 1 mile for reproduction.	Director, Bengal Surveys.
6	Assam . . .	45	Mr. E. C. Barrett . .	16″ = 1 mile for reproduction.	D. S. G., Rev.
7	Lower Burma . .	48	Mr. C. Wood . . .	16″ = 1 mile for reproduction.	D. S. G., Rev.
8	Orissa . . .	51	Lieutenant-Colonel I. E. Sandeman, S.C. Lieutenant R. T. Crichton, S.C.	16″ = 1 mile for reproduction.	Director, Bengal Surveys.

Statement of Survey Operations and Parties—continued.

No. of Party.	Nature and *locale* of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
12	Lower Burma . .	58	Mr. W. H. Patterson . .	16″=1 mile for reproduction.	D. S. G., Rev.
Det.	Garhwal . . .	63	Mr. T. F. Freeman . .	32″=1 mile for reproduction.	Ditto, ditto.
Det.	Burdwan . . .	66	Mr. T. Shaw . . .	16″=1 mile for reproduction.	Director, Bengal Surveys.
	Traverse Surveys.				
9	Central Provinces .	69	Mr. G. H. Cooke . . „ H. Dowman . .	16″=1 mile (skeleton plots).	D. S. G., Rev.
Det.	Bihar . . .	71	Mr. J. S. Pemberton . .	16″=1 mile (skeleton plots).	Director, Bengal Surveys.
	Geodetic.				
22	India . . .	74	Captain S.G. Burrard, R.E..	.....	D. S. G., Trig.
23	Ditto . . .	*ib.*	Lieutenant G. P. Lennox-Conyngham, R.E.	.....	Ditto, ditto.
	Tidal and Levelling Operations.				
25	India . . .	75	Lieutenant-Colonel J. Hill, R.E.	.....	Ditto, ditto.
	Geographical Surveys.				
11	Upper Burma . .	78	Captain H. M. Jackson, R.E. Colonel R. G. Woodthorpe, C.B., R.E.	¼″=1 mile.	D. S. G, Topo.
21	Ditto . . .	79	Captain F. B Longe, R.E. Captain T. F. B. Renny-Tailyour, R.E.	¼″=1 mile.	Ditto, ditto.
Det.	Hazara border . .	81	Captain R. A. Wahab, R.E.	¼″=1 mile.	Ditto, ditto.

OUT-TURN.

8. The total area that has been surveyed in detail during the year amounts to 80,101 square miles. In addition to this, the traverse operations carried on in the Central Provinces for the purpose of furnishing a basis for field surveys under the Settlement Department, and in Bihar in preparation for the cadastral survey by the Survey Department, embrace an area of 5,921 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.

9. The principal triangulation of Upper Burma was continued by one party along the meridian of 96° 30′, and no other principal series has been taken up during the year. Seven figures extending over a direct distance of 195 miles, and covering an area of 4,300 square miles, were completed. A secondary series emanating therefrom on the parallel of 21° north latitude, comprising six stations, at three of which observations were completed, was laid out for a distance of 96 miles eastward.

TOPOGRAPHICAL SURVEYS.

10. Three parties and two detachments have been employed on this class of operations during the year, one of the four parties so employed during last year, *viz.*, No. 13, having been reduced to a detachment. The three parties, Nos. 10, 15 and 18, have continued the topographical surveys on various scales in the Bombay Presidency, in Baluchistan and in the Himalayas, respectively, and the detachment of No. 13 Party extended its previous operations over the tin-bearing tracts in Mergui district, Lower Burma. The second detachment was specially organized to undertake the survey of the districts in the

neighbourhood of Aden, which was carried to a successful conclusion in the face of many physical and political difficulties.

11. Besides the work executed by the regular topographical parties, various small areas, principally of intervening tracts not required to be surveyed for revenue purposes, have been surveyed topographically by some of the cadastral parties, in order to complete the survey of the standard topographical maps or for other special purposes. In connection with the cadastral surveys in Upper Burma, a special survey, on the 1-inch scale, has been made of certain coal fields in the Upper Chindwin district by No. 3 Party, comprising an area of 106 square miles. A section of No. 4 Cadastral Party was employed on the survey, on the 2-inch scale, of the waste lands in the Jalpaiguri district in the parts where the cadastral survey was considered unnecessary: an area of 337 square miles was thus completed. Another detachment of the same party was engaged on the demarcation of the Jalpaiguri-Bhutan boundary, which has been re-laid and new marks have been put up, wherever practicable, each one of which is visible from the next. A survey on the 4-inch scale has been made of the boundary and of a strip of country on each side, by which the positions of the marks can be readily identified.

12. The areas topographically surveyed on various scales during the year amount to 9,909 square miles, as compared with 10,193 square miles in the previous year, the decrease being due to the smaller establishment engaged on this class of work.

The total area is made up as follows:—

5,279	square	miles	surveyed	on	the	½-inch scale.
871	"	"	"	1	"	"
3,446	"	"	"	2	"	"
270	"	"	"	4	"	"
15	"	"	"	6	"	"
28	"	"	"	8	"	"

FOREST SURVEYS.

13. The four parties engaged on forest survey operations last year in the Central Provinces, the Bombay and Madras Presidencies and in Lower Burma, have continued their previous operations during the year under review. Forest surveys were also carried on by the cadastral party working in the Western Duars, Bengal, and to a small extent by the Himalaya party in the Punjab.

14. In the Central Provinces, the surveys of all the forest reserves allotted for survey in districts Hoshangabad and Betul were completed during the year, and a considerable area was triangulated in advance in district Nimar for next season's detail work. The classification of forest growths and soils of the entire area was also completed. The season was exceptionally unhealthy, but nevertheless the out-turn, *viz.*, 483 square miles, exceeds that of the previous season by 22 square miles.

15. In the Bombay Presidency, the party continued the survey of the forest tracts in the northern and southern forest circles. The work done comprises surveys on the 16-inch scale in Poona and Sholapur districts, on the 8-inch scale in the Thana and Kolaba districts, and on the 4-inch scale in the Kanara district. In addition, an elaborate survey on the 8-inch scale was made of the Singhar hill, near Poona, to furnish an accurate map for purposes of instruction in forestry. The aggregate out-turn amounts to 437 square miles, which is less than that of the preceding season by 102 square miles: this is partly attributable to a severe outbreak of fever among the establishment, which caused considerable delay at the beginning of the season, and to a larger amount of preliminary triangulation having been done in advance for future detail work.

16. In the Madras Presidency, forest survey operations on the 4-inch scale were continued in the Madura district, and commenced in the Coimbatore district, while a small area left unsurveyed in the previous season in the Tinnevelly district was completed. The out-turn comprises an area of 659 square miles, which is the largest yet accomplished by this party, and exceeds that of last year by 194 square miles, which is very satisfactory. The cost-rate of the survey has been further decreased, the mileage-rate for the year being

17. In Lower Burma, the party continued the survey of the forest reserves in the Toungoo district on the 4-inch scale, the intervening unreserved tracts being surveyed on the 2-inch scale. The total out-turn comprises 294 square miles, which is less than that of last year by 77 square miles, but the decrease is counterbalanced by the 4-inch area done this year being much larger than that of last year. The difficulties of the country under survey are exceptionally great.

18. A detachment from the cadastral party, No. 4, employed in the Western Duars, Bengal, completed the survey, on the 4-inch scale, of the reserved forests in the Jalpaiguri district, amounting to an area of 327 square miles. The party working in the Himalayas completed the survey of 45 square miles of forest reserves in the Simla Hill States.

19. The total out-turn of forest surveys executed on the various scales amounts to 2,245 square miles, as compared with 1,841 square miles surveyed by the same parties last year. The areas on the different scales are as follows:—

68	square miles surveyed	on	the	2-inch	scale.
1,935	"	"	"	4 "	"
202	"	"	"	8 "	"
40	"	"	"	16 "	"

CADASTRAL SURVEYS.

20. The number of parties engaged on cadastral operations during the year has been as follows:—Three parties (one of double strength) and one detachment in Bengal; three parties in Burma; one party in Assam; and a detachment in the North-Western Provinces.

21. In Bengal, the three parties were employed in the Western Duars, in Chittagong and in Orissa, and the detachment in Burdwan. The cadastral survey of the cultivated portions in the Jalpaiguri district of the Western Duars was for the most part completed in the previous year, an area of only 23 square miles being left, which was finished this year. The principal work of the section employed on the cadastral operations has been the completion of the records, which occupied it throughout the season. The bulk of the party was employed on topographical work in the reserved forests and waste lands, and the demarcation of the Bhutan boundary, which have been referred to under previous heads. The survey of the district is now completed: the difficulties and obstructions met with were exceptionally great, and prolonged the operations over four seasons. The extreme unhealthiness of the climate and the consequent difficulty of getting efficient *amins* and sub-surveyors to take service there, the very scattered nature of the work, as well as the large amount of jungle met with interspersed with the cultivation, have all tended to hinder the progress of the work, and have largely enhanced the cost of the operations. The total area cadastrally surveyed in the Jalpaiguri district is 782 square miles, and its cost, including the preparation of the record of rights, has amounted to ₹3,69,801, which gives the high rate of 11½ annas per acre.

22. In Chittagong, the cadastral operations were continued. The original programme was to complete the survey in the Sadar sub-division, but by orders received in October, 1891, the operations were extended to Cox's Bazar. The area of cadastral survey completed on the 16-inch scale comprises 459 square miles in the Sadar sub-division and 26 square miles in Cox's Bazar. An additional area of 3 square miles was surveyed within the Municipality of Chittagong, partly on the 16-inch and partly on the 32-inch scale. The boundaries of tea gardens were also surveyed on the 16-inch scale, but in skeleton only, the interior details being omitted: the out-turn of this skeleton boundary survey is 187 square miles. Cholera was raging all over the area under survey during the latter months of the season, and there were 93 casualties therefrom in the establishment which however remained at its work with commendable zeal.

A cadastral survey of the Chakla Roshnabad estate in Tippera, belonging to the Maharaja of Hill Tippera, was decided on late in the season, and a detachment from the Chittagong party commenced the traverse survey thereof in April, and with considerable difficulty completed an area of 105 square miles. Preparations have been made for the coming cadastral survey by training 200 local men, and 100 more were under instruction at the close of the season.

23. In Orissa, the survey operations were continued in the Puri and Cuttack districts and commenced in the Balasore district. With a view to accelerating the progress and decreasing the cost-rate of the work, the strength of the party was greatly increased, and when it took the field it was equivalent to two ordinary cadastral parties. The area cadastrally surveyed on the 16-inch scale amounted to 1,402 square miles. In addition to this, the revision of 364 square miles of the Irrigation survey of 1878-79 on the 32-mile scale was effected and the maps brought up to date, a task which proved to be very little less arduous than making a survey *de novo*. Uriyahs have been only partially employed on the survey, as their progress was extremely slow: the average amount of work done by the Uriyah *amin* was only one-fifth of that done by the upcountry *amin*; their services were therefore utilized for the *khanapuri*. In the areas cadastrally surveyed, the record writing of 3,075 villages, covering an area of 1,452 square miles, was accomplished: this includes the records of the revised survey area which had not previously been written. The difficulties experienced in *khanapuri* has been very great during this season: the slow progress of the Uriyah *amin*, the constant changes in procedure, the non-supply of the *khewats*, and the inexperience of some of the *khanapuri* officers supplied by the Settlement Officer, interfered greatly with progress. The large amount of work which has been accomplished under such circumstances is very creditable to Lieutenant-Colonel Sandeman, who held executive charge of the party till the end of January, and to Lieutenant Crichton, who succeeded him.

The result of increasing the strength of the establishment has been the reduction of the cost-rate per square mile from ₹179 in the previous season to ₹157 in the present one, or a saving of ₹22 per square mile. The present year's rate is inclusive of the cost of completing considerable arrears of the work of the former year, and it is anticipated that the mileage-rate will be still further reduced during the ensuing season.

24. The survey of the estates of the Maharaja of Burdwan, situated principally in the Bankura district, was resumed by the small detachment which has been employed on this work for the last three years, in consequence of the manager having been able to recover possession of some missing villages from the light thrown on them by the survey of previous seasons. The difficulties experienced in this survey have been of an extraordinary nature: owing to the inaccuracy of the list of *patnidars* furnished by the Raj, it was found impossible to ascertain who were the real tenants, and therefore their attendance could not be enforced; the necessary information required to identify all the lost villages which by years of mismanagement had been lost sight of could not therefore be obtained. Operations were moreover obstructed by the deliberate uprooting of survey marks by the *patnidars*. The actual area surveyed cadastrally was only $13\frac{1}{2}$ square miles out of $62\frac{1}{2}$ square miles which the Raj officials claimed but were unable to point out. In addition to this, 621 square miles have been traversed.

25. Of the three parties engaged on cadastral surveys in Burma, one was employed in Lower Burma and two in Upper Burma. In the former, an area of 1,010 square miles were surveyed on the 16-inch scale in the districts of Amherst, Tavoy and Mergui; and in addition to this, 106 square miles of hilly country intervening between the cadastral portions were mapped on the 2-inch scale. The extent of the country to be surveyed, both in Tavoy and in Mergui, proved to be very much greater than had been anticipated, and it was found impossible to complete the required areas in these two districts in one year, as had been hoped. There were 54 Burmans employed as field surveyors during this year, the same number as in the previous year. The average out-turn of the Burman surveyor has again been found to be four-sevenths of that of the Hindustani *amin*, which agrees with the results of last year, and the loss on this account has been calculated at ₹100 for each Burman employed per season, after allowing for the cost of the passage to and from India for the Hindustani *amin*.

26. In Upper Burma, one party (No. 5) completed the cadastral survey of 1,818 square miles, on the 16-inch scale, in the Sagaing district, and commenced traverse operations in the Shwebo district, where 800 square miles were traversed in advance. At page 88 will be found a table in which are given cost-rates and other particulars of cadastral surveys completed since 1890-91.

The districts of Kyaukse, Mandalay, and Meiktila were surveyed by this party. It is satisfactory to see how greatly the cost-rate per square mile has been reduced since the first year of the operations in Upper Burma. During the first year the rate in Kyaukse was ₹227 per square mile, and this has now been reduced to ₹103 in Sagaing; it should however be noted that the difficulties in Kyaukse, owing to the lands having been to a great extent flooded, were much greater than in any of the other districts. The reduction in the cost-rate is largely due to the partial employment of local labour for chaining purposes in place of *khalâsis* imported from India, which has been found practicable in Upper Burma. Thirty-six Burmans were employed this year on the field survey against 30 during the previous year. With regard to the larger employment of Burmans as surveyors, the officer in charge reports that they are so uncertain that complete reliance cannot be placed on them.

27. The second party working in Upper Burma was employed in the Minbu district. This was the first season's cadastral work of this party, it having been for the last two years occupied in traverse operations in Lower Burma. In the Minbu district, 784 square miles of cadastral survey and 1,288 square miles of traverse survey were completed; a small amount, *viz.*, 156 square miles, was also traversed in the adjoining district of Magwe for next season's cadastral survey. Of the area cadastrally surveyed, 673 square miles were executed by Hindustani *amins* and 111 square miles by Burmans. Here, again, it was proved that though the work of the Burman may, so far as quality is concerned, compare well with that of the Hindustani, he is a slower, and consequently a more expensive, agent. A certain amount of local labour was also utilised in this party.

28. In Assam, cadastral operations were completed in the districts of Kamrup, Darrang, Sibsagar, and Lakhimpur in the Assam valley and continued in Sylhet. The detail surveys were made by a mixed establishment, in which the local agency largely preponderated: to the Hindustanis were allotted, as a rule, the more difficult portions, owing to their being better skilled than the locally trained men; to each Hindustani *amin* was attached a deputy *mandal* to write the Bengali records. The out-turn consists of 756 square miles of 16-inch survey in the Assam valley and 72 square miles in Sylhet. Extraordinarily heavy rains set in towards the end of March and almost paralysed all field operations; it was not until the 15th May that work was fairly resumed. The field season was less unhealthy than usual.

29. In the North-Western Provinces, the party which had hitherto been employed there for many years was partly transferred to Bengal, and a detachment only retained to continue the survey operations in the Garhwal district. The scale of the cadastral survey is 32 inches = 1 mile, the small size of the field necessitating the adoption of this large scale. Arrangements had been made for training a number of hill *amins* in anticipation of the non-return of many of the *amins* from the plains in consequence of the inconveniences they had to put up with from the physical difficulties of the country and the inclemency of the climate: this expectation was realized, for not half the old staff of *amins* returned. The area surveyed amounts to 252 square miles; it includes small patches of intervening waste, and it is estimated that at least 157 square miles will be classified as assessable land, in which at the time of last settlement only 65½ square miles were assessed. The cost-rate of the detail survey was only ₹183 per square mile, as against ₹283 last year. This reduction is chiefly due to the increased rate of progress made by the *amins* and to the reduced pay granted to the menials. The traverse operations were completed over all the tracts assigned for survey.

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

	Square miles.
Bengal	1,926
Burma	3,612
Assam	828
North-Western Provinces	232
TOTAL	6,598

This shows an increase of 1,565 square miles of cadastral survey over the out-turn accomplished in 1890-91, when there were 7 parties and 1 detachment

employed ; during this year there have been 7 parties (one being double) and 2 detachments at work. In addition to the above out-turn, 187 square miles of skeleton boundary survey, on the 16-inch scale, was executed in district Chittagong, and 364 square miles of revision survey in district Cuttack, which, as before stated, involved almost as much labour as a new survey.

TRAVERSE SURVEYS.

31. This year one party and one detachment were engaged on traverse operations: the first in the Central Provinces in continuation of previous operations, to furnish skeleton plots on an accurate basis for the field surveys to be executed by village *patwaris* and other local agency under the Settlement Department ; the second in Bihar in preparation for the cadastral survey to be commenced by the Survey Department in October 1892.

32. The out-turn of work in the Central Provinces amounted to 4,311 square miles, of which 2,174 square miles were in the Mandla district, 1,215 in Balaghat, and 922 in Bhandara. The country was for the most part hilly and densely wooded, the cultivation being scattered and difficult of approach on account of the intervening stretches of hill and forest. Skeleton plots, on the 16-inch scale, of 1,171 villages have been transmitted to the Settlement Department. The party suffered considerably from the malarious nature of the climate until about the end of February ; influenza also prevailed throughout all the districts under survey, no less than 27 men dying of it.

33. In Bihar, a total area of 1,610 square miles has been completed, of which 1,247 are in the Muzaffarpur district and 363 in Champaran. In addition to this, there is a balance of 301 square miles of traverse survey left over from the experimental survey executed under Colonel Barron in 1885-86, which gives an area of 1,911 square miles ready to commence cadastral work in October 1892. Stone marks two feet long have been embedded at tri-junctions and at the adjoining stations on each side; the rest of the traverse stations have been marked by pottery cylinders locally made.

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

	Square miles.
Central Provinces	4,311
Bihar	1,610
TOTAL .	5,921

This out-turn is 1,328 square miles in excess of that accomplished in the previous year by two full parties.

SPECIAL OPERATIONS.

35. The electro-telegraphic determinations of differences of longitude were resumed this year and six arcs were measured, *viz.*, Waltair-Madras, Waltair-Bolarum, Waltair-Jubbulpore, Calcutta-Waltair, Bolarum-Bombay, and Fyzabad-Dehra, thus completing the scheme of differential longitude determination within India proper. There remains some more work of this description to be done in Burma, Baluchistan, and Persia at some future date, but it has been postponed for the present in favour of other more pressing wants. The final reduction has also been completed, and will probably appear in Vol. XV of the professional series in the spring of 1893.

36. The tidal operations have been continued as usual. Observations with the self-registering tide-gauges have been made at 14 stations in India, Burma, Ceylon, the Andaman Islands and Minicoy. Two observatories have been dismantled during the year under report on completion of the necessary registrations, and four new ones are in course of erection.

37. In connection with these operations, spirit-levelling operations have been also continued and 452 miles of levelling were run, chiefly along the Bengal-Nagpur Railway, eastwards of Bilaspur.

GEOGRAPHICAL SURVEYS AND RECONNAISSANCES.

38. The area geographically surveyed during the year is considerably less than that which was obtained during the past two seasons, owing to the circumstance that no opportunity offered for explorations in Persia this year, which in the two previous years added large areas to the out-turn. The sphere of unknown country within our eastern and western borders is now considerably contracted, and the main part of this year's operations have been confined to the more regular surveys. Large areas of new country have however been mapped in Burma and Southern Baluchistan again this year.

39. The two parties, Nos. 11 and 21, employed in Upper Burma, have continued the preliminary survey of the country on the $\frac{1}{4}$-inch scale, which has now been brought within measurable distance of completion, except in the extreme northern part of the province, where the country is not sufficiently settled for survey operations, and which can only be accomplished in connection with military expeditions. In addition to the regular survey by districts, surveyors were as usual detailed to accompany the military and police expeditions proceeding into new country. The officers in charge of the parties were chiefly engaged in triangulation and in the general supervision of the regular work; but Captain Jackson, R.E., in charge of No. 11 Party, found time to explore the Bret country lying to the south-west of Karenni and to draw up a report on the country traversed and its inhabitants.

40. Mr. Kennedy accompanied the Maingkwan column under Major Dalzell, the object of which was to explore the Hukong valley. He joined the expedition at Mogaung in November 1891, whence it proceeded in a north-westerly direction to Laban and across the watershed, *vid* Sadusot, to Maingkwan in the Hukong valley. From this place he was able to secure a considerable area of new topography during excursions made to important surrounding villages. He returned to Mogaung in February by the Chindwin route, passing through the Taro valley. During the expedition, Mr. Kennedy succeeded in obtaining an area of 3,750 square miles of new country.

41. The total areas mapped by the two parties in Upper Burma amount to 42,078 square miles.

42. In addition to the regular topographical surveys executed by No. 15 Party in Baluchistan, a detachment was employed on geographical surveys in Kolwah and Makrán, and brought in an area of 19,084 square miles of previously unexplored country, mapped on the $\frac{1}{4}$-inch scale.

43. The military expedition under Sir William Lockhart, K.C.B., which operated against the Isazai tribes in the Indus valley in October, 1892, was accompanied by a small survey party under Captain Wahab, R.E. The brief time occupied by the expedition did not admit of much survey work being done, but Captain Wahab was able to reconnoitre an area of about 250 square miles on the $\frac{1}{2}$-inch scale in the Chamla and Buner valleys. This area has been included in the out-turn given under the head of topographical surveys.

44. Captain Bower, in his adventurous journey through Tibet during 1891-92, was accompanied by Atma Ram, an employé of the Survey Department, who was utilized for keeping the record of the route traversed. He succeeded in maintaining an unbroken traverse of over 2,000 miles in length, extending over 24 degrees of longitude. His services while employed on this duty, which was voluntarily undertaken, have been warmly commended.

45. The aggregate areas geographically surveyed during the year amount to 61,162 square miles, mapped on the $\frac{1}{4}$-inch scale.

HEAD-QUARTERS OFFICES.

46. The work done in the various offices at head-quarters is described in detail in Part III of this report.

47. The cartographic and other offices at the head-quarters have been superintended, as usual, by three Assistant Surveyor-Generals, *viz.*, the Drawing and Engraving Offices by Colonel W. H. Wilkins, S.C., except for a period of about six weeks when Colonel J. R. Wilmer, S.C., acted in charge; the Photographic and Lithographic Office by Colonel J. Waterhouse, S.C.; and the

Correspondence and Mathematical Instrument Offices by Lieutenant-Colonel M. W. Rogers, R.E., except for a period of seven weeks when Colonel W. H. Wilkins, S.C., acted.

48. In the Drawing Branch the maps of Burma on various scales have again formed the principal work. The second edition of the general map of Burma, on the 32-mile scale, has been published in a preliminary form, pending the final settlement of some of the district boundaries. The new map of Upper Burma, on the 16-mile scale, has been almost completed and will be published by June 1893. The third edition of the 32-mile map of India is ready for printing, but the publication is delayed for want of orders from Government regarding the boundaries.

There has been a steady increase of work as in former years, but now that an additional establishment of 16 draftsmen has been sanctioned, there are hopes that, when they have been efficiently trained, the Drawing Office will be able to cope in a satisfactory manner with these yearly increasing demands.

49. In the Engraving Office, the new plates of the 32-mile map of India, with the borders extended to the east and west, so as to include the limits of Burma and Baluchistan, are in a forward state of progress and will be ready before the end of 1893. The various provincial maps on the 16-mile scale have been still further advanced. The duplicate plates of the 96-mile map of India and the 96-mile railway map of India for the administration report of the Railway Department have been completed. The maps of India on the 128-mile and 256-mile scales are still in progress.

50. In the Calcutta City Survey Office, the final examination and completion of the fair sheets have now been taken in hand and 12 have been sent to press. One block, No. XII, has been sent to the Municipal Office to be placed on view for two months before final publication, and this procedure, which is in accordance with the Act, will be adopted for the remaining blocks. Only 864 holdings were left for final demarcation at the close of the year under report, and these will be completed by the end of February 1893. Progress is being made with the preparation of the fair sheets on the 16-inch scale by the process of heliogravure.

51. The work done in the Photographic and Lithographic Office again shows a large increase, chiefly in the printing sections, and it has been exceedingly difficult to comply with all the demands for colour printing, even with the aid of the steam machinery. An additional quad-crown steam litho-press has been obtained and is being put up, which will, it is hoped, enable the office to keep abreast of the increasing demands upon it. Out of a total of 7,532 original maps received for reproduction during the year, 4,956 were cadastral maps, 1,152 were ordinary departmental maps, etc., and 1,424 were miscellaneous subjects for other departments. The printed out-turn of extra-departmental work was again considerably in excess of the ordinary departmental work, and the value of it was ₹ 72,677-12. The number of pulls of maps and various other subjects printed off was 756,068; besides which there were 1,318,597 impressions from type, 92,415 heliogravure prints, and 5,464 photographic prints. The total value of the work done was about ₹2,10,357, being ₹ 1,703 more than that of last year and ₹9,982 greater than in the year before it.

52. Maps of districts Shahabad, Sylhet, and Patna have been lithographed by transfer from the copper plates, and several others of the same series prepared. A panoramic view of the snowy range, as seen from Simla, was drawn on stone from Colonel Woodthorpe's original drawing, but has not yet been printed off. The additions and corrections on stone to the 32-mile map of India (3rd edition) have again occupied much of the time of the lithographic section, and the publication of the map is awaiting the orders of the Government in regard to the boundaries.

53. Among the departmental maps photo-zincographed and published may be noticed maps of districts Benares and Basti, on the scale of 1 inch = 2 miles, prepared for the North-Western Provinces Government, plans of the stations of Dinapore, Kampti and Satara, and divisional maps of Kumaun, Rohilkhand, and Gorakhpur. Ninety-nine standard sheets of the topographical and revenue surveys were published either as new maps or re-prints with corrections and additions; and thirty sheets of the Madras forest surveys have also been published. A commencement has been made of the work of reproducing the original

sheets of the Calcutta survey on the scale of 50 feet = 1 inch, but no sheets have yet been printed. The preparation of the reduced map on the scale of 330 feet to the inch noticed in last year's report has not made progress, as the system proposed for preparing the reduced maps was not found to answer; but further experiments are being made.

54. Although the number of extra-departmental subjects received for reproduction was somewhat less than last year, the number of printed impressions shows a further large advance, owing to the increased demands for colour printing. The ordinary demands upon the office have been swelled by the preparation and supply of the maps and diagrams illustrating the report of the Leprosy Commission and the Census Reports for Assam, Rajputana, Central India Agency, and Berar. The preparation of these maps, as well as the increasing requirements of the meteorological departments for weather charts and diagrams in colour, have been a heavy tax on the resources of the office. The work done for other departments also includes the following: a new and elaborately coloured geological map of India for the Geological Survey Department; maps illustrating the gauges and systems of railways and an unusually large number of diagrams for the Railway Department; a series of colonial emigration maps; a coal and iron map; the administration report maps for Bengal and the Punjab, which have largely increased in their scope in recent years; a large number of maps, etc., many of them in two colours, for the Quarter Master General's Department; and a series of 8 plates of native soldiers illustrating the records of the Bengal Army.

55. Good progress has been made in the heliogravure section, though the number of plates photo-etched is somewhat less, owing to the introduction of photo-blocks. Fifty plates were reproduced by photo-etching, including 12 plates of Fishes and Crustacea for the illustration of Dr. Alcock's report on "The Zoology of H. M.'s. I. M. S. "Investigator," 13 plates of the Bower manuscript, and 8 plates of the Technical Art Series. Fifty-seven photo-blocks were prepared, most of them being for the illustration of Mr. Cotes' notes on Economic Entomology published by the Trustees of the Indian Museum. Fourteen hand engraved plates have also been electrotyped for the Engraving Office.

56. Colonel Waterhouse reports on a method of preparing a very sensitive orthochromatic collodio-bromide emulsion he has had under trial. Plates with the new emulsion require to be used in a moist state in order to obtain the greatest sensitiveness and clearness in the results; but this has inconveniences, and if some means could be found of preparing dry plates in this way with almost equal sensitiveness, the process might be introduced with considerable advantage. Trials have been made of new developers for dry plates, but the increased pressure of office work has left but little time for experiment in this or other new directions.

57. The number of new maps and new editions of departmental subjects published during the year amounted to 5,103, of which 4,897 were cadastral maps. The total number of maps issued was 190,579 and their value ₹ 1,36,079, which is somewhat less than the corresponding figures of last year. The cash sales of maps amounted to ₹22,091 during the year against ₹12,917 in the previous year. The increase under this head is principally due to the introduction of the ruling that public departments have to pay in cash for supplies under the value of ₹50—a procedure which involves considerable extra clerical labour and responsibility.

58. The demands on the Mathematical Instrument Office for scientific instruments are again in excess of last year, the total number of instruments issued on 1,500 indents being 83,202, valued at ₹3,16,373, as compared with 64,203 instruments, valued at ₹2,88,337, issued during the previous year. This has not been the result of any particularly heavy demand from any one department but of a general increase of demands throughout.

During the year 93,661 serviceable instruments, valued at ₹ 3,85,697, and 5912 repairable instruments, valued at ₹75,365, have been received into store. Owing to the partial introduction of cash payments for supplies under the value of ₹50, the cash receipts have increased from ₹14,871 in the previous year to ₹23,137 in the present year.

59. In the Trigonometrical Branch Office, Dehra Dun, the computing section has made considerable progress with Volume XV of the "Account of the Operations of the Great Trigonometrical Survey of India," containing the results of the electro-telegraphic differences of longitude, as well as the final reduction of all the longitude materials collected up to date: this volume will, it is expected, be published in the spring of 1893. Progress has also been made with the volume containing the tidal observations and with the synoptical volumes of the several chains of principal triangles. Of the latter, five of the Southern Trigon and five of the South-West Quadrilateral were occupying special attention. The pamphlet of spirit-levelled heights, No. 6, Bombay Presidency, was also published. Photographs of the sun were, as usual, taken on all days when it was visible, and the negatives forwarded to the Solar Physics Committee at South Kensington.

60. In the Drawing Office at Simla, the principal work of the year has been the preparation of the sheets of the South-West Asia series (comprising Western Persia) and of the North-West Trans-Frontier series, on the 8-mile scale. The first edition of the former series was completed. The North-West Trans-Frontier series is about half complete, and the publication of the sheets is progressing satisfactorily. The revision of the Turkestan map has made considerable progress during the year, and it is hoped that the new edition will be ready at an early date. Among other miscellaneous work done may be mentioned the compilation of Captain Bower's route traverse through Tibet, which was practically carried out in the field by Atma Ram, an employé of this office, who accompanied Captain Bower on his journey.

ESTABLISHMENT.

61. During the year, the Department has lost the services of five officers, of the senior division, who have been connected with it for many years.

Mr. W. H. Cole, M.A., Superintendent, 2nd grade, retired on the 7th April 1892, after a service of 25 years, during the whole of which time he was employed in the Trigonometrical Branch. Mr. Cole was an officer of high mathematical attainments, and his services have been of great value, especially in the preparation and publication of the scientific records of the Department.

Colonel R. Beavan, S.C., Deputy Superintendent, 1st grade, retired on the 11th June 1892, after a service of nearly 24 years in the Revenue and Topographical Branches.

Mr. A. D'Souza, Deputy Superintendent, 2nd grade, was superannuated on the 13th August 1892, after a service of 36 years, principally in the Topographical Branch. He was appointed originally in the junior division, and was promoted to the senior division in 1884.

Mr. M. J. Ogle, Assistant Superintendent, 1st grade, died while on furlough in England on the 4th April 1892, after a service of nearly 29 years in the Topographical Branch. The greater part of his service was rendered on the North-East frontier, where he gained a high reputation as an intrepid explorer. He was appointed originally to the Department in the junior division, and was promoted for his services to the senior division in 1890.

Mr. F. Grant, Assistant Superintendent, 1st grade, retired owing to ill-health on the 12th October 1892, after a service of 36 years, the whole of which was spent in the Revenue Branch. Mr. Grant was originally appointed to the junior division, and was promoted to the senior division in 1889.

62. During the year, the sanction of the Government of India was obtained, merely for departmental convenience, to an alteration in the designations of officers of the junior division, the object of which was to bring them more into accord with the duties now performed by them, as well as into harmony with the present titles in other allied or similar departments. The designation of Surveyor, as applied to members of the lower controlling staff, was considered to be inappropriate and calculated to lead to misconception and inconvenience; the titles of Surveyor and Assistant Surveyor have accordingly been changed to Extra Assistant Superintendent and Sub-Assistant Superintendent respectively. At the same time the Government has been pleased to concede the rank of gazetted officers to Extra Assistant Superintendents in consideration of the fact

that the duties now performed by officers in these grades are of a more onerous and responsible nature than they formerly were, and in conformity with the status held by the officers of the subordinate executive service with whom they are brought into official dealings under the new system of survey-cum-settlement procedure.

63. In the junior division seven vacancies occurred—two by the deaths of Messrs. G. A. McGill and J. Newland, one by the retirement of Mr. D. Atkinson, superannuated, one by the promotion of Mr. J. S. Pemberton to the senior division, and three by the deputation of officers to the Land Records Department in Burma.

INDEX TO THE CHARTS OF THE PRINCIPAL TRIANGULATION OF THE MANDALAY SERIES, BURMA.

No. 24 PARTY.

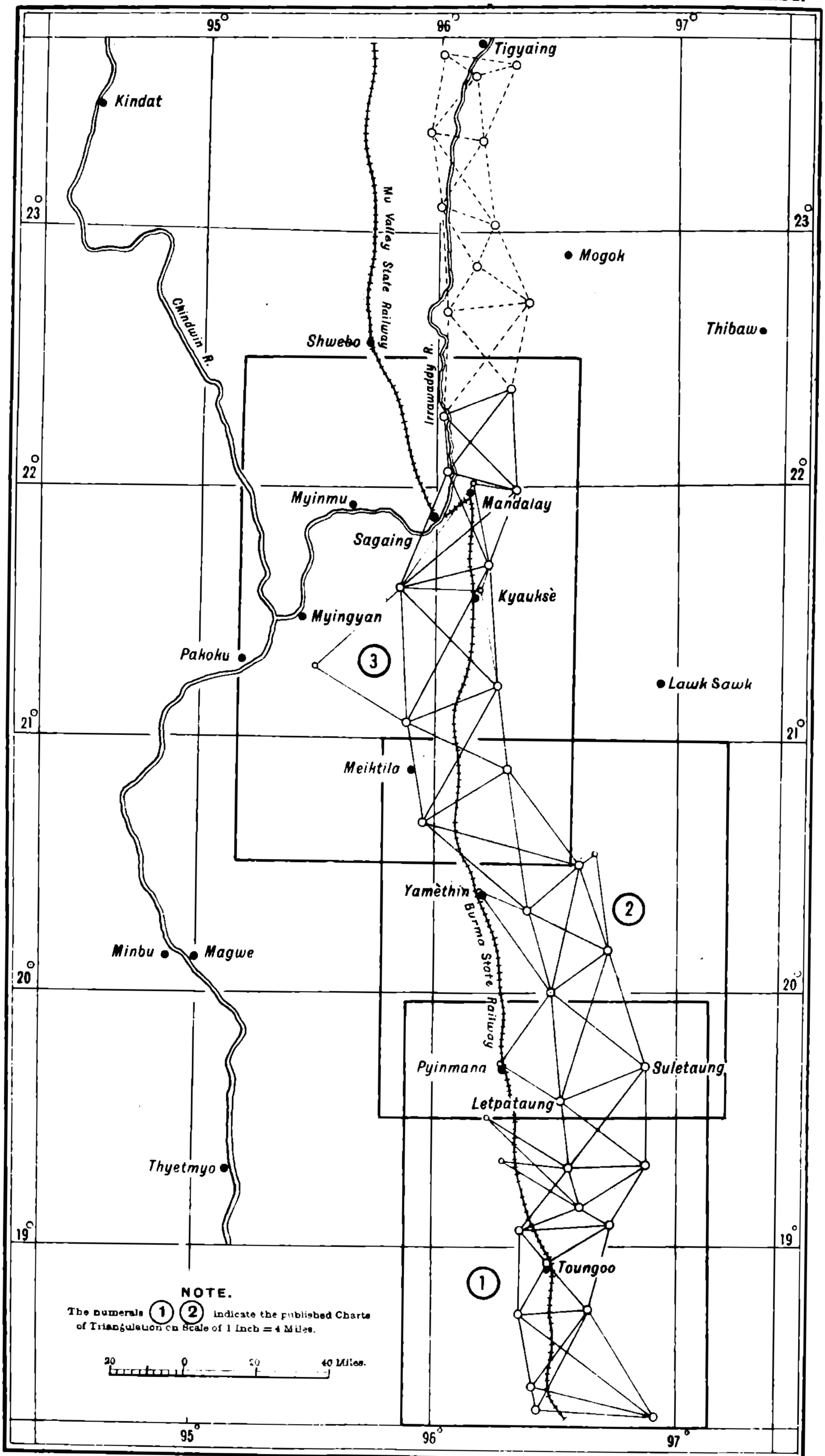


Photo S. I. O., Calcutta

PART II.

THE OPERATIONS OF THE SEVERAL FIELD PARTIES.

TRIGONOMETRICAL SURVEYS.

PRINCIPAL TRIANGULATION.

BURMA.

No. 24 Party.

64. This party, under Lieutenant Close, continued the principal triangulation in Upper Burma northward from the side Letpataung—Suletaung, up to which it had been carried in the previous season. For two figures, the direction of the series was nearly due north. It was then diverted slightly west of the original adopted meridian of 96° 30′, in order to avoid some difficult country, and to bring the west flank on to the plains, where the stations are most needed. The two southern figures were entirely in the hills which border the Southern Shan States: the remaining stations were partly on the same hills and partly on lower ones in the plains. The principal triangulation was carried through the districts Pyinmana, Yamethin, Meiktila, Kyaukse and Mandalay. A detachment of the party, under Mr. Christie, made a commencement with a secondary series, starting from the base Lethataung—Sintaung, and going eastwards through Mone towards the Mekong river.

Personnel.

Lieutenant C. F. Close, R.E., Deputy Superintendent, 2nd grade, in charge.
Lieutenant J. M. Burn, R.E., Assistant Superintendent, 1st grade.
Mr. A. Christie, Extra Assistant Superintendent, 2nd grade.
„ T. H. Rendell, Extra Assistant Superintendent, 3rd grade.
„ J. Hickie, Extra Assistant Superintendent, 4th grade.

65. The assistants arrived at Pyinmana on the 30th October, 1891, and Messrs. Rendell and Hickie completed the selection of a figure that the haze had rendered doubtful at the end of the previous season. Lieutenants Close and Burn arrived on the 13th November. The distribution of work was as follows: Lieutenant Close to undertake the observations of the four northern figures, and Lieutenant Burn those of the three southern ones; Mr. Christie to commence the secondary series, while Messrs. Rendell and Hickie were detailed to select and build forward stations north of Mandalay on the west and east flanks respectively. The principal observations were commenced by Lieutenants Close and Burn in the middle of November, and were continued till the 14th February 1892.

66. Cloud and rain hindered the work at the beginning of the season, and the haze set in unusually early. When the haze interrupted the terrestrial observations, astronomical observations were taken for azimuth. The work on the approximate series was continued till the 21st March 1892, and the building of covering pillars till the 14th April, when the field operations were closed.

67. With a view of comparing the heights obtained by the trigonometrical survey with those by the railway, levels were taken from a railway bench-mark at Mandalay to the trigonometrical survey station there, and from a trigonometrical survey bench-mark at Rangoon to a railway bench-mark there. The result gives a difference of 21 feet in the height of Mandalay hill station, the trigonometrical value being 783 feet and the railway value 762 feet above sea-level.

It is intended during the current season to run a line of levels from Rangoon to Mandalay, with necessary subsidiary lines, to the trigonometrical survey stations. This, besides checking the trigonometrical heights, will furnish a series of bench-marks for reference in irrigation and other projects of the Public Works Department, which it has been ascertained will be of the greatest utility.

68. In the recess, the computation of the principal triangulation and the drawing of the charts were finished. It is interesting to compare the resulting

latitudes and longitudes with those of the same hill stations used by the topographical survey party. These latter were based on a value of Mandalay Palace station obtained by Major Hobday on the first occupation of Upper Burma, the latitude being obtained from astronomical observations with a 14-inch vernier theodolite, and the longitude by frequent comparisons of the 4 P.M. Madras telegraphic time signal with the local time. The error in latitude was 3″·5 and in longitude 1″·2 of arc, which are remarkably small quantities.

69. The result of the season's outturn is as follows: Horizontal and vertical angles have been taken at fifteen principal stations, and star observations for determination of azimuth were taken at three stations. The series was extended over a direct distance of 195 miles, embracing an area of 4,300 square miles. Ten stations were selected and built in advance of the completed principal work, extending to a point 30 miles south of Katha. Seven important points were fixed by intersection, and seven covering pillars were built over principal stations. Six stations of the Kyaingsen secondary series were selected and marked, and six angles of that series observed.

70. The principal triangulation has been adjusted in seven figures, all quadrilaterals. The observations were made with Troughton and Simms' 12-inch microscope theodolites Nos. 1 and 2, and the mean triangular error for the whole season was 0″·62.

71. A statement giving the details of the outturn executed during the year will be found at page i of the appendix.

72. The party left Mandalay for recess quarters at Mussoorie on dates varying between April 15th and May 5th, 1892, Lieutenant Close leaving on the latter date. During recess, the party was working in the office of the Deputy Surveyor-General, Trigonometrical Branch, who thus had frequent opportunities of inspecting the work, concerning which he reports very favourably.*

TOPOGRAPHICAL SURVEYS.

GUJARAT AND SOUTHERN MARATHA COUNTRY.

No. 10 Party.

73. This party continued the detail survey in Gujarat and the Southern Maratha country, on the scale of 2 inches = 1 mile. Field operations commenced about the 15th November, 1891, and closed in Gujarat about the 15th May, 1892, and in the Southern Maratha country about the 1st June, 1892. Messrs. Todd and Stotesbury conducted the work in Gujarat, and Mr. Tapsell that in the Southern Maratha country, whilst Mr. Dickenson carried on the triangulation in advance for next field season's detail survey.

Personnel.

Lieutenant-Colonel J. Hill, R.E., Superintendent, 2nd grade, in charge up to 19th October, 1891, and from 1st to 12th November, 1891.
Colonel H. S. Hutchinson, S.C., Superintendent, 2nd grade, in charge from 13th November up to 4th December, 1891.
Major J. R. Hobday, S.C., Deputy Superintendent, 1st grade, in charge from 20th to 31st October, 1891, and from 5th December, 1891.
Lieutenant H. A. D. Fraser, R.E., Assistant Superintendent, 2nd grade, from 20th October, 1891.
Mr. W. Todd, Extra Assistant Superintendent, 1st grade.
" W. Stotesbury, ditto ditto, 3rd "
" C. Tapsell, ditto ditto, 4th "
" W. M. Kelly, Sub-Assistant Superintendent, 1st "
" R. R. Dickenson, ditto ditto, 1st "
" J. A. Freeman, ditto ditto, 3rd " from 23rd November, 1891.
24 surveyors, sub-surveyors and others.

74. The total outturn of the season's work is as follows:—

Detail survey, 2-inch scale	2,522 square miles.
Ditto 8 " "	12 " "
Triangulation	2,110 " "
Traversing	642 linear miles.

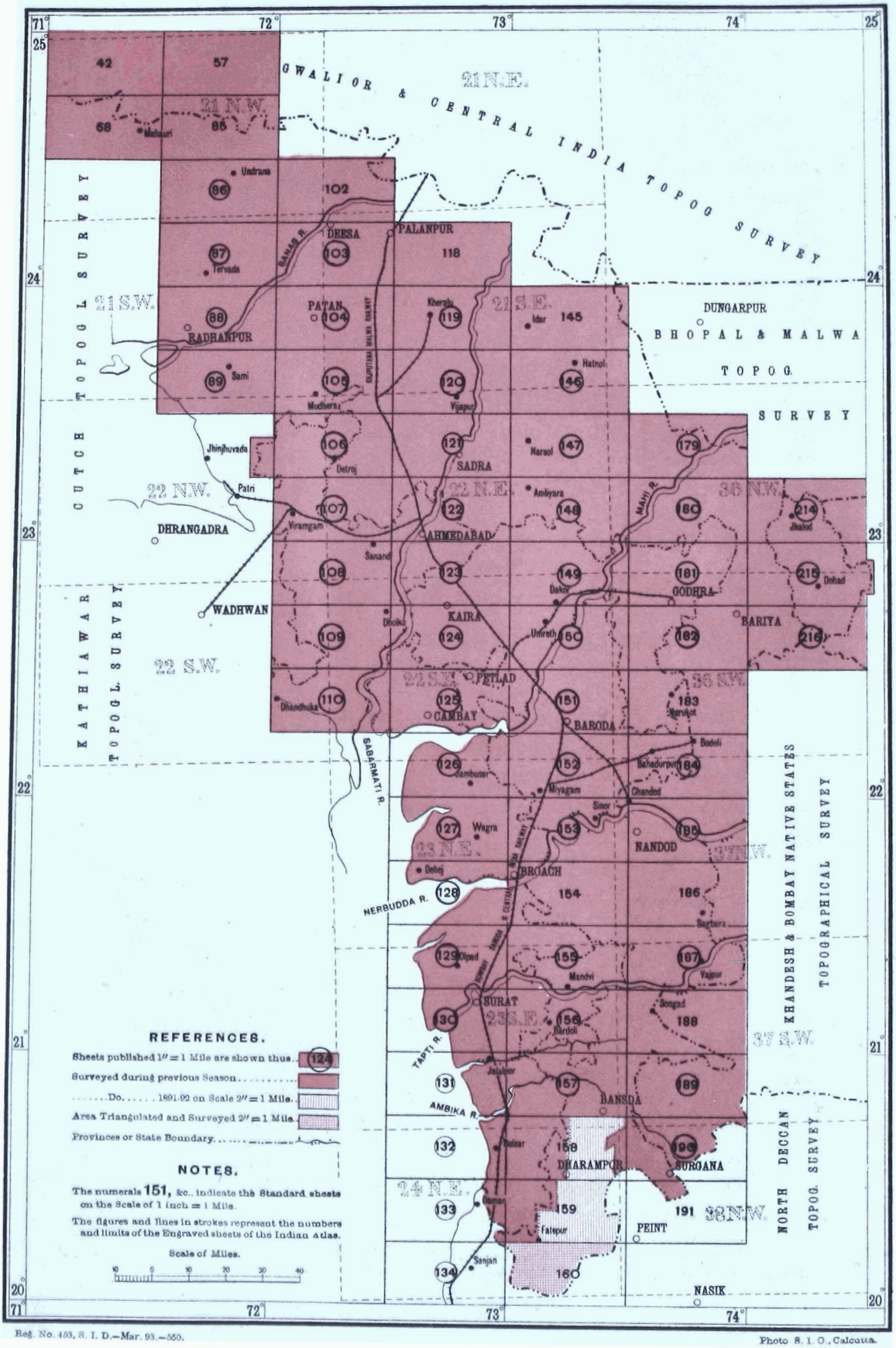
The operations of the different sections will be described separately.

* Lieutenant Close reports favourably of all his assistants, and speaks in high terms of the zeal and ability shown by Mr. J. Hickie in carrying out the most difficult part of the approximate work.

BOMBAY SURVEY.

INDEX TO THE TOPOGRAPHICAL SURVEY IN GUJRAT.

No. 10 PARTY.



REFERENCES.

Sheets published 1″ = 1 Mile are shown thus.. 124

Surveyed during previous Season.....

.....Do..... 1891-92 on Scale 2″ = 1 Mile.

Area Triangulated and Surveyed 2″ = 1 Mile.

Provinces or State Boundary.....

NOTES.

The numerals **151**, &c., indicate the Standard sheets on the Scale of 1 inch = 1 Mile.

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

Scale of Miles.

0 10 20 30 40

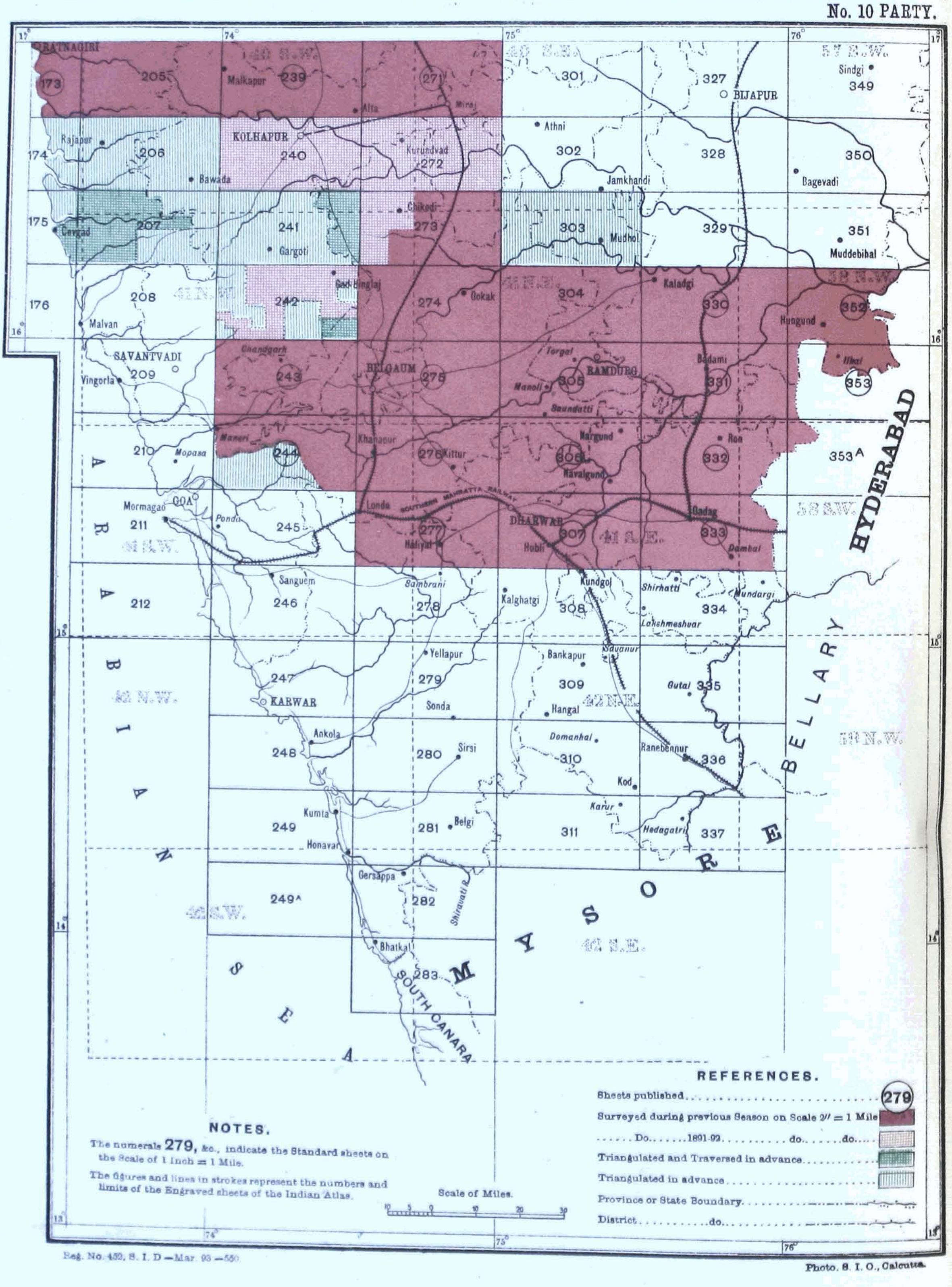
Reg. No. 453, S. I. D.—Mar. 93.—550.

Photo S. I. O., Calcutta.

BOMBAY SURVEY.

INDEX TO THE BOMBAY TOPOGRAPHICAL SURVEY IN SOUTHERN MARATHA COUNTRY.

No. 10 PARTY.



Reg. No. 452, S. I. D—Mar. 93—550.

Photo. S. I. O., Calcutta.

Gujarat Survey.

75. The area surveyed in Gujarat, amounting to 841·2 square miles, formed part of sheets Nos. 158, 159 and 160, and comprised the remaining portions of the State of Dharampur and the detached *pargana* of Nagar-Haveli belonging to the Portuguese Settlement of Daman. The out-turn of the season's work in Gujarat is as follows:—

Triangulation	300 square miles.
Detail survey, on 2-inch scale	841 „ „

The survey of the Gujarat Province is now completed.

76. The country operated in is covered with forest, and the features of the ground are of an intricate nature. Towards the close of the field season, fever was rife among the men forming the Gujarat detachment; Mr. Stotesbury himself was also a sufferer. The accuracy of the work was tested by 149 linear miles of traversing, besides a number of *in situ* examinations.

Southern Maratha Survey.

77. The survey in the Southern Maratha country was carried on in sheets Nos. 240, 242, 272 and 273, comprising portions of Native States under the Kolhapur Agency and portions of the Belgaum district.

Triangulation in advance of detail survey for next field season was effected in sheets Nos 303, 241, 207 and 175; also the traversing of the tri-junctions of village boundaries in British territory. The traversing in sheet No. 303 had to be abandoned owing to the famine prevailing in that locality.

78. In addition to the above, a survey of Kolhapur City and Cantonment was made, on the scale of 8 inches = 1 mile: the original sheets of the City portion, surveyed by Mr. Owen, of the Bombay Revenue Survey, some five years ago, and kindly lent by the Kolhapur Durbar, were utilised for incorporation in the map by the process of reduction.

79. The out-turn for the season in the Southern Maratha country amounts to—

Triangulation	1,810 square miles.
Traversing	642 linear „
Detail survey, on 2 inch scale . . .	1,680·4 square „
Ditto, on 8-inch scale . . .	11·5 „ „

80. The accuracy of the survey was tested by 136·4 linear miles of traverse, as well as by *in situ* examinations.

81. The country is open, flat and easy, except in the vicinity of the *ghâts* in sheets Nos. 240 and 242, where it is hilly and occasionally covered with scrub jungle.

82. Influenza was prevalent at the beginning of the field season, and incapacitated Mr. Tapsell for a short time, whilst one of the surveyors died of this complaint. There were also many cases of guinea-worm amongst the surveyors and *khalásis*.

83. The mapping, including certain arrears of the previous season, is well in hand, and every effort will be made to complete it all before the party takes the field again.

84. Lieutenant Fraser, R.E., was posted to this party when appointed to the Department in October, 1891. He surveyed 94 square miles in the hilly portions of the Southern Maratha country in a very creditable manner, and during the recess has become thoroughly conversant with the various computations. He has proved himself to be an intelligent, painstaking and zealous officer.

85. The recess office was inspected by the Officiating Surveyor-General in August, 1892, who expressed his satisfaction with the season's progress and the general arrangements made by the officer in charge.*

* Major Hobday reports favourably of all the Extra and Sub-Assistant Superintendents, and makes special mention of Messrs. Stotesbury and Tapsell both in the field and in recess.

BALUCHISTAN.

No. 15 Party.

86. The operations upon which the party was employed during the season were—

Personnel.

Colonel T. H. Holdich, R.E., Superientendent, 1st grade, in charge.
Captain R. J. H. L. Mackenzie, R.E., Deputy Superintendent, 2nd grade.
Mr. T. E. M. Claudius, Extra Assistant Superintendent, 3rd grade.
„ E. A. Wainwright, Extra Assistant Superintendent, 4th grade.
„ H. T. Kitchen, Extra Assistant Superintendent, 4th grade, from 25th June 1892.
„ G. P. Tate, Sub-Assistant Superintendent, 1st grade, from 13th July 1892.
Yusaf Sharif, Khan Bahadur, Sub-Assistant Superintendent, 3rd grade.
Hira Singh, Rai Bahadur, Sub-Assistant Superintendent, 3rd grade.

Surveyors and Sub-Surveyors.

Imam Sharif, K.B., Ahmed Ali, K.B., Abdul Guffar, K.S., Hussain Bux, Sheik Mohiuddin, Mohammed Naki, Nizammuddin, Madhat Khan, Ahmed Hussain, Jamuldin, and Wahid Bux.

(1) A detailed reconnaissance for a line of railway communication between Kurrachee and Kharán.

(2) Triangulation, including the extension of the Makrán series to the west, the revision of previous triangulation in Wad, and the extension of triangulation southwards to the coast, for $\frac{1}{2}$-inch scale topography.

(3) Topography on the 2-inch, $\frac{1}{2}$-inch, and $\frac{1}{4}$-inch scales.

87. Kurrachee was selected as the most convenient field head-quarters for the general direction of the party. The country under survey is generally so rough and inaccessible that inter-communication between the different sections of the party actually in the field is almost an impossibility. There is no treasury at Bela on which any reliance can be placed for money supplies, and only an inefficient postal service between that place and Kurrachee, whilst the generally unsettled state of the trans-frontier of Sind renders constant appeals to the local political authorities a necessity. From Kurrachee then, as the local head-quarters, the party took the field early in December 1891.

88. The reconnaissance, which was specially applied for by the Military authorities, was entrusted to Captain Mackenzie, R.E., who was employed on it during the whole season. The work was completed and will form the subject of a separate report.

89. As regards the employment of the European and native subordinate staff, the same procedure, as regards the breaking up of the native establishment into squads and placing them directly under the supervision of a European assistant, was adopted as in previous years, and with the same success. In a wild and difficult country like Baluchistan, young hands are especially dependent on constant supervision, even after their instruction is complete.

90. The extension of the Makrán series was carried out by Mr. T. E. M. Claudius, and forms a perfectly connected series based on the Great Indus Series of the Great Trigonometrical Survey, extending through the districts of Bela and Makrán, and on to the borders of Persia, following closely the parallel of 26° N. latitude.

91. Mr. Claudius was also in charge of a squad of detail surveyors working in Kolwah and Makrán on the $\frac{1}{4}$-inch scale, which brought in an area of 19,084 square miles of previously unexplored country. The country was generally very hilly and barren, and the squad experienced a great deal of difficulty owing to the unsettled state of the tribes. The out-turn of this section is—

	Square miles.
Triangulation	7,500
Topography, $\frac{1}{4}$-inch scale	19,084

92. The revision of the previous triangulation in Wad was entrusted to Mr. E. A. Wainright, who completed it with much difficulty owing to the wild and barren nature of the country in that tract. On completion of his triangulation, Mr. Wainright had charge of a squad of surveyors, who were to carry out the detail survey on the $\frac{1}{2}$-inch scale of the ground in which the triangulation had been revised, but this could not be effected on account of political difficulties and the unsettled state of the country. He was, therefore, obliged to move his squad down to Bela, where the survey was on the $\frac{1}{2}$-inch scale in connection with

Captain Mackenzie's reconnaissance. The out-turn of Mr. Wainwright's section is—

	Square miles.
Triangulation	1,900
Topography, ½-inch scale	603

93. The extension of triangulation for the ½-inch detail survey was carried out by Rai Bahadur Hira Singh, the area triangulated amounting to 3,000 square miles. He also effected a reconnaissance on the ¼-inch scale of his triangulated area.

94. In addition to the ordinary geographical surveys on the ¼-inch scale, Khan Bahadur Yusaf Sharif was deputed to make a survey on the 2-inch scale about Gwatar, and returned with an area of 26 square miles of topography along the coast.

95. The services of three of the best draftsmen in the party were retained during the field season at the field head-quarters, Kurrachee, to bring up arrears in mapping under the direct supervision of Colonel Holdich. Besides this supervision, and the general direction of the different detachments in the field, Colonel Holdich was enabled, through the kindness of the telegraph officials, who gave him occasional passages in the telegraph steamer, to visit the coast of Makrán, and inspect the work of such of the detail surveyors as were working near the coast. Colonel Holdich has submitted an interesting report on this part of the country, which has been separately printed. Subsequently he was enabled to visit some of the principal ports of the Persian coast, and thus to make arrangements for a general scheme for the purpose of obtaining reliable data, which may be of great value in revising Persian mapping.

For the facilities thus afforded him, Colonel Holdich is much indebted to Mr. Brooke, the Director General of Telegraphs, and to Mr. B. Ffinch, the Director of the Indo-European line.

96. The field operations closed with the return of the last surveyor to Quetta on the 20th May. The health of the party on the whole was not good. Three deaths occurred among the *khalásis*, and two soldier-surveyors had to be invalided from the field.

97. The total out-turn of work executed by the party is as follows:—

	Square miles.
Triangulation	12,418
Topographical survey, 2-inch scale . . .	26
" " ½ " " . . .	603
Geographical " ¼ " " . . .	19,084

98. The following reports were drawn up by the officers of the party during the year, and extracts therefrom will be found in the appendix:—

(1) History and Ethnography of Makrán, by Colonel Holdich.
(2) Description of the country surveyed, by Mr. Claudius.

99. During the recess, all the computations appertaining to the triangulation executed during the field season have been completed in duplicate, and the fair mapping of three sheets on the ½-inch scale and six sheets on the ¼-inch have been completed and sent for publication. A map on the scale of 16 miles = 1 inch, comprising the past season's work of this party, has been prepared and sent to the Drawing Office at Simla. In addition to the above, the mapping of six sheets on the ¼-inch scale is in hand.

100. A special survey on the 6 inch scale in the neighbourhood of Quetta has been started on the requisition of the Military authorities and has made fair progress. Two sub-surveyors were attached to the camp of the Political Agent at Fort Sandeman to accompany that officer in his tour through the Kundar and Chakan valleys. The services of Khan Bahadur Imam Sharif were placed at the disposal of the Home Government for employment in Africa.

101. During the year Surveyor Ahmed Ali Khan has received the title of Khan Bahadur for his good work on the frontier; and Surveyor Abdul Guffar has been distinguished by the title of Khan Sahib for his services in the Black Mountain Expedition of 1891.

His Excellency the Commander-in-Chief also has been pleased to consider

the services rendered in military interests of the undermentioned subordinates of this party:—

Sub-Assistant Superintendent Yusuf Sharif, K.B.,
Sub-Assistant Superintendent Hira Singh, K.B.,
Sub-Assistant Superintendent Imam Sharif, K.B,
Surveyor Ahmed Ali, K.B.,

and has caused a letter to be addressed to each of them conveying His Excellency's recognition and approbation of their services, and further has awarded them the sum of Rs. 500 each as an honorarium.

102. The programme for the ensuing season, which is subject to considerable modification, may be roughly indicated as follows:—

Messrs. Claudius and Graham, with five surveyors and sub-surveyors, will remain with the field head-quarters of the party at Quetta, and will be employed on large scale surveys for military and for revenue purposes in the Quetta district. When the weather does not admit of field work, they will be employed on mapping.

Mr. Wainwright with two surveyors will be detailed for special duty on the Persian border, where a good deal of important reconnaissance can be done and where triangulation is still possible.

Mr. Kitchen will continue the $\frac{1}{2}$-inch topography of the Las Bela district, working from the Sind border, near Kurrachee, northward.

One surveyor will remain attached to the Political Agent at Fort Sandeman; another will complete the $\frac{1}{4}$-inch survey of the Kolwah district; and another will be employed on special duty near Kharán.

Finally, Captain Mackenzie, with Rai Bahadur Hira Singh and a small party, will remain as at present on the Gomal line, strengthening triangulation in the first instance and awaiting future eventualities in that direction.*

HIMALAYAS, PUNJAB.

NO. 18 PARTY.

103. The party continued under the charge of Major Gore for the greater part of the field season, and on that officer proceeding on six months' furlough to England, the charge devolved on Captain J. M. Fleming, who held it until the 16th July 1892. Captain Fleming's services then being required in Burma, Capta in Bythell, R.E., was placed in charge until Major Gore's return from furlough.

Personnel.

Major St. G. C., Gore, R.E., Deputy Superintendent, 1st grade, in charge up to 25th March 1892.
Captain J. M. Fleming, S.C., Deputy Superintendent, 2nd grade, in charge from 25th March up to 16th July 1892.
Captain W. J. Bythell, R.E., Officiating Deputy Superintendent, 2nd grade, in charge from 16th July 1892.
Lieutenant C. H. D. Ryder, R.E., Assistant Superintendent, 2nd grade.
Mr. C. D. Potter, Extra Assistant Superintendent, 3rd grade.
„ W. Robert, ditto, 4th „
„ W. A Fielding, Sub-Assistant Superintendent, 1st grade.
„ P. F. Prunty, ditto, 1st „
„ R. W Senior, ditto, 1st „

Surveyors and Sub-Surveyors.

Shah Nasir-uddin, Atma Singh, Wahid Ali Khan, Ramsaran and 33 others.

104. In November 1891 Lieutenant Ryder, R.E., on appointment to the Department, was posted as an assistant to this party with a view to his being trained in survey duties.

105. The work now in progress consists of—

I.—A survey, on the scale of 4 inches = 1 mile, of the cultivated portions of Kángra district with its sub-division of Kulu, the more mountainous portions and grazing-grounds being mapped on the smaller scale of 1 inch = 1 mile.

* Colonel Holdich speaks in high terms of the services rendered by his assistants, both European and native. Of Messrs. Claudius and Wainwright he reports as follows:—

"I am much indebted to both these officers for the able way in which they carried out my instructions. Without the steady support of experienced European surveyors of their type, it would be almost impossible to deal with such a country as Southern Baluchistan."

PUNJAB SURVEY.

No. 18 PARTY.

INDEX TO THE SURVEY OPERATIONS IN THE HIMALAYAS.

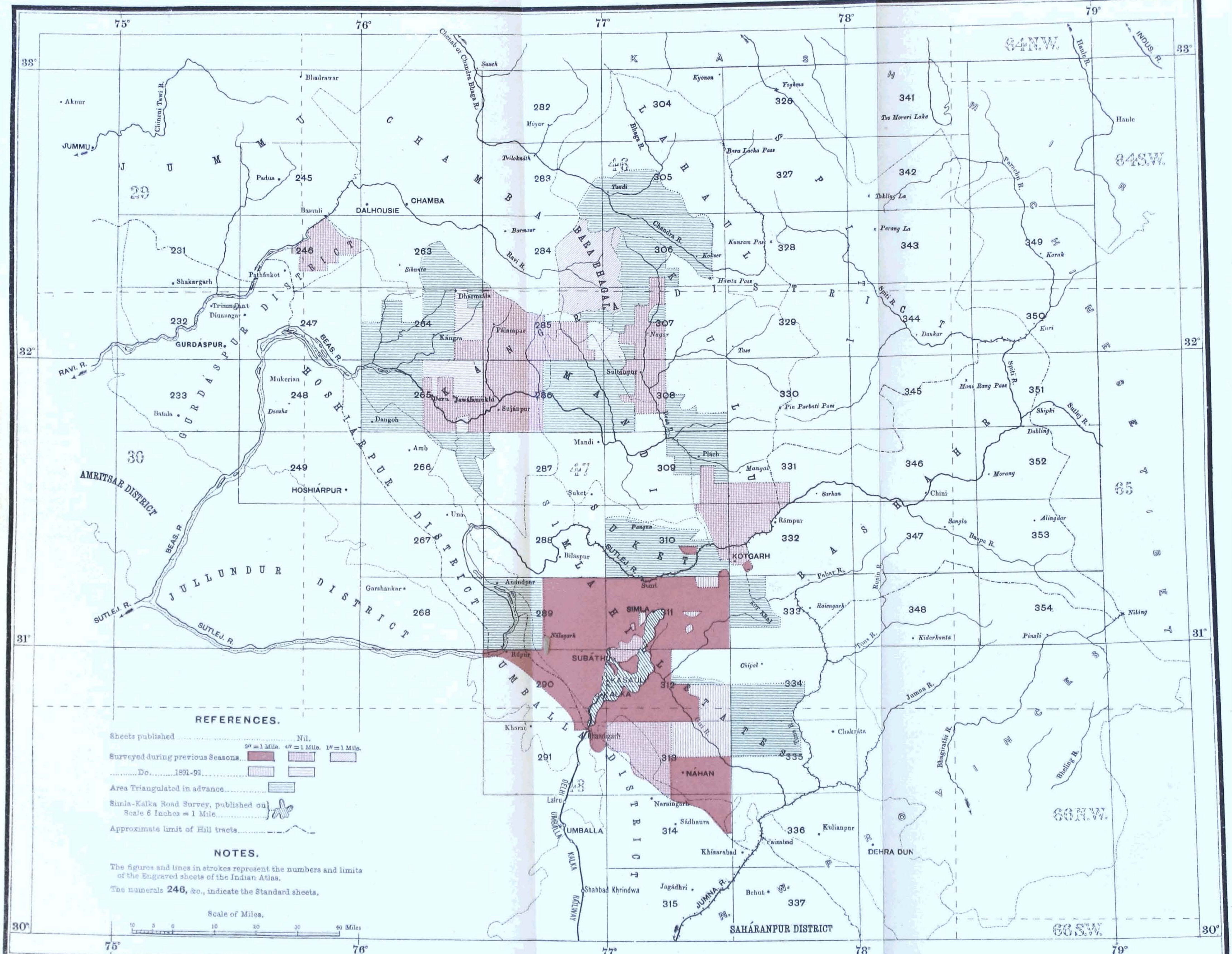


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Photo. S. I. O., Calcutta.

II.—A survey, on the scale of 4 inches=1 mile, of the Government forests in Kángra and Kulu.

III.—Surveys, on the scale of 2 inches=1 mile, of the Simla Hill States with Mandi and Suket, particular attention being paid to the State boundaries.

To this has now been added—

IV.—A special survey, on the scale of 4 inches=1 mile, of the reserved forests situated in various Native States constituting the Simla Hill States. These forests have only lately been reserved and are in process of demarcation, and standard forest maps of them are required.

106. The party took the field early in November, with the exception of Mr. Senior, who was sent earlier into Kulu to carry on triangulation. On account of the arrears of mapping which had accumulated under Major Gore's predecessor, it was determined to retain a portion of the party at Simla to work off as much as possible of the arrears. With this view Messrs. Potter and Robert with five surveyors remained at Simla, and were employed throughout the field season in correcting and completing the sheets in arrear. This arrangement has proved very satisfactory, no less than 32 sheets having been cleared off.

107. The detachments for the most part returned from the field during May, some few remaining out until June, having been employed in completing those portions of Chota Bangahal which were left incomplete last season on account of the heavy snowfall.

108. No regular work was done in Kulu during this season, as it had been decided to utilize the fine weather immediately after the rains for this purpose in future; and as it was not possible to commence this arrangement during the season under report, the men of the Kulu detachment were utilized in Simla as above mentioned.

109. In consequence partly of these arrangements and partly of the disorganization of the country caused by a serious epidemic of cholera, the out-turn of the party is much smaller than usual, the areas topographically surveyed being as follows:—

Localities.	Scale.	Area in square miles.
District Kángra . . .	4 inches=1 mile	245
Simla Hill States . . .	2 inches=1 mile	239
Ditto Forests . .	4 inches=1 mile	45
	TOTAL .	529

The area triangulated in advance for future topography during the year was 1,157 square miles, 556 square miles having been prepared for 4-inch and 601 square miles for 2-inch survey.

110. For the Forest Department in Kángra, 51 forest blocks were surveyed either wholly or in part, those under the direct charge of the Forest Department being found well demarcated with permanent pillars at the salient points. In Kulu four forest blocks were surveyed.

111. The special surveys of the forests in the Simla Hill States were commenced during the season. Those belonging to the Patiala State were first commenced, as their demarcation was in a more forward state: two surveyors were employed on them, and in all 45 square miles, or 28,804 acres of demarcated forest, were surveyed.

This area is comprised in 10 first class and 64 second class forest blocks of which the survey is completed, and 7 first class and 5 second class blocks which have been partially surveyed. A little delay occurred owing to the demarcation of the second class forests not being at first quite finished, but this was soon rectified by Mr. Minniken, the Forest Officer deputed for the purposes of the

demarcation. This demarcation is well carried out, and promises to be permanent. As yet however no interior boundaries between the various forests have been laid down.

112. In the ground which came under survey on the 2-inch scale in the Simla Hill States no forests were found demarcated, the territory belonging to the Sirmur State and their forests being only in process of demarcation. These forests will be surveyed on the 4-inch scale, and their boundaries also subsequently entered on the 2-inch maps.

113. Three soldier-surveyors were under instruction during the season. Of these, Havildar Budhihal completed his course and returned to his regiment a well qualified surveyor and reconnoitrer. The other two men who where sent direct from the Assam Military Police without any previous training at Roorkee College are still under instruction, but they are reported as never likely to become very efficient.

114. The programme for the ensuing field season includes the extension of the triangulation in Kulu, Mandi, and the Simla Hill States, the continuation of the 4-inch detail survey in Kángra and Kulu, the 2=inch work in Mandi, and the special 4-inch forest surveys in Patiala and Sirmur.

115. The recess office of the party at Simla was inspected by the Deputy Surveyor-General in October, who reports that good progress has been made in working off the arrears alluded to in last year's report. In consequence of improved administration the party is now working very efficiently, and no further necessity exists for withdrawing surveyors from their field work during the cold weather to bring up accumulated arrears of mapping or computation. They are not yet entirely cleared off, but have been reduced to manageable dimensions under Major Gore's judicious control.*

MERGUI DISTRICT, LOWER BURMA.

DETACHMENT.

116. In consequence of the representation of Mr. Hughes, Superintendent, Geological Survey Department, and of the local district officials, the Burma Government again requested that the topographical survey of the district of Mergui should be continued, but suggested that the party should be reduced to a detachment. This was accordingly done, and it was placed under the superintendence of Mr. A. J. Gibson.

Personnel.
Mr. A. J. Gibson, Extra Assistant Superintendent, 1st grade, in charge.
„ J. A. Higgs, Sub-Assistant Superintendent, 1st grade.
7 sub-surveyors.

117. The programme was arranged in consultation with Mr. Hughes, and consisted of the 1-inch topographical survey of—

(1) the country comprised in sheets Nos. 218 and 219 round Maliwun and to the south as far as Point Victoria, after which the work was to be extended northwards up to the parallel of latitude 10°30″ if possible.

(2) a portion of country near Banhuni in sheet No. 217, covering an area of about 40 square miles.

(3) a portion of sheet No. 226 on the Great Tenasserim river.

(4) a traverse survey along the courses of the Pagchan and the Great and Little Tenasserim rivers.

(5) surveys of the separate tin mines on the 8-inch scale. These were undertaken at the request of the Financial Commissioner, made after the commencement of the field season.

118. It will be seen from the index map that the work in the south of the peninsula is about 120 miles from that on the Tenasserim river : this necessitated the sub-division of the detachment into two portions. One, consisting of four

* Maior Gore reports very favourably of Lieutenant Ryder, R.E., and of Messrs. Potter, Roberts, Fielding and Senior, and also of Surveyor Shah Nasiruddin and Sub-Surveyor Asmatullah.

BURMA SURVEY.

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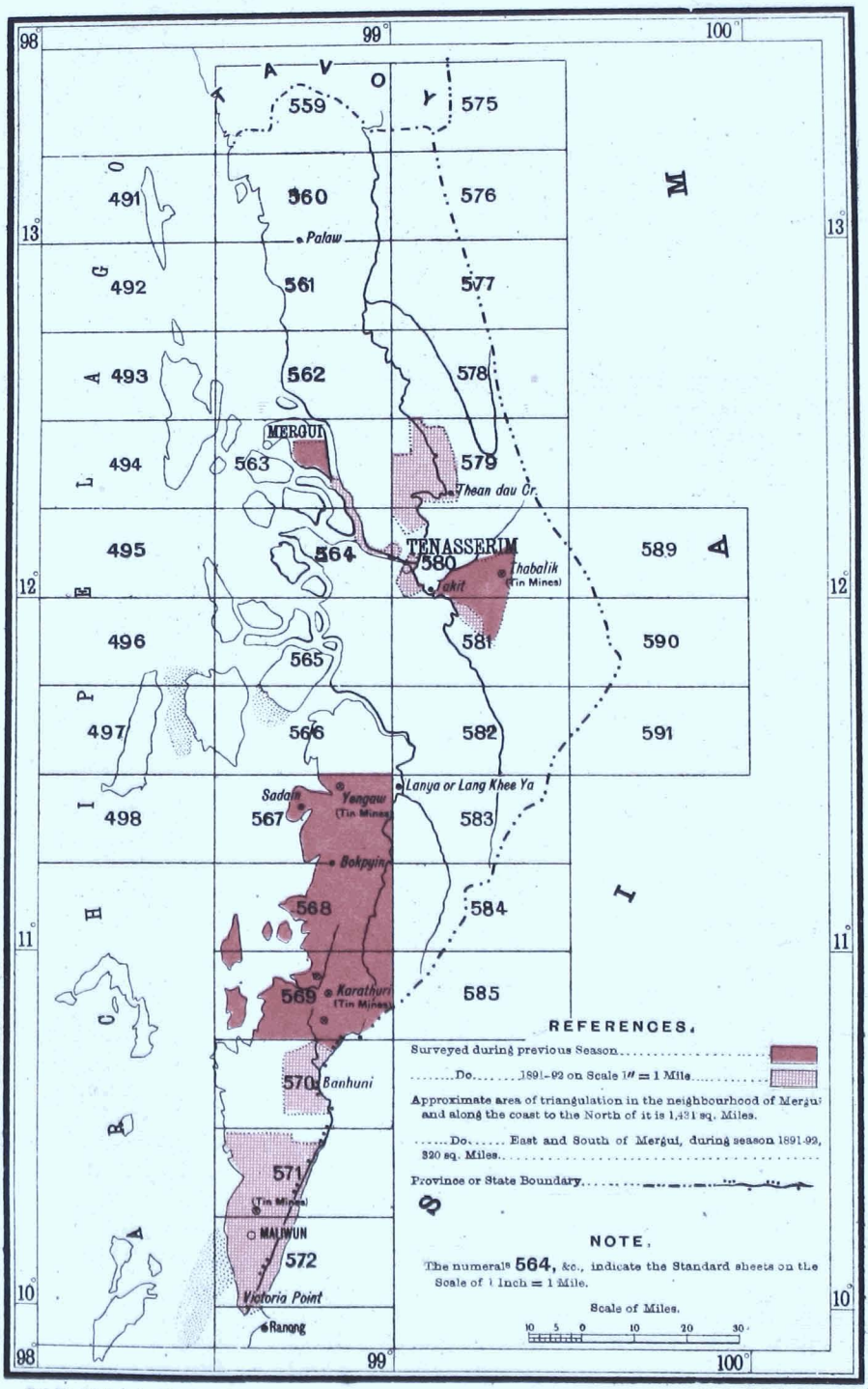
DETACHMENT.



Reg. No. 433, S. I. D.—Mar. 93.—550.

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

sub-surveyors under Mr. Higgs, worked in the south and completed the work under (1) and (2) as well as the traverse along the Pagchan river; the remainder of the party worked under Mr. Gibson on the Tenasserim rivers, and completed (3) and the traverse survey of the Tenasserim rivers. The 8-inch surveys of the tin mines, which were dotted about in the different areas under survey, were taken up by the sub-surveyors as was found convenient.

119. The total out-turn of the party was 765 square miles of topography on the 1-inch scale; 86 linear miles of plane table traverse along the Pagchan and Great and Little Tenasserim rivers; surveys of 81 separate tin mines on the 8-inch scale; 31 linear miles of theodolite traversing, and about 320 square miles of triangulation: this more than completed what had been originally asked for as absolutely necessary, and, considering the nature of the country, the out-turn may be considered very satisfactory and creditable to Mr. Gibson and his assistants.

120. The party, which had recessed at Bangalore, assembled at Mergui on the 4th November 1891. As Mr. Gibson had been detained at Bangalore in order to meet Mr. Hughes, the starting of the field parties devolved on Mr. Higgs. During the latter part of November and December progress was slow, owing to bad weather, but in January a satisfactory out-turn was reported, and this continued until the end of May, when the field season closed. Recess work recommenced at Bangalore on the 21st June 1892.

121. The nature of the country has already been alluded to in previous reports; and the same dense forest, steep hills, mangrove swamps and absence of roads were again met with this year in the Maliwun sub-division. The Tenasserim valley however is not so rugged, and owing to the existence of villages and open ground and the possibility of occasionally obtaining rice, the difficulties experienced in that portion of the work were not so great. The Great Tenasserim river is navigable by steam-launch as far as Tenasserim only; from thence it is possible to take country-boats up another 15 miles to Tarabong, after which only canoes can proceed. The Little Tenasserim river is navigable for only a few miles above its junction with the larger river.

122. As in previous seasons, the provisioning of the detached camps was a source of great responsibility to the officer in charge, as a failure in this respect might have led to very serious results. Arrangements were made with a native firm at Mergui to furnish rice, *dhal*, flour and other necessaries, but, owing to the prevailing scarcity, rice was not forthcoming in sufficient quantity to stock the depôts for the whole season; enough was despatched to last for two months, the remainder being subsequently forwarded by the S.S. "Mergui" and by boats, as the steam-launch was temporarily laid up through an accident to her rudder. Two main depôts were formed at Tenasserim and at Victoria Point, and these two were supplied direct from Mergui: the minor depôts, from which the detached camps drew their supplies obtained their stores from these two main depôts. A further source of difficulty was the want of water on the islands: in one case two signallers had been left on an island where there was no water, and their boat, which had gone to the mainland for a fresh supply, was detained by stress of weather; the men were thus left without water for 1½ days, when they were relieved by Mr. Gibson in the steam-launch; had it not been for the launch, the men would probably have died before assistance could have reached them. The above were not the only dangers the men were exposed to, for on two occasions they were attacked by bears: in one case a man was mauled, though not very severely, and on another occasion a small squad of men were attacked and driven into the jungle, where they lost themselves; search parties were sent out, but owing to bad weather and fog the men could not be found, and it was not until after five days that the almost starved men found their way back to camp. One man died subsequently of bronchitis brought on by exposure at that time.

123. In the Tenasserim valley, a comparatively small amount of sickness was experienced, and there were no deaths. The men working in Maliwun were not so fortunate, and suffered a good deal from fever, dysentery, bronchitis, and sores caused by leech bites. There were five deaths from fever, besides the one from bronchitis alluded to above. This represented a loss of about 5 per cent. on the establishment of the Maliwun section.

124. During the recess, the computations of the season's triangulation were completed, and tracings of the field sheets were made for the Geological Survey

Department and for the local authorities. The final completion of the standard sheets will be made next year when the field work and the triangulation are all finished: to make fair copies of the work as it stands at present would only entail double labour, as some parts have not as yet been correctly located by triangulation.

125. Mr. Hughes having again applied for the service of the detachment for the survey of the Tenasserim coal field and the completion of the Maliwun township, sanction has again been given by the Government of India to its continued employment on condition that the extra expenditure shall be borne by the Burma Government. It has accordingly been decided that the programme for 1892-93 shall be the 1-inch topographical survey of the coal field near Tenasserim and of the country between it and Mergui, and as much as possible of sheets Nos. 211 and 212, and the completion of sheet No. 217 to the south. The detachment has been still further reduced by the transfer of Mr. Gibson to Assam, which has necessitated giving charge of the detachment to Mr. Higgs. This officer is very junior to have independent charge of a detachment in so difficult a country, but he has been so highly spoken of in connection with his energy and good arrangements in this very work that there is no doubt he will carry it through to a satisfactory conclusion. The work near Tenasserim will, in the first instance, be undertaken by Mr. Gastaud and three sub-surveyors of No. 7 Party, a part of which will be employed on the cadastral survey of the cultivated portions of the valley in the immediate neighbourhood; as Mr. Higgs completes the work to the south he will move his men northwards, and all will work together.

126. The detachment was inspected at Bangalore by the Officiating Surveyor-General, who was well satisfied with the state in which he found the party.*

DISTRICTS IN THE NEIGHBOURHOOD OF ADEN.

DETACHMENT.

127. This detachment was formed in October, 1891, for the survey of the districts around Aden, occupied by the various Arab tribes protected or subsidised by Government. This area is roughly a semi-circle with a radius of about 70 miles described with Aden as centre, and extends from the coast to the borders of Turkish Arabia. The detachment was placed in charge of Captain Wahab, Deputy Superintendent.

Personnel.

Captain R. A. Wahab, R.E., Deputy Superintendent, 1st grade, in charge.
Mr. E. Graham, Sub-Assistant Superintendent, 1st grade.

Surveyors.

Asghar Ali and Jaffir Ali.

128. The party reached Aden on the 25th October, and remained in the field until the beginning of April, returning to India by the I. M. S. "Dalhousie" on the 24th idem. The out-turn of work during this period included the triangulation of nearly 7,000 square miles, and the detail survey on the ½-inch scale of 4,426 square miles of country. The latter area includes all the tracts under British influence with the exception of a small portion of the Subaihi country and the Radfan range, which could not be entered by the surveyors owing to the hostility of the inhabitants.

129. The country surveyed consists of two distinct zones differing widely in physical character. The southern portion, about one-third of the whole, is an open plain, extending some 80 miles along the coast on either side of Aden, and varying in width from 6 to 30 miles. The remaining two-thirds is a mountainous tract, rising steadily from the maritime plain to the Yaman highlands, where

* The officer in charge of the detachment speaks very highly of Mr. Higgs' zeal and energy in overcoming difficulties; he had the superintendence of the men working in the Maliwun township, and in addition to this he himself completed 258 square miles of topography. Mr. Hughes has also made special mention of the good services rendered by Mr. Higgs. Shedi Lall, Sub-Surveyor, is commended for a good out-turn in a difficult country, and the writer, Babu S. K. Chatterjee, is reported as having given satisfaction.

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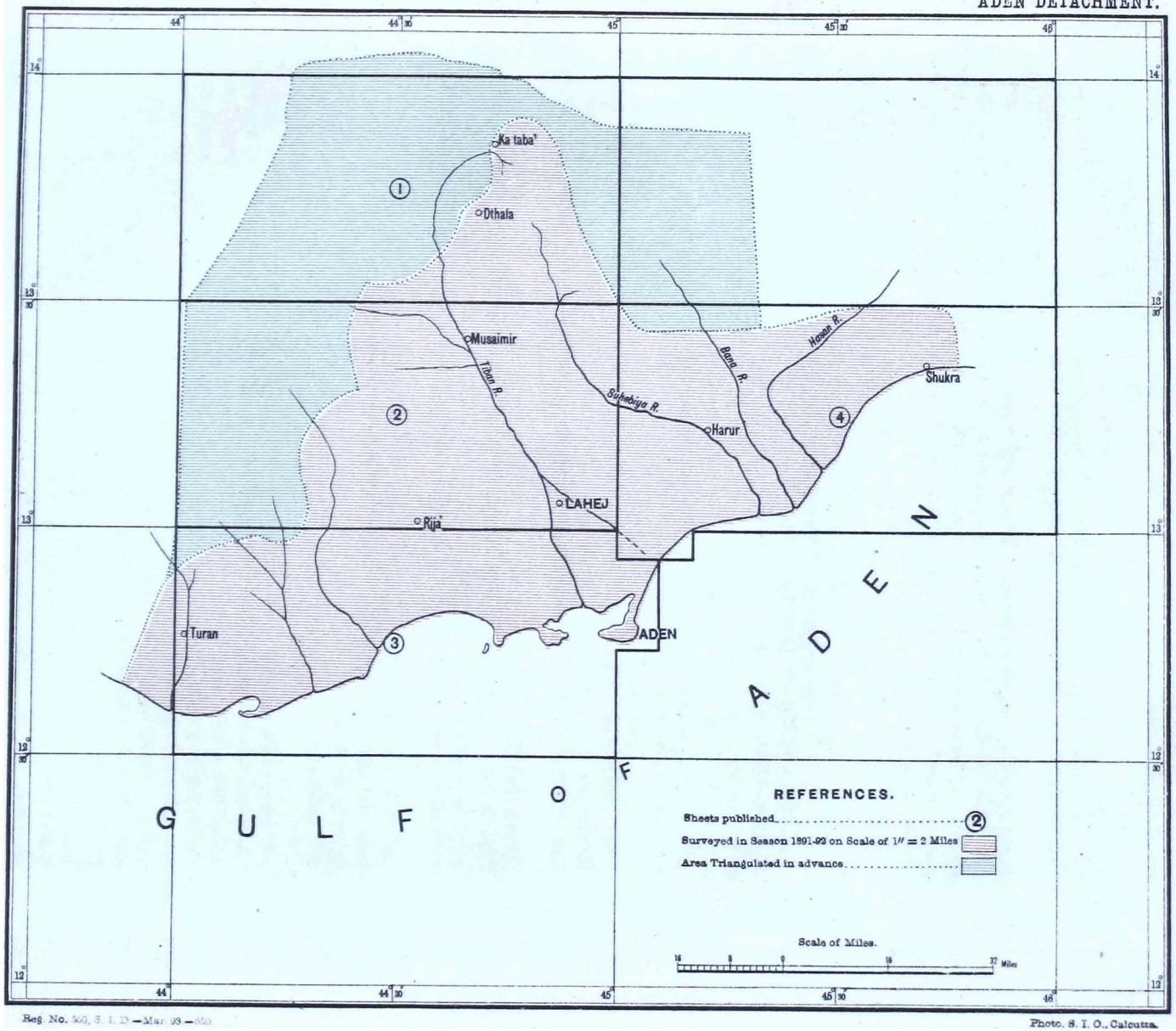
ADEN DETACHMENT.



Reg. No. 500, S. I. D.—Mar. 93.—500.

Photo. S. I. O., Calcutta.

several peaks on the northern margin of the season's work exceed 10,000 feet in altitude.

130. The greater part of the maritime plain is a sandy tract, covered in places with coarse desert grass and acacia jungle ; but it contains in Lahej and Abyan oases of the highest fertility, watered respectively by the Tiban and Bana rivers, both perennial streams draining a large area of mountainous country. Several other mountain torrents cross the plain, along the dry beds of which water is found in wells at a depth of 60 to 100 feet. Except in the oases, there are no villages or settled inhabitants, but encampments of nomads are always to be found in the neighbourhood of the wells.

The lower hills consist for the most part of barren, stony ridges with occasional fertile valleys; the higher ranges are generally flat-topped, often forming plateaux of considerable extent, with villages and fields on their highest summits.

131. The inhabitants are Arabs divided into various tribes and sub-tribes, independent as far as their internal affairs are concerned, but receiving subsidies from Government, in return for which they agree to abstain from raids on British territory and on caravans trading between Aden and the interior. These tribes in the neighbourhood of Aden, such as the 'Abdali and some sections of the Fadthli and Subaihi tribes, are amenable to British influence, but those inhabiting the remoter hills have little or no respect for our power.

An interesting description by Captain Wahab, R.E., of the country surveyed and of the tribes inhabiting it, will be found in the appendix.

132. Prior to the arrival of the party, the Political Resident had communicated with all the local chiefs of importance, and made all possible arrangements to avoid friction with the inhabitants. Military escorts were provided to each detached party, of sufficient strength to protect the surveyors, and a native political officer of great experience, Mr. Mahomed Salih Jaffir, K.B., was placed at the disposal of the Deputy Superintendent, and his assistance and advice were of the greatest value throughout the operations. Still, the survey was not carried out without opposition; twice the surveyors were attacked by large numbers of hostile Arabs, but were fortunately able to retreat without loss; as a rule, however, the judicious distribution of *bakhshish* was sufficient to overcome any opposition offered.

133. The party suffered greatly from sickness, chiefly malarial fever, during January and February, while working in the Tiban valley. No deaths occurred among the survey establishment, but four sepoys died and several more were invalided from illness contracted while acting as escort to the survey party.

134. During the recess, the whole of the mapping of the season's work has been completed in four standard sheets on the $\frac{1}{2}$-inch scale. A map has also been prepared on the scale of $\frac{1}{4}$ inch to a mile, embracing the whole area surveyed in one sheet, as well as a skeleton map on the same scale, showing the distribution of the tribes and principal sub-tribes.

135. Orders were received before the party left Aden for the survey, on the 8-inch scale, of the peninsula of Aden. As this would have involved the retention of the party in Aden during May and June at least, permission was given to its postponement till the next cold season, and it has now been further postponed on financial grounds for another year. If this work is taken up in 1893-94, advantage should be taken of the opportunity to extend the small scale survey in the unsurveyed part of the Subaihi country on the west and the Radfan hills and Bana valley on the east. One surveyor could do all that is required in three or four working days in each locality; but he should be accompanied by an experienced political officer, and a military escort strong enough to ensure the safety of the party, and to avoid the necessity of retreat in the event of hostile demonstrations.*

* Captain Wahab reports as follows regarding his assistants :—

"Both in the field and in office Mr. Graham is a thoroughly efficient officer, energetic, trustworthy and resourceful."

"Asghar Ali Beg is a quick and accurate topographer, and promises to make an excellent frontier surveyor."

"Jafir Ali is an excellent topographer and a good draftsman, but has not the personal qualities essential in a frontier surveyor."

FOREST SURVEYS.

CENTRAL PROVINCES.

No. 14 Party.

136. This party, under the charge of Colonel Wilmer, was employed in surveying the forest reserves of districts Hoshangabad and Betul on the 4-inch scale in continuation of the previous year's operations.

Personnel.

Colonel J. R. Wilmer, S.C., Superintendent, 2nd grade, in charge.
Mr. N. C. Gwynne, Extra Assistant Superintendent, 2nd grade.
„ J. Keating, Sub-Assistant „ 1st „
„ D. Campbell „ „ „ „
„ B. R. Hughes „ „ 2nd „
„ J. O. Greiff „ „ 3rd „

Surveyors and Sub-Surveyors.

Mohammad Zakaria, Hydar Ali, Gurdutt Singh, Kadir Sharif and 40 others.

137. It took the field in the first week of January, 1892, and by the end of April had completed the following work :—

(*a*) Triangulation in the forest reserves of district Nimar in sheets Nos. 8, 9, 14 and 15 below latitude 21°30′; also in a small portion of sheet No. 7.

(*b*) Theodolite traversing for laying down forest boundaries and fire lines and for supplying more fixed points for detail survey ; 454 linear miles were done in district Nimar in advance of topography, and 120 linear miles in district Hoshangabad for current season's detail work.

(*c*) Detail survey, on the 4-inch scale, in the Bori forest reserve, and the 2nd class forest in sheets Nos. 23, 24, 34 and 35 in district Hoshangabad. This completes the whole of the forests in districts Hoshangabad and Betul so far as they have been allotted to this party for survey.

(*d*) Classification of forest growth and soil of the area surveyed in detail during the season under report.

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

1. Triangulation of 684 square miles of country, fixing 669 points (including stations) and 670 heights.
2. Detail survey, on the 4-inch scale, of 483 square miles of forests.
3. Traversing of 574 linear miles.
4. The classification of forest growth and soils of the entire area surveyed in detail, *viz.*, 483 square miles.

139. The whole country under survey is very hilly, and operations were greatly impeded by the dense jungle and high grass which abounded in many parts. The forests in sheets Nos. $23\frac{S.E.}{3}$ and $24\frac{N.E.}{2}$ have been the regular haunt of man-eating tigers for many years, and in this year reports were continually being received of the presence of a man-eater, which were confirmed by kills in the vicinity. This retarded survey work very much, as the villagers deserted their fields in consequence, and labour could not be obtained. Scarcity of water was also felt, especially after the middle of March. There are no passes or roads of importance in the tract surveyed, except a few miles of the well-known Piparia-Pachmarhi road. The only rivers met with were the Tawa and the Denwa : these are fordable almost everywhere.

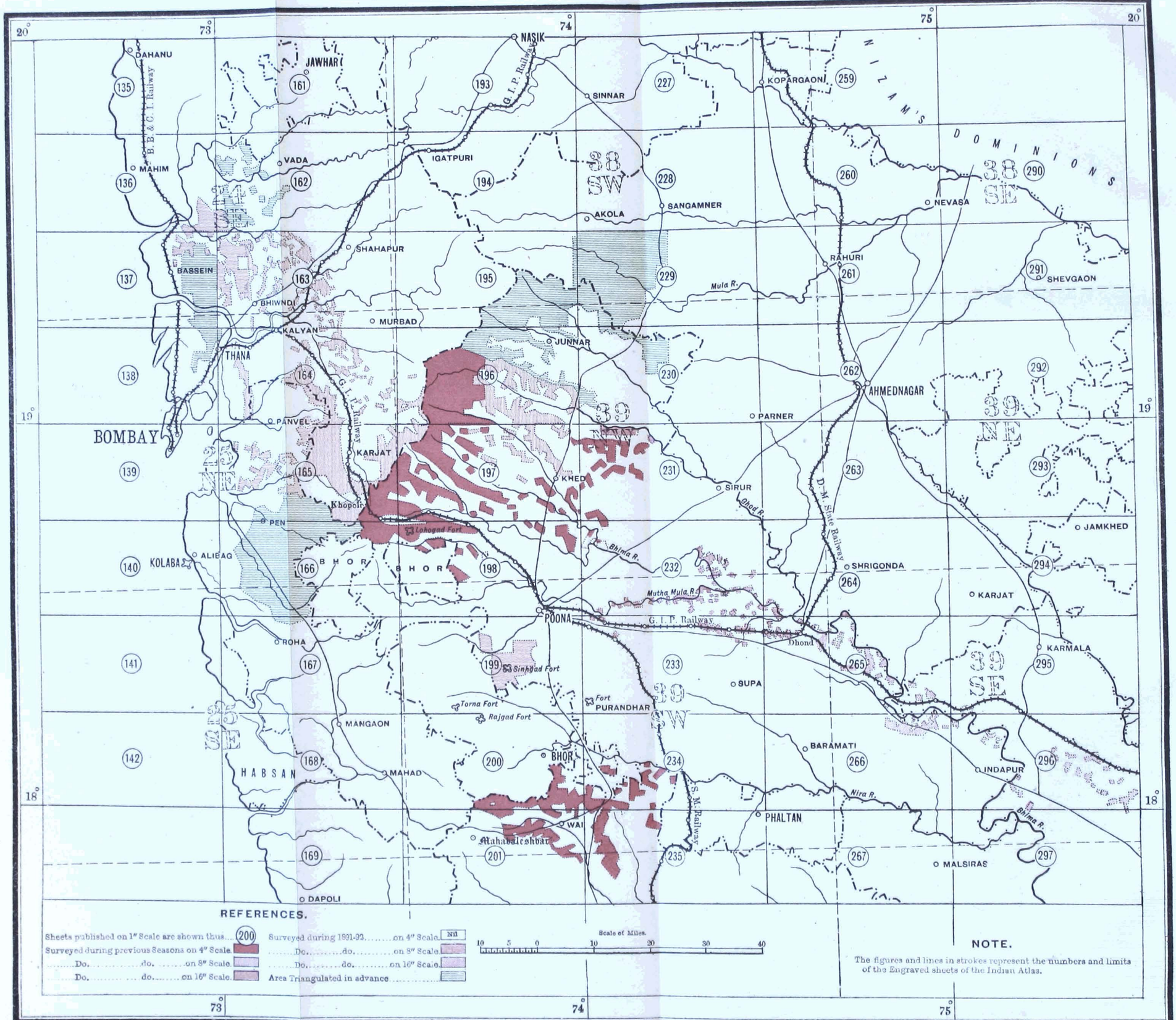
140. Judging from the number of casualties, the season under report has been exceptionally unhealthy. In the very beginning of the season, and before the party left Hoshangabad, pneumonia broke out in the camp. The timely distribution of quilts, and the administration of frequent doses of tea and quinine, had a beneficial effect in reducing the malady. Later on in the season the men suffered from fever and dysentery, and towards the end there were some severe cases of sunstroke. From one cause and another, thirteen deaths occurred in the party, being the greatest number on record since the commencement of this survey.

141. During the recess, all the sheets pertaining to the season's work have been drawn for reproduction and submitted to the office of the Deputy Surveyor-General in charge Trigonometrical Branch. They consist of 25 standard-sized

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 1921-22.....on 4" Scale. Nil

.....Do.....do.....on 8" Scale.....

.....Do.....do.....on 16" Scale.....

Area Triangulated in advance.....

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.

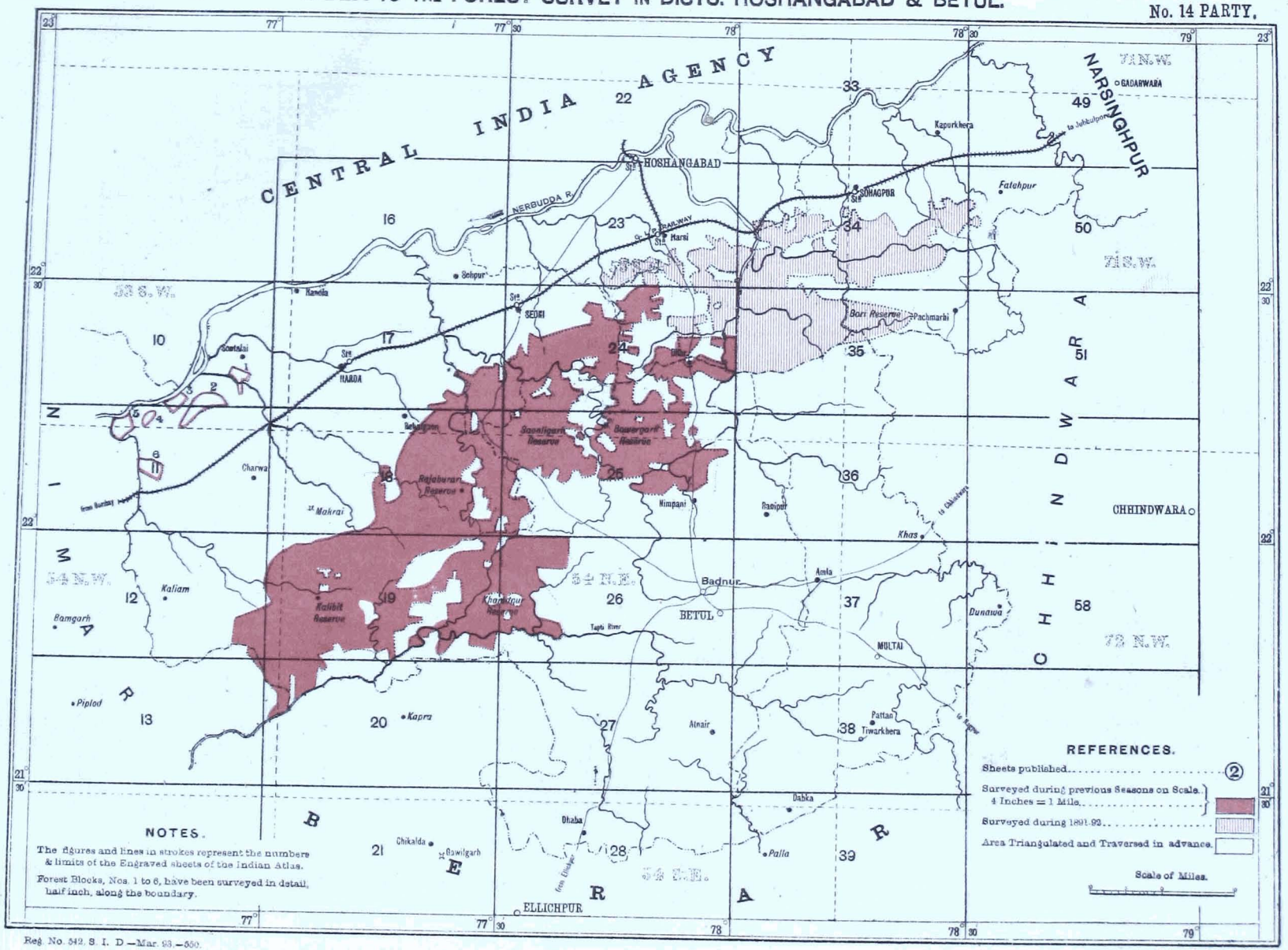
Reg. No. 593. S. I. D.—Mar. 23.—500.

Photo S. I. O., Calcutta.

CENTRAL PROVINCES SURVEY.

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

No. 14 PARTY.



NOTES.

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

Forest Blocks, Nos. 1 to 6, have been surveyed in detail, half inch, along the boundary.

REFERENCES.

Sheets published ..... ②

Surveyed during previous Seasons on Scale, 4 Inches = 1 Mile. .....

Surveyed during 1891-92. .....

Area Triangulated and Traversed in advance.

Scale of Miles.

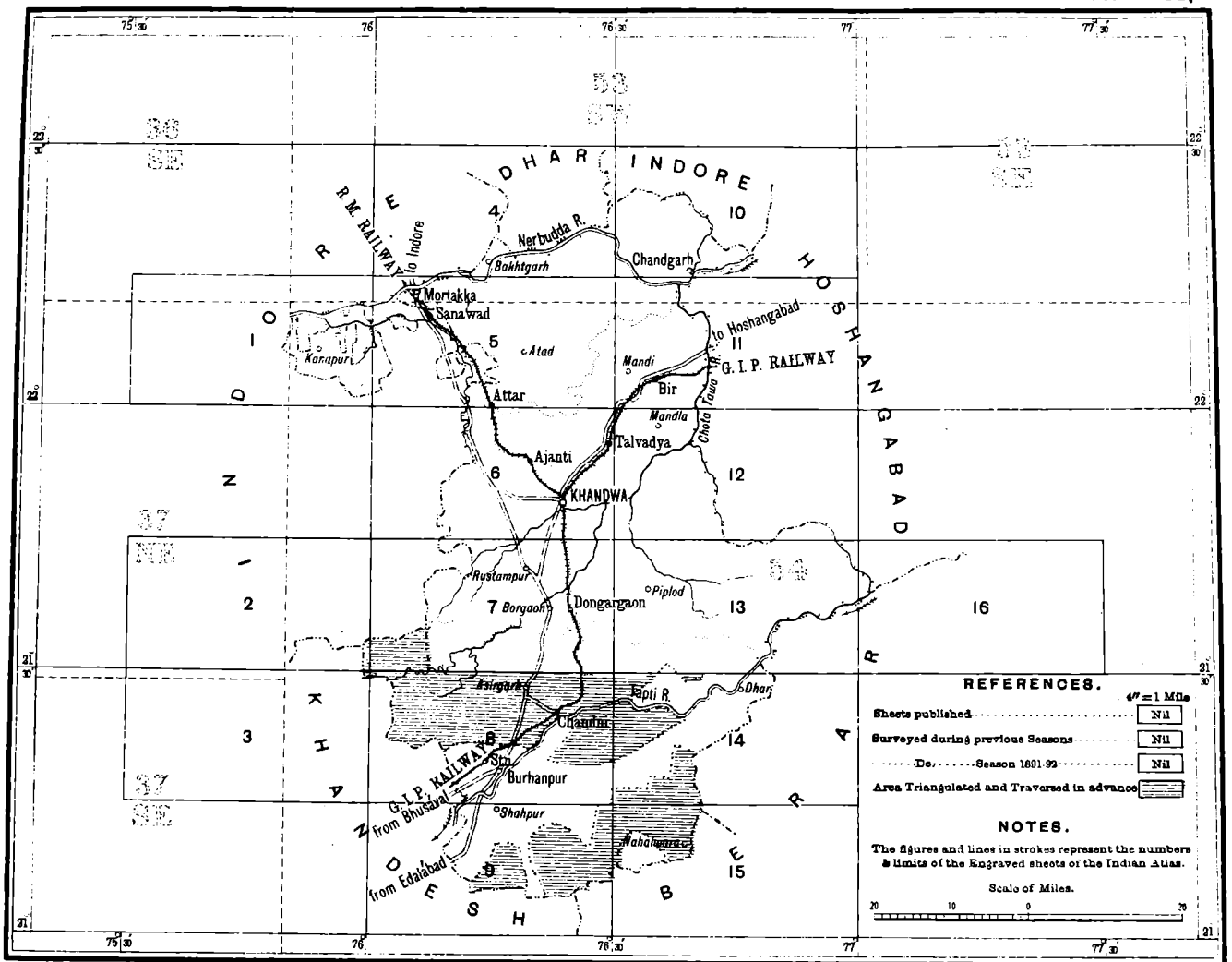
Reg. No. 542. S. I. D.—Mar. 93.—550.

Photo S. I. O., Calcutta.

CENTRAL PROVINCES SURVEY.

INDEX TO THE FOREST SURVEY IN DISTRICT NIMAR.

No. 14 PARTY.



REFERENCES.

4" = 1 Mile

Sheets published	Nil
Surveyed during previous Seasons	Nil
..... Do. ..... Season 1891-92	Nil
Area Triangulated and Traversed in advance	

NOTES.

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

Scale of Miles.

20 10 0 20

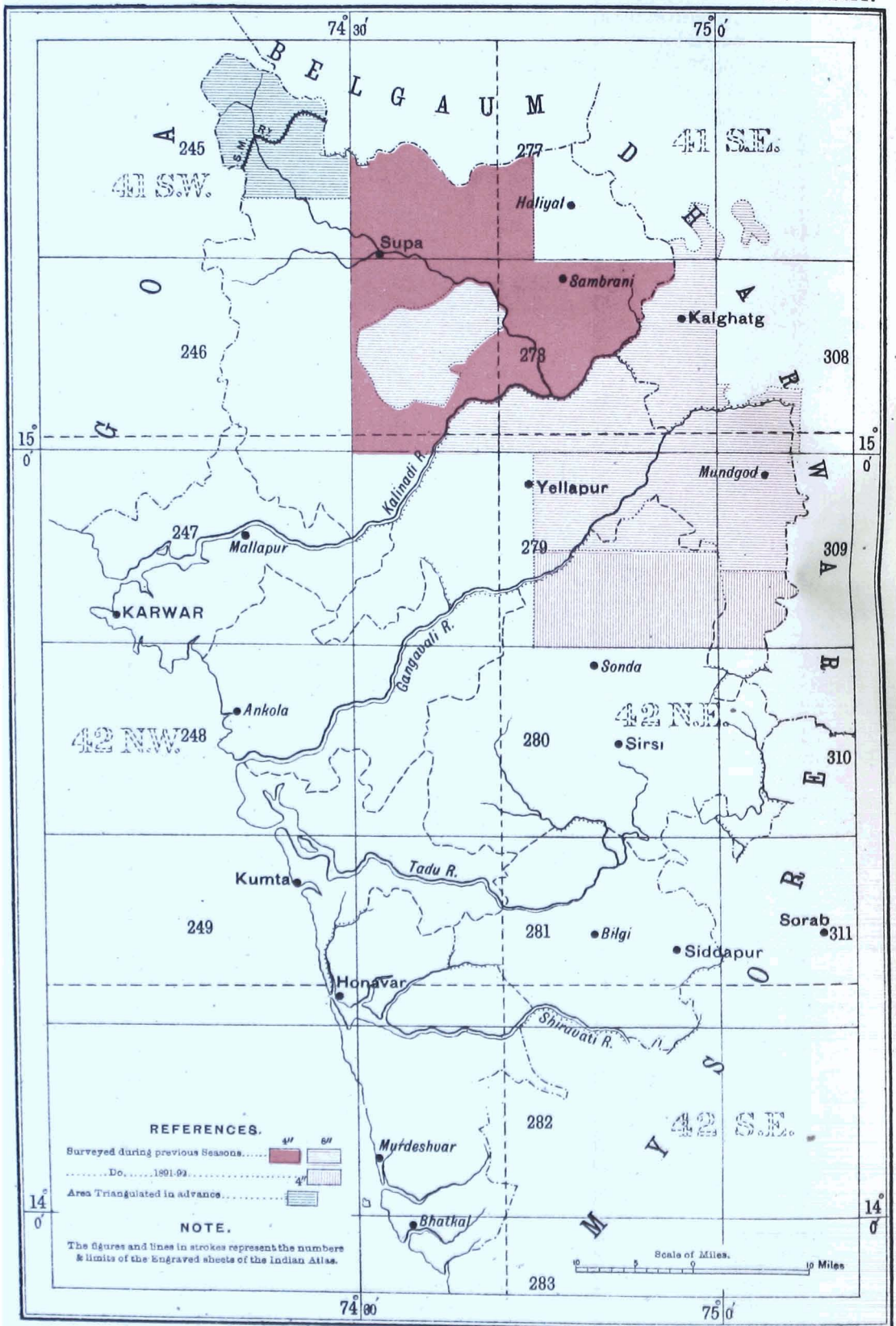
Reg. No. 355. S. I. D.—Mar 93.—550.

Photo S. I. O., Calcutta.

BOMBAY SURVEY.

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

No. 17 PARTY.



Reg. No 842, S.I.D.—Mar. 93.—550.

Photo S. I. O., Calcutta.

sections in sheets Nos. 23, 24, 34 and 35. Office copies of the triangulation charts of sheets Nos. 8, 9, 14 and 15 have also been prepared. Besides this, an index map of forest surveys in district Nimar was drawn in the office of the party and printed in the Trigonometrical Branch Office, Dehra Dun.

142. The computations of traverses and triangulation executed during the year have been finally completed. The General Report of the Hoshangabad and Betul Forests has been taken in hand and is making fair progress.

143. Four native military students have been with the party for the past two seasons and a fifth joined in September 1891. The first four men were employed on independent detail survey on the 4-inch scale; they have also been taught traversing with theodolite and route surveying, and before they go back to their regiments in April 1893 they will be further instructed in the use of the boiling point thermometer, the sextant, and the artificial horizon for time and latitude observations. They have also had practice in drawing, and two of them are neat draftsmen. The fifth man, who joined in September 1891, has been transferred to No. 11 Party from 1st October 1892.

144. The programme of work for the next field season is as follows:—

(*a*) The triangulation of about 500 square miles in district Nimar in sheets Nos. 6, 7, 12 and 13.

(*b*) Theodolite traversing over the ground to be triangulated.

(*c*) The detail survey of about 520 square miles in sheets Nos. 7, 8, 9, 14 and 15 in district Nimar, where triangulation was done last year.

(*d*) The classification of forest growth and soil of the area specified in (*c*).

145. The system of classifying forest growth and soil has been carried out by Colonel Wilmer in consultation with the Chief Commissioner, Central Provinces, and the Forest Officers of the districts of Hoshangabad and Betul. At present it is not known whether the Forest Officers of the Nimar district will require it. The Conservator of Forests has been written to on the subject, and the continuation of the classification in the Nimar district will depend upon the reply received.

146. Colonel Wilmer acknowledges his indebtedness to Mr. W. P. Thomas, Forest Divisional Officer, Hoshangabad, for assistance freely given to all members of the party.

147. The Officiating Surveyor-General and Deputy Surveyor-General in charge Trigonometrical Branch inspected the recess office of the party at Mussooree on the 27th September, 1892, and the following is an extract of his letter No. 2585, dated 4th October 1892:—

"I am glad to be able again to place on record my appreciation of the very efficient state in which I found your party at my recent inspection."*

BOMBAY PRESIDENCY.

No. 17 Party.

148. This party remained in the charge of Colonel Hutchinson throughout the year. The field operations were commenced early in October, 1891, and the work was restricted as before to the surveys of the forest tracts in the northern and southern circles of the Bombay Presidency.

Personnel.

Colonel H. S. Hutchinson, S.C., Superintendent, 2nd grade, in charge.

Mr. A. M. Lawson, Extra Assistant Superintendent, 1st grade.

Mr. S. F. Norman, Sub-Assistant Superintendent, 1st grade.

Mr. C. A. Norman, Sub-Assistant Superintendent, 1st grade.

Sub-Surveyors.

G. R. Bhopatkar, Gopal Vishnu, Gobind Gopal, R. V. Joshi, N. V. Bhopatkar, V. G. Bhat, Ramrao Yadhoo and 21 others.

149. The establishment was divided into three sections, which were supervised by Messrs. A. M. Lawson, S. F. Norman and C. A. Norman, respectively. The first section undertook the surveys on the 16-inch scale of *babul* reserves in

*Colonel Wilmer reports most favourably of all his European assistants, and makes special mention of the following members of the native establishment, *viz.*, Syed Zille Hasnain, Hydar Ali, Gurdutt Singh, Kadir Sharif, Karimdad Khan, Ram Singh, Mahadeo Daji, Sutto Charan Ghosal, Surjan Singh, Abdul Haq (1), Dharmu and Muhammad Zakaria, and military students Daffadar Fazaldad Khan and Lance Daffadar Dost Mohammad Khan.

the Bhima valley, Poona and Sholapur districts, and of the forest reserves in the Kanara district on the 4-inch scale. The second section was employed on 8-inch surveys of forests in the Bhiwndi and Bassein *talukas*, Thana district; and the third upon surveys on the same scale in the Panvel *taluka*, Kolaba district. In addition to these, an elaborate survey on the 8-inch scale of the Singhar hill in the neighbourhood of Poona was effected.

150. Section 1, under Mr. Lawson, commenced work on the *bábul* reserves of the Northern Circle in the Bhima valley on the 10th October, and completed the survey on the 16-inch scale of 40 square miles by the end of December. The whole of this work was checked in the field by Mr. Lawson.

151. On the completion of the above work, Mr. Lawson proceeded to the Kanara district with eight sub-surveyors, to take up the 4-inch survey of the forest tracts of the Southern Circle, in continuation of the previous season's work. The operations were commenced on the 10th January, 1892, and continued up to the 10th April, during which time an area of 195 square miles was topographically surveyed in sheets Nos. 279 and 309. By this arrangement the unhealthy months in these tracts, *viz.*, November and December and the end of April and May, when heavy rain falls, were avoided, and a satisfactory out-turn accomplished without detriment to the health of the establishment. On the completion of the topography, Mr. Lawson was employed till the end of May in extending the triangulation and traversing in the Kanara district for the next season's detail survey, and an area of 100 square miles of country was thus prepared.

152. Section 2 was employed on the 8-inch survey of forests in the Northern Circle in the Bhiwndi and Bassein *talukas*, Thana district, and completed an area of 83 square miles, the work having been commenced early in November by Mr. S. F. Norman with six sub-surveyors.

153. Section 3 under Mr. C. A. Norman, with ten sub-surveyors, undertook the 8-inch work appertaining to the Southern Circle in Panvel *taluka*, Kolaba district, and commenced operations early in November. This ground had been prepared for survey two years previously; it was therefore imperative to take the detail survey in hand without further delay to prevent the loss of the survey marks. The area surveyed amounted to 68 square miles.

154. The 8-inch contoured survey of the Singhar hill was work of a special character, undertaken at the request of the local authorities to furnish a good map of ground close to Poona suitable for educational purposes in forestry. The preliminary triangulation was carried out by Surveyor Gopal Vishnu in October and November, 1891, and the detail survey, amounting in area to 51 square miles, was made in the months of April and May, 1892, under the supervision of Mr. S. F. Norman, by the establishment which had been employed in Kanara, and a few selected sub-surveyors from the Konkan. The hill is over 4,000 feet in height, and contour lines at 500 feet intervals were laid down with the aid of the clinometer. The work was carried out under the personal superintendence of Colonel Hutchinson, and a very accurate map has been obtained.

155. The Superintendent visited each of the several works in succession, and examined a percentage of survey in each locality. Every plane-table section was tested by European agency, either by rigid chain measurements or by *in situ* examination, and found to be on the whole accurate; the aggregate length of the check traverses amounted to 254 linear miles. Of the area triangulated, 100 square miles are in advance of the detail survey in the Southern Circle and 383 square miles in the Northern Circle for next season's work. Of the traversing effected, 104 linear miles are in advance in the Southern Circle and 237 linear miles in the Northern Circle.

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

Triangulation	608	square miles.
Traversing	496	linear ,,
Topography, 16-inch scale	40	square ,,
Ditto, 8 do.	202	,, ,,
Ditto, 4 do.	195	,, ,,

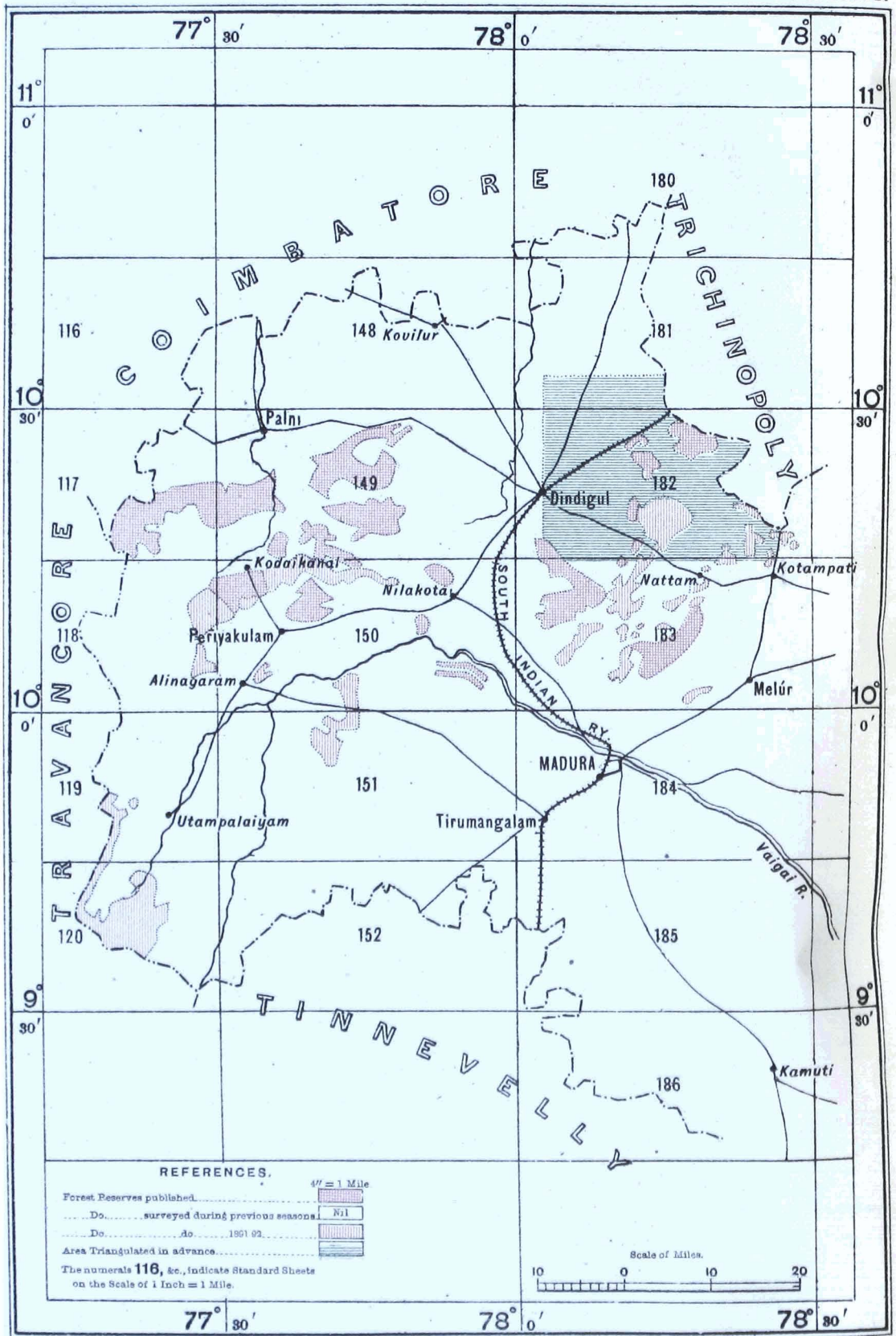
157. The cost-rates of the surveys, including triangulation and traversing, on the various scales are as follows:—

In the Northern Circle, for the 16-inch surveys ₹187 per square mile, and for the 8-inch surveys ₹178 per square mile. In the Southern Circle, for the

MADRAS SURVEY.

INDEX TO THE FOREST SURVEYS IN THE MADURA DISTRICT.

No. 19 PARTY.



Reg. No. 339, S. I. D.—Mar. 93.—550.

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

MADRAS SURVEY.

INDEX TO THE FOREST SURVEYS IN THE COIMBATORE DISTRICT.

No. 19 PARTY.

Reg. No. 330, S. I. D.—Mar. 93.—550.

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

MADRAS SURVEY.

INDEX TO THE FOREST SURVEYS IN THE TINNEVELLY DISTRICT.

No. 19 PARTY.

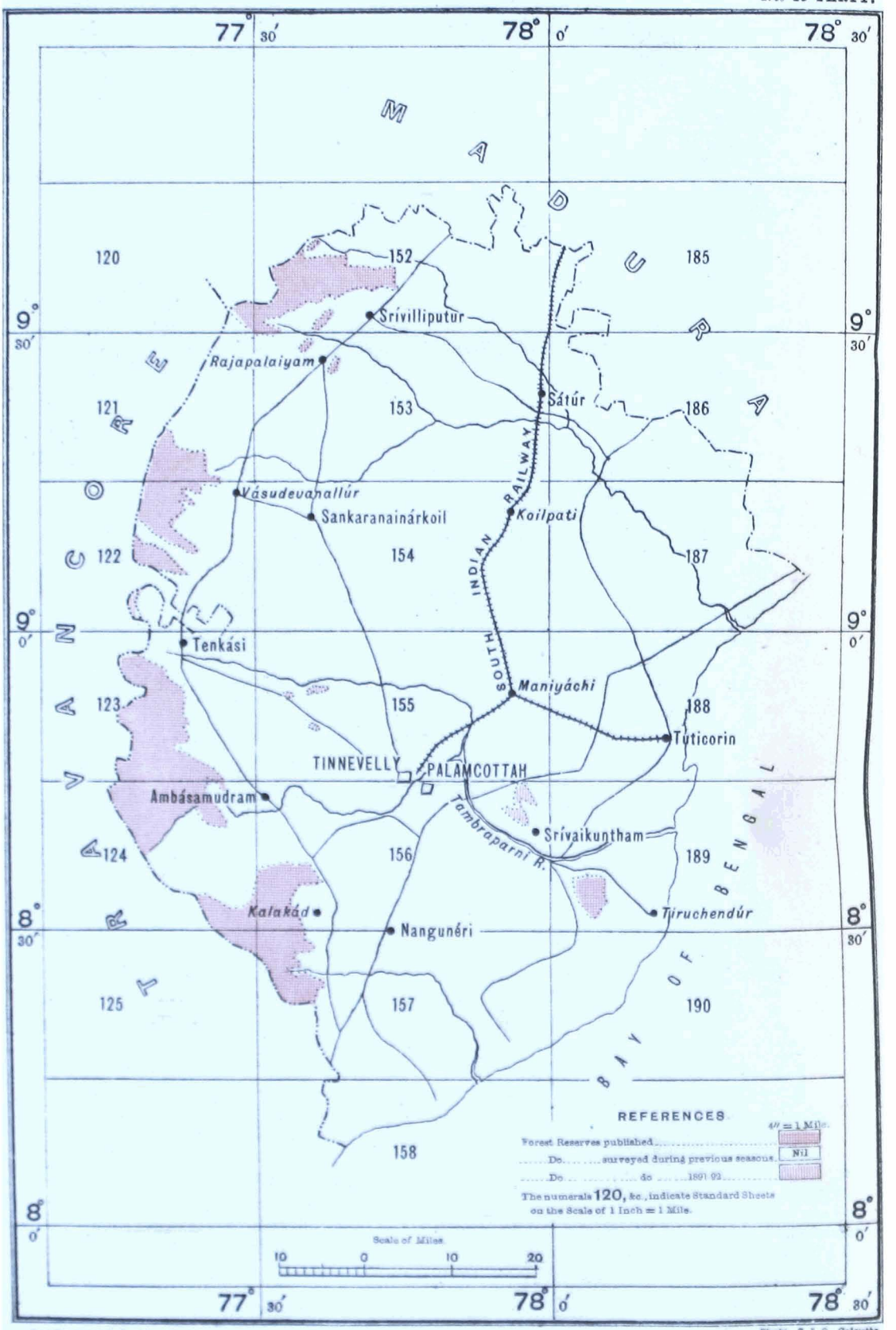


Photo., S. I. O., Calcutta.

8-inch surveys R195 per square mile, and for the 4-inch surveys R126 per square mile.

The comparatively low rate for the 16-inch survey is due to the circumstance of the country operated in being quite flat and almost featureless.

158. During the recess, the mapping of the areas surveyed was completed and comprised the fair drawing of 104 standard sheets. A revised and extended index map for the Northern Circle was also prepared.

159. At the commencement of the season there was much fever amongst the men working in the Konkan, both in the Panvel and Bhiwndi *talukas*, especially in the former, and it was so bad at one time that the work almost came to a standstill. Matters, however, improved as the season advanced, and in the hot months in Kanara the health of the men was above the average of ordinary seasons.

160. The programme for the ensuing season comprises—

(*1*) *Northern Circle.*—The completion of the survey of *babul* forests in the Indapur *taluka*, Poona district, on the banks of the Bhima river (consolidating the work done last season, which is somewhat scattreed), and the commencement of 16-inch work on the Neera river; also the completion of the 8-inch forest surveys in Salsett, Bassein and Bhiwndi *talukas*, Thana district, and the commencement of similar work in Jaoli Bholeshwar in the Sangamner *taluka* of the Ahmednagar district.

(*2*) *Southern Circle.*—Surveys on the 4-inch scale in sheets Nos. 245 and 246, Kanara district, and the commencement of 8-inch surveys in the Pen *taluka*, Kolaba district. Advance triangulation and traverse will be executed in sheets Nos. 246 and 247.

161. The recess office of the party at Poona was inspected by the Officiating Surveyor-General in August, 1892, and found to be working very satisfactorily in all respects. The maps have been executed with much artistic skill, the records are carefully kept, and the work of the party appears to meet fully the requirements of the forest officials. The general reports of the triangulation and traversing are in a somewhat backward state, chiefly owing to the scattered nature of the operations of the party, but they will be taken in hand at once and brought into a condition suitable for permanent record in the Head-Quarters Office.*

MADRAS PRESIDENCY.

No. 19 Party.

162. This party has remained in the charge of Colonel McCullagh, R.E., throughout the year, and has continued the surveys on the 4-inch scale of the forest reserves in the Madras Presidency.

Personnel.

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

Surveyors and Sub-Surveyors.

T. Raghava Ayengar, Tiruvenkatsami Mudelliar, Lachman, D. Jadow, Balaji Dhondiba, Govindaraju Mudelliar, Ramasami Naidu, Anantarao Dhondiba, and 14 others.

163. The recess office was closed during the third week in August, 1891, when the different sections of the party moved to the various localities in which the survey operations were to be carried on, *viz.*, No. 1 section, under Mr. R. Todd, to the Coimbatore district, to continue the preliminary triangulation and carry out any traversing that might be found necessary; No. 2 section, under Mr. Hamer, to continue the detail survey of the reserve forests in Madura district, together with any supplementary triangulation and traversing that might be needed; No. 3 section, under Mr. H. Todd, to

* Colonel Hutchinson reports well of the work done by his assistants, Messrs. Lawson, S. F. Norman and C. A. Norman, all of whom had arduous duties to perform in a trying season. The native establishment is also well reported on.

commence the topography of the reserved forests in the Coimbatoredistrict; and a small detachment was told off to complete a small amount of work standing over in the Tinnevelly district.

164. Field operations were well in hand by the 1st of September and were continued till the first week of March 1892, when the party returned to recess quarters in Bangalore.

165. In Coimbatore, the triangulation was extended over the western portion of the district, while a part of the Anaimalai Hills left over from the previous year was also completed; it embraces an area of 1,000 square miles obtained by observations at 133 stations, from which 400 points and 391 heights were fixed. In Madura, the existing triangulation was extended over an area of 196 square miles by observations at 19 stations, whereby 84 points were fixed and an equal number of heights were obtained.

166. The traversing carried out during the season amounts to 253 linear miles. The small quantity of this class of work compared with the area topographically surveyed is due to the circumstance that the exterior boundaries of the reserves had in some cases been completely, and in others partially, surveyed by the Madras Survey Department, and the data having been obtained and utilized, the labour and expense of fresh traverse survey was thereby saved.

167. The area topographically executed amounts to 659 square miles, which is a satisfactory advance on that of the year before, and the largest outturn so far accomplished. The country operated in was in no way less difficult than that met with before, and the party experienced great difficulties in connection with the weather, as well as a large amount of sickness which prevailed more or less throughout the season. The result therefore is very creditable.

168. The country surveyed this season closely resembles that described in previous reports; it is for the most part very mountainous and very inaccessible, many of the hill-tops being as much as six and seven thousand feet above sea-level. In places also a dense forest growth was met with, rendering a correct representation of the ground a very ardous task to accomplish, and the nature of the country generally caused the arrangements in connection with supplies, labour, and carriage to be a matter of peculiar difficulty.

169. During the recess, the various computations have been brought up to date; and the fair mapping of the season's work has also been done, with the exception of a small portion coming into sheets which cannot be completed. The mapping is included in thirty-nine sheets and comprises 17 forest reserves in Madura made up of 56 blocks, 6 complete ones and a portion of a seventh in Tinnevelly, and about three-fifths of one very large forest and about one-sixth of another in Coimbatore as far as surveyed.

170. It is satisfactory to note that the cost-rate of the survey has this year been still further reduced, as the following statement, which gives the rate for final survey, including the cost of triangulation and traversing, will show:—

			₹
In 1888-89,	cost-rate per square mile	. . .	162
„ 1889-90	ditto	ditto . . .	149
„ 1890-91	ditto	ditto . . .	112
„ 1891-92	ditto	ditto . . .	97

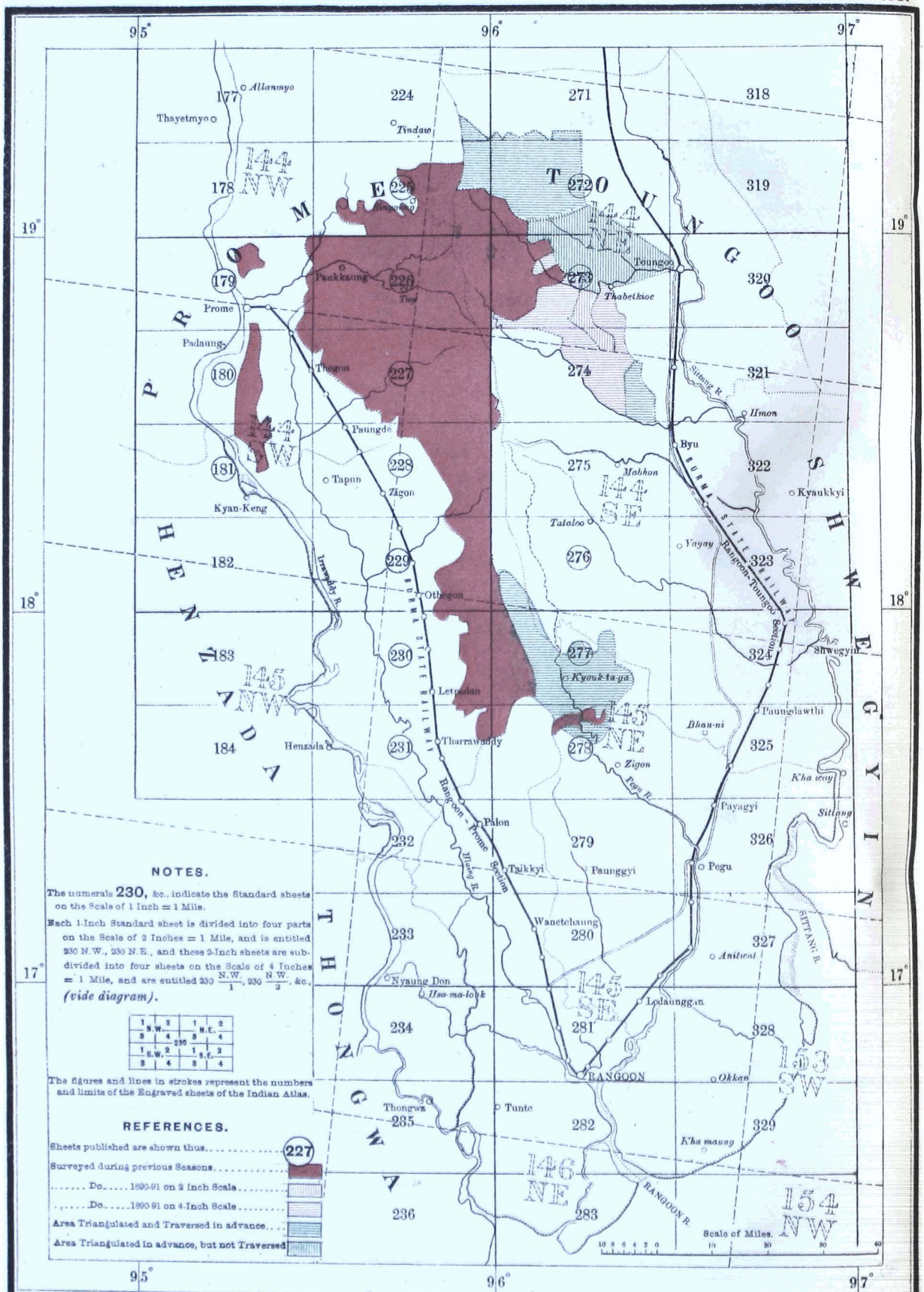
171. The Surveyor-General proceeded to Madras in April 1892 to inspect Colonel McCullagh's party and to confer with the local authorities regarding its operations. The Forest Member of the Board of Revenue and the Conservator of Forests were consulted and arrangements made for the future programme of work. The recess office of the party was inspected at Bangalore, and the results of the season's work carefully examined. The field maps were found to be carefully executed, and the professional and other records kept in thorough order, testifying to the efficient supervision which Colonel McCullagh maintains, and to which, with the aid of his assistants, the marked increase in the out-turn of work is attributable.

172. The programme for the ensuing season, which has been approved by the local authorities, comprises briefly the completion of the detail survey in Madura, and also, it is hoped, in Coimbatore; the commencement of

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	2	1	2
N.W.		N.E.	
3	4	3	4
	230		
1	2	1	2
S.W.		S.E.	
3	4	3	4

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....

Area Triangulated in advance, but not Traversed

Reg No. 594, S. I. D.—Mar. 93.—550.

Photo S. I. O., Calcutta.

topographical operations in Salem, where the triangulation will be resumed; and the starting of preliminary triangulation in the North Arcot district.*

LOWER BURMA.

No. 20 Party.

173. Mr. D'Souza held charge of the party throughout the field season and up to the 12th August, 1892, when he retired on a superannuation pension and was succeeded by Captain Fleming.

Personnel.

Colonel R. Beavan, S.C., Officiating Superintendent, 2nd grade, in charge up to 25th November 1891.
Mr. A. D'Souza, Officiating Deputy Superintendent, 1st grade, in charge from 26th November, 1891, up to 12th August 1892.
Captain J. M. Fleming, S.C., Officiating Deputy Superintendent, 1st grade, in charge from 13th August 1892.
Mr. W. A. Wilson, Extra Assistant Superintendent, 1st grade.
„ . A. Barker „ „ 4th „
„ A. Ewing, Sub-Assistant „ 1st „
„ H. A. Charrier „ „ 2nd „

Surveyors and Sub-Surveyors.

Venkat Swamy, Abdulla Khan, Sharfuddin, Amjad Ali, Moung Kyaw Nyein, Moung Hpo Nyein and 20 others.

174. The party has been engaged, as heretofore, in carrying on the survey of forest reserves in the Toungoo district, on the scale of 4 inches = 1 mile, and of the enclosed unreserved tracts on the 2-inch scale.

175. The members of the party took the field early in December on the arrival of *khalásis* from India, and proceeded *viâ* Toungoo to the work allotted to them. The topography of the Kabaung Chaung (left unfinished last year) and the Bhondaung reserves was first commenced, and in spite of a good deal of sickness at the start was completed about the beginning of April. A move was then made into the Pyu forest reserve, which had in the meantime been taken in hand by the traverse detachment of the party, and prepared for topography. Owing to the weather and sickness among the hands, it was found impossible to complete this reserved forest, and about 40 square miles remain to be done next season. On the termination of traversing in the Pyu forest, the traverse camp was moved to the north, and commenced work in the East and West Swa forest, which, with the enclosed Karen area, was traversed as far north as latitude 19° 15′ by the end of April, when it was found impossible to do more owing to the heavy rains which had set in.

176. The season's out-turn consists of triangulation over about 400 square miles of country, to furnish points by which to check the traverses. Traverse operations were carried on over an area of about 350 square miles, comprising a total length of chain-measured lines of nearly 640 miles. The detail survey covered an area of 227 square miles of forest reserve on the 4-inch scale, while an area of 68 square miles was completed on the 2-inch scale.

177. The field work was continued until the beginning of June, when the party returned to recess quarters in Rangoon. Owing to the early setting in of the rains, work was much retarded during the latter end of the field season, and the examination of several field sections has had to be postponed till next season. Most of the topography completed was tested by chain measurements, of which 86 miles were run through the various field sections: on the whole, the work was found accurate.

178. The latter part of the field season proved very unhealthy. Every member of the party suffered more or less from fever; and in the traverse camp, in particular, quite half the strength was unfit for work towards the close. Fever and dysentery were the chief complaints: six deaths occurred among the *khalásis*. All through the recess the fever contracted during the field season was constantly recurring.

* Lieutenant-Colonel McCullagh reports very favourably of his European assistants. Mr. Hamer worked his section with considerable success; Mr. H. Todd showed much zeal and ability in the direction of the section he had charge of; Mr. R. Todd was most energetic in prosecuting the triangulation in the face of considerable obstacles and much sickness among his men; Mr. Mills gave satisfaction in the way he carried out the miscellaneous duties entrusted to him.

The sub-surveyors generally are well spoken of, special mention being made of the good work done by Raghava Ayengar, Anantarao Dhondiba, Balaji Dhondiba and Eknath Battu.

The hospital assistant, J. Nathaniel David, is also commended.

179. The eastern portion of the country surveyed during the season is bounded by a long range of hills, rising very abruptly from the plains to the west of Toungoo, and extending from the Kabaung river on the north to the Pyu river on the south. The highest point on this range rises to a height of 1,512 feet. From about the centre of this range, another range having an average elevation of about 1,000 feet runs towards the Yomas in a north-westerly direction, and from this range again a series of small, low spurs extends to the northward. These are all densely jungle-clad, and the features are very intricate and difficult to survey. The hills throughout the country are all about the same height, and though the ridges are less densely wooded than the slopes, the country presents unusual difficulties to the triangulator. The most important streams are the Kabaung and Pyu rivers; both take their rise in the Yomas and fall into the Sittang river. The Pyu river has a very rocky bed and there are many waterfalls in its course. The Kabaung, on the other hand, has a broad, sandy bed, with only sufficient water during the winter months to float down bamboo rafts. In the rains, however, both become impetuous torrents and timber can then be floated down. Throughout the country travelling is very difficult, and the best way of getting about is by following the water-courses, or the tops of ridges where the jungle is less dense. The country is almost entirely uninhabited, except in the Karen tracts.

180. During the recess, the triangulation computations have been completed, and the results show fair agreement with those obtained by traverse. A certain amount of revision has unfortunately been found necessary in the previous season's traverse results, which has somewhat delayed the fair mapping of the current season's work. It is hoped, however, that seven standard sheets, on the 4-inch and two on the 2-inch scale, will be fair-mapped before the recess closes.

181. During the coming field season, it is proposed to undertake the survey on the 4-inch scale of that portion of the Pyu reserve left unfinished last field season, and also of the East and West Swa forest reserves, while the Karen area lying between the last-mentioned reserves will be mapped on the 2-inch scale. Should time allow, a portion of the Saing reserve will also be undertaken on the 4-inch scale. The advance triangulation and traversing will be carried on regularly to the northward, as far as the old frontier line between Upper and Lower Burma, in continuation of the present season's advanced work.

182. The party was inspected by the Deputy Surveyor-General during his tour in Burma in August 1892. Captain Fleming had but very lately taken over charge from Mr. D'Souza; the office records and books were all found in good order, and the field sheets had all been signed by Mr. D' Souza before he left. It was gratifying to see that the two best field sheets had been surveyed and drawn by Burman sub-surveyors. Directions were given to increase the amount of triangulation, the traverse work having been carried on too far during previous seasons without check. The nature of the country makes it very difficult to carry on regular triangulation, but Captain Fleming was directed to pay more attention to this in future*.

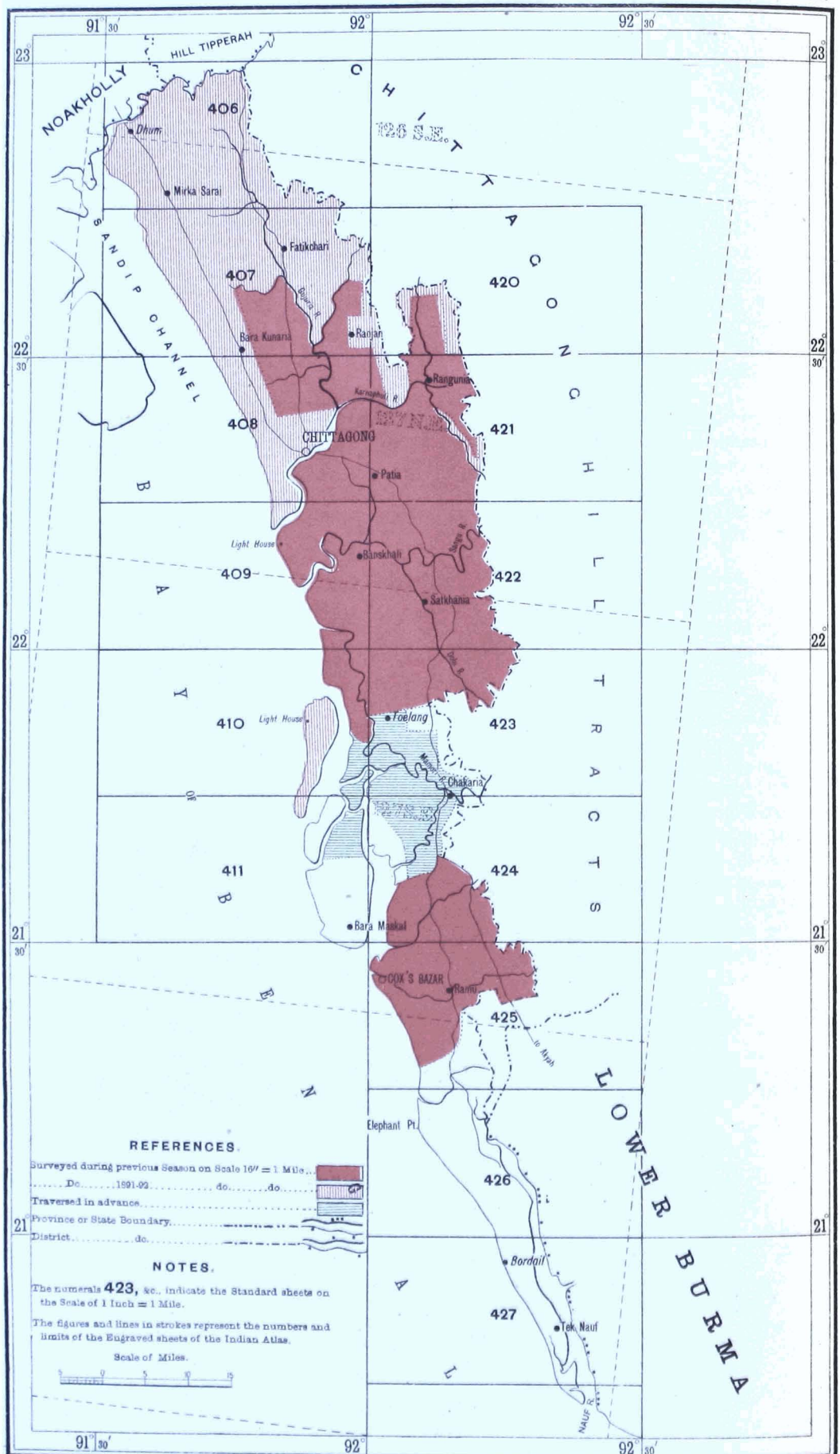
* Mr. D'Souza, who held charge of the party during the field season, reports as follows regarding his assistants :—

" Mr. W. A. Wilson has most ably and satisfactorily performed his duties. Mr. J. A. Barker has exercised a most careful supervision over all the members of his detachment; he is a hardworking assistant and regular in his attendance during recess". Mr. A. Ewing and Mr. H. A. Charrier are also well reported on; and the native establishment for the most part are said to have worked well.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT CHITTAGONG.

No. 2 PARTY.



Reg. No. 379, Bengal & S. I. D.—Jan. 93—2,252.

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

CADASTRAL SURVEYS.

CHITTAGONG AND TIPPERA DISTRICTS, BENGAL.

No. 2 Party.

183. This party, of the strength shown in the margin, continued its operations in the Chittagong district and commenced the survey of the Chakla Roshnabad estate, district Tippera, belonging to the Maharaja of Hill Tippera, who made application for the survey under the provisions of the Tenancy Act. Mr. Grant, Officiating Deputy Superintendent, who had been recently granted a further extension of service to enable him to complete the survey of the Chittagong district, was compelled to retire in the beginning of July on account of ill health and handed over charge of the party to Mr. O'Sullivan.

Personnel.

Mr. F. Grant, Officiating Deputy Superintendent, 2nd grade, in charge from 2nd December, 1891, up to 11th July 1892.
„ W. J. O'Sullivan, Extra Assistant Superintendent, 2nd grade, in charge up to 1st December, 1891, and from 12th July 1892.
„ J. McHatton, Extra Assistant Superintendent, 4th grade.
„ C. G. Lee, Sub-Assistant Superintendent, 2nd grade.
„ M. F. Berkeley, Sub-Assistant Superintendent, 3rd grade.
11 sub-surveyors, etc.

Temporary Establishment.

1 supervisor.
155 field-surveyors.

184. Field operations were commenced in the Chittagong district on 1st November 1891; those in Tippera were begun about the middle of April 1892, when a small party was despatched from Chittagong to commence the preliminary traversing.

Survey of the Chittagong District.

185. The original programme for the field season comprised the completion of the survey of the Sadar sub-division only, but later by the orders of the Government, dated the 24th October 1891, the operations were extended to the rest of Cox's Bazar sub-division, old Thana Ramu having been previously surveyed and settled.

186. The traverse survey of the *thanas* of the Sadar sub-division was well advanced in season 1890-91, so that only 167 square miles remained, which were completed. In this area were included the very difficult portions of the boundary between Kumira and Mirsarai and Hathhazari and Phatikchari *thanas*. In Cox's Bazar 130 square miles of traverse survey were completed in Kutubdia and Mashkhal islands and in the cultivated area of Chakiria. The work in Mashkhal, however, was stopped after 20 square miles of traversing had been completed, as, with the exception of one village, it is stated to be permanently settled. The details of the out-turn of traversing are shown in the following statement:—

Sub-division.	Number of village circuits and sub-traverses.	Number of stations.	Area in square miles.
Sadar	629	13,603	167
Cox's Bazar			130
Total	629	13 603	297

187. The detail survey on the 16-inch scale was commenced in November 1691 with 17 surveyors only. In December, 140 men were at work, but the strength was increased to 172 in January and to 189 in February 1892. Within the cultivated area all the *kittas* of fields (the unit of survey) were mapped, their average size being 0·13 of an acre. The boundaries of tea gardens were surveyed

in skeleton only, on the 16-inch scale, the interior details being omitted The following table gives the season's out-turn of detail survey :—

Sub-division.	Cadastral Survey.			Skeleton Survey.
	16 inches=1 mile.			
	Number of villages.	Number of fields.	Area in square miles.	Area in square miles.
Sadar	428	2,194,393	462	177
Cox's Bazar	6	96,792	26	10
Total .	434	2,291,185	488	187

188. A survey of the Municipality of Chittagong was undertaken on the requisition of the Settlement authorities, and an area of 3 square miles was surveyed on the 16-inch scale and in the more densely populated portions on the 32-inch scale, but the work was then stopped pending the decision as to how the cost is to be met.

189. A survey of the hilly tracts on the 2-inch scale, based on a projection of the theodolite stations, was also undertaken. This part of the work caused the officer in charge great anxiety, as he had no trained topographical surveyors available to undertake it. But the survey was continued fitfully, and eventually, by the 15th June, 184 square miles were completed. Under the orders of the Government of Bengal no more surveys of the kind will be undertaken.

190. The cost-rate of the cadastral survey amounted to ₹171 per square mile; that of the skeleton survey to ₹92·5 per square mile; and that of the topographical survey of the hills on the 2-inch scale to ₹23 per square mile.

191. Of the settlement records, the areas of 297 villages of new work, containing 853,434 numbers, had been submitted to the Settlement Officer by the end of September 1892, and those of 171 villages, containing 463,099 numbers, were in hand, but the officer in charge hoped to submit these before the end of December 1892 without interfering with next season's work. Traces of all the new mapping have been submitted, except those of five villages which have been completed as far as possible, but cannot go in on account of changes made by the Settlement Department.

192. The officer in charge commends the establishment for remaining at their work while cholera was raging all over the area under survey during the latter months of the season. The casualties therefrom were 93, including one inspector and three *amins*.

193. The Director, Bengal Surveys, inspected the party in March 1892, and reports that Mr. O'Sullivan has done his best to meet the wants of the Settlement Department, but that under the current procedure it is impossible to make the work succeed.

194. The cadastral operations were closed by the end of May 1892. The weather during the season was fortunately most favourable, for there was really no bad weather till the setting in of the rains. The boundary skeleton survey and the hill topography was not completed till the 24th July 1892.

195. Mr. O'Sullivan complains of many difficulties due to the complicated procedure. He writes:—

"Owing to the order in which the sheets are received back, it is quite impossible to do more than complete them, as far as possible, and submit them, often, without comparing the boundaries.

* * * * * * * *

"It was not till July that all the sheets had been received back from the Settlement Office.

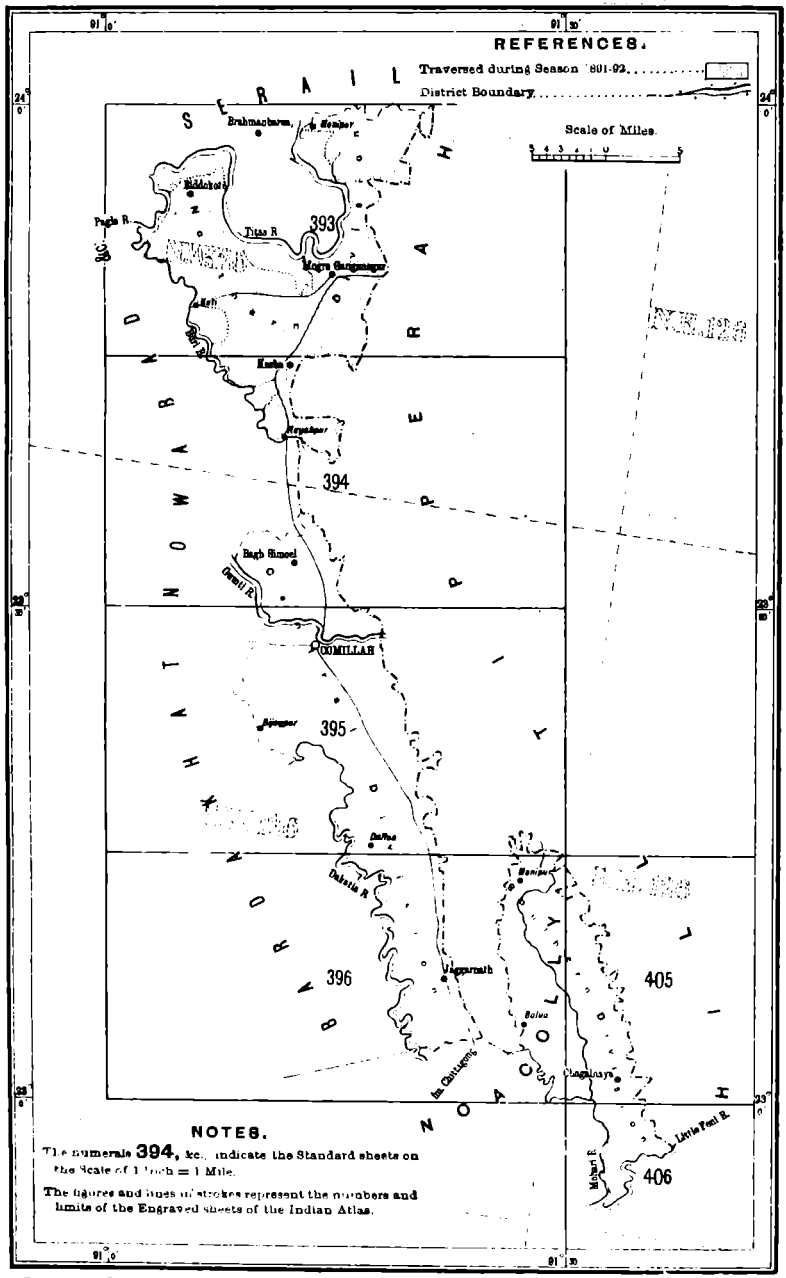
* * * * * * * *

"The comparison of boundaries having to stand over till the return of the sheets from the Settlement Department, has proved a source of great delay and expense. The orders of the Settlement Officer were that as soon as a sheet was finished it was to be sent on to

BENGAL SURVEY.

INDEX TO THE TRAVERSE SURVEY OF CHUKLA ROSHNABAD, DIST. TIPPERA.

No. 2 PARTY.



Reg. No. 32, Bengal & S. I. D.—Jan., 93.—2 252.

Photo S. I. O., Calcutta.

him without delay, and this prevented any proper check being exercised either by the *partalling* or camp officer.

* * * * * * * *

"A large staff of *amins* had to be kept in to revise when necessary.

* * * * * * * *

"The chief cause of delay was the transfer of *chaks* from one village to another, which orders are often revised by the attestation officer months afterwards."

196. During the ensuing field season a detachment under Mr. O'Sullivan will complete the operations remaining to be done in Chittagong, of which the following is a summary:—

1. The cadastral survey of cultivation in Chakiria and Teknaf and in one village in Mashkhal, aggregating an area of 110 square miles.
2. The traverse circuit of the island of Mashkhal.
3. The 4-inch survey of the boundaries of all villages in Chakiria and Teknaf.
4. The traverse circuits of jungle tracts included in the original *patta* of a *taluk*, when the *talukdars* have cleared their boundaries.

It is anticipated that the field operations of the above work will be finished by April, and the completion of the maps and areas for the Settlement Officer will engage the detachment till October 1893.

Survey of the Chakla Roshnabad Estate, Tippera District.

197. This survey has been undertaken, under the provisions of the Tenancy Act, on the requisition of the Maharaja of Hill Tippera. The area of the estate is 572 square miles, of which about 10 square miles are situated in the Sylhet district. The area to be surveyed is thus 556 square miles.

198. Late in the season a small party was despatched from Chittagong to commence the preliminary traversing for a 16-inch cadastral survey. Comilla was reached on 15th April 1892, and operations commenced shortly after in *pargana* Nurnagar, in the northern division of the estate, as being most convenient. During the first month practically nothing was done, for the people declined to point out their boundaries. The *talukdars* held aloof, and no list of them could be obtained from the estate authorities, although applied for several times. At length, on the 31st May, the Collector visited the survey camp and personally explained the objects of the survey to the *talukdars*, after which matters mended.

Personnel.
Mr. J. MacHatton, Extra Assistant Superintendent, 4th grade.
Ten sub-surveyors.
Seven computers and draftsmen.

199. In the absence of all demarcation, the villages were traversed as pointed out, the surveyors being supplied with the Collector's registers and with copies of the old 4-inch map to help them. In these latter, all villages are not shown as separately measured, but several are grouped together under one *thak*. They have now been separated. The particulars of the out-turn of traverse survey are shown in the following statement:—

	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Chakla Roshnabad estate . . .	351	306	5,225	150

200. Notice was given of 19 disputes on boundaries, which will be disposed of as the cadastral survey proceeds. A number of petitions were received by the officer in charge from the *talukdars*, which consist for the most part of objections to have their *taluks* measured in different *mauzas*. But this cannot be avoided while the *mauza* is a recognized local unit, which there can be no doubt it is.

201. Great difficulty was experienced in connecting the work with that of *pargana* Sarail, which was surveyed in 1889-91 as it was found that all the stone marks, which had been embedded by the surveyors along the northern bank of the Pilas river in 1889-90, had been uprooted and thrown away; at least this is

the supposition: an enquiry will, however, be made. The *zamindars* are responsible for the maintenance of these marks under the Survey Act, and should be called to account if such is the case. The Act appears to be defective, and there is no section that actually applies in such circumstances, although the Act was doubtless framed for the purpose.

202. The tract which has been under survey is a low-lying flat plain, bounded on the east by the Tippera hills, on the north by the Pilas river, and on the west and south by the Buri river. It is subject to inundation during the rains by the overflow of the rivers. One of the features of the country is the existence of occasional large *bils*, the edges of which are cultivated by a coarse kind of paddy called *boro dhan*. The soil is exceedingly fertile, the staple crop being paddy.

203. The cost of the operations has been ₹14,575 which is very high, but ₹1,560 were spent on instructing local cadastral establishments. It is due to the causes already mentioned as having impeded the work, but also to the inexperience of the traverse surveyors, which might be avoided if establishments were not so often broken up and dispersed, so that there are few theodolite surveyors of experience left who can show a really good out-turn.

204. The Collector did his utmost to arouse the people to assist the surveyors, and called upon the *chaukidars* to submit weekly reports on the state of preservation of the theodolite stations, as it was too late in the season to imbed permanent marks. Babu Hemendra Nath Roy, the Sub-Manager of the northern division, also gave substantial aid.

205. The detachment left the field for recess quarters at Comilla on the 11th July.

206. It is anticipated that the arrangements which have been made for the next season's work will result in comparatively low cost-rates, if Mr. MacHatton's management is good. In the northern division 54 square miles remain to be traversed; as this area chiefly consists of *bils*, it is not expected that the water will subside sufficiently to allow of the traverse operations being begun till February. In the central division 228 square miles and in the southern division 124 square miles remain for traverse survey.

207. A survey training school for local men was opened at Comilla on the 10th April 1892, and by the end of September 200 men had been trained and 100 more were under instruction. These men will survey and write the records and gradually supplant the Hindustani *amins* who have been imported. As the Maharaja of Hill Tippera has requested for various reasons that the cadastral operations should be prolonged over at least two seasons, only 300 square miles are to be surveyed during 1892-93 and the remaining 256 miles in 1893-94.*

* Mr. O'Sullivan reports that credit is due to Mr. MacHatton for the work accomplished by him under difficult circumstances. Mr. C. G. Lee is said to have worked with untiring energy, and Mr. F. Berkeley promises well. Of the subordinate establishment employed in the Chittagong district, the following are specially mentioned :—

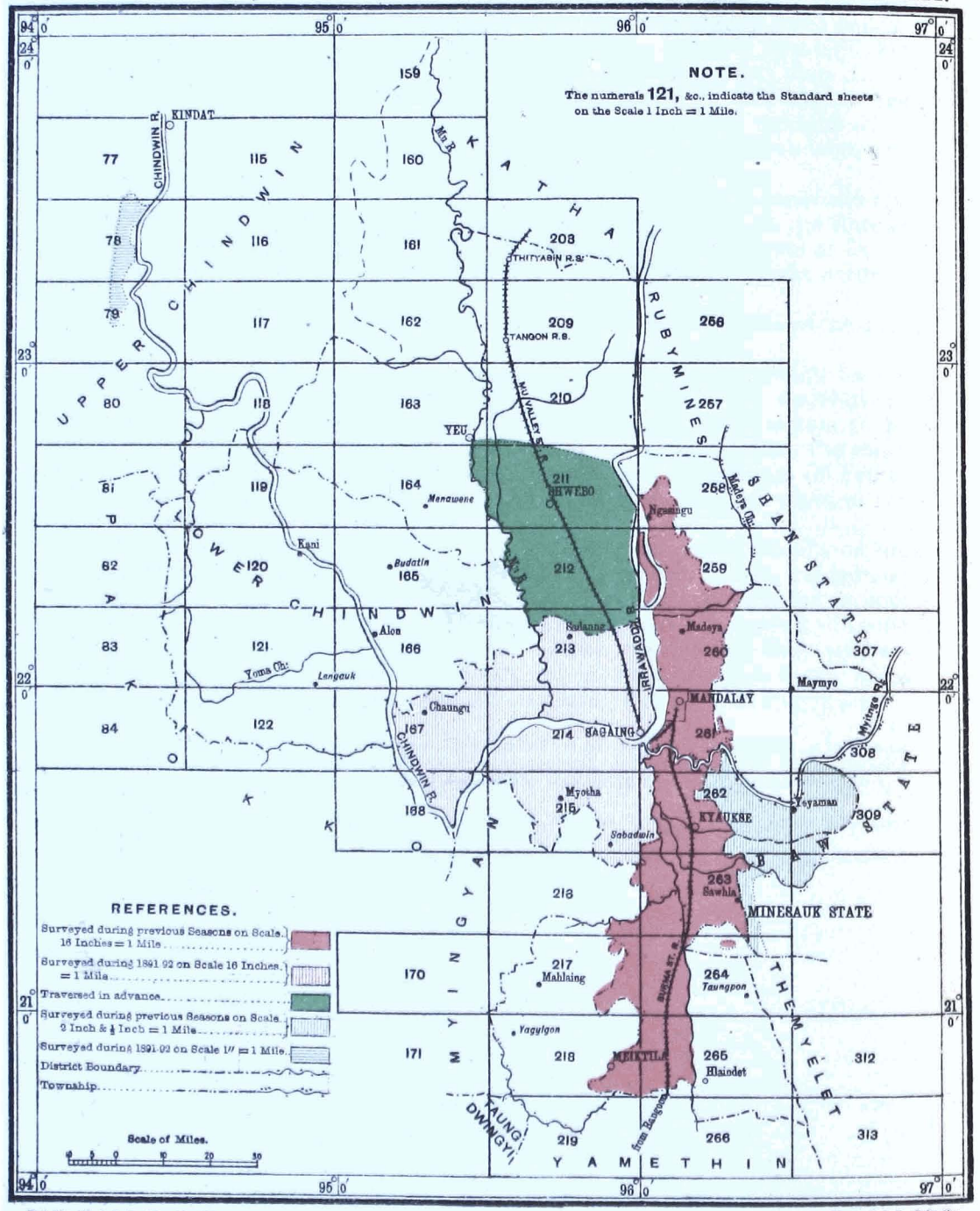
Mr. McIntyre, Babu Ramji Lall, Binda Lall, Narain Prashad, Hamil Husain, Augamothu, Ram Narain, Candaswamy, Israr Husain, Abu Mahomed, Basit Ali and Kampta Pershad.

The traverse surveyors employed in the Tippera district are unfavourably reported on by Mr. MacHatton, but he states that the computers have worked well.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. SAGAING, SHWEBO, MANDALAY, MEIKTILA, & KYAUKSE.

No. 3 PARTY.



Reg. No. 488. S. I. D.—Mar. 93.—550.

Photo. S. I. O., Calcutta.

SAGAING DISTRICT, UPPER BURMA.

No. 3 Party.

208. The programme of work of this party comprised the cadastral survey of the Sagaing district, advance traverse work in the Shwebo district, and the topographical survey on the 1-inch scale of a portion of the coal-bearing tract in the Upper Chindwin district. The strength of the party is given in the margin.

Personnel.

Mr. G. B. Scott, Deputy Superintendent, 2nd grade, in charge from 21st December 1891.
„ B. G. Gilbert-Cooper, Assistant Superintendent, 1st grade, up to 16th May 1892, and in charge up to 20th December 1891.
„ J. Connor, Extra Assistant Superintendent, 3rd grade.
„ J. Newland, Extra Assistant Superintendent, 4th grade, up to 16th March 1892.
„ O. D. Smart, Sub-Assistant Superintendent, 1st grade.
„ P. J. Serrao, Sub-Assistant Superintendent, 2nd grade.
„ F. P. Walsh, Sub-Assistant Superintendent, 2nd grade.
„ W. J. Baker, Sub-Assistant Superintendent, 2nd grade.
„ H. B. Powell, Sub-Assistant Superintendent, 3rd grade.
24 surveyors, sub-surveyors and others.

Temporary Establishment.

16 inspectors.
160 field surveyors (Indian).
32 ditto (Burman).

209. Field work commenced in Sagaing about the 20th November 1891, and closed on the 20th June 1892, when the party returned to recess quarters in Mandalay.

210. The demarcation of Sagaing district had been carefully completed, and tracings of plans showing *taiks* or circles, and *kwins* or villages, were made over to the survey office before the party took the field. The demarcation in Shwebo had only just been commenced when traverse operations began in that district in April; consequently only circle boundaries as laid down by *thugyis* could be traversed, but a sufficient number of sub-traverses were run to allow of the *kwin* or village boundaries being correctly plotted by the *amins* during next season, by which time it is hoped the plains portion of the district will have been demarcated.

211. In the Sagaing district, 15,342 theodolite stations have been marked by baked clay cylinders about two feet in length, which, with those fixed last season, make a total of 20,724 permanently marked stations: in Shwebo, 11,995 stations have been marked in the same manner. Arrangements are being made to procure glazed clay cylinders at Kyoukmyoung on the Irrawaddy for future use in the Shwebo district. The Deputy Commissioners of the districts have been asked to arrange for the preservation of these marks in accordance with the Burma Boundaries Act. Where the Chindwin and Irrawaddy rivers touch on districts Lower Chindwin, Pakkoko and Myingyan, both banks of the rivers were enclosed by traverse lines, the stations being permanently marked. Plots were sent to the respective Deputy Commissioners to assist them in identifying and preserving the stations.

212. The total area traversed in Sagaing this season was 1,219 square miles, which, with 714 surveyed last season, gives a total of 1,933 square miles; but of this, 101 square miles are river circuits, and of these again 40 square miles lie in adjoining districts. There were 3,582 linear miles of chaining run in Sagaing district and 2,866 in Shwebo district, double sets of chains being used throughout, as in last season. The angular work was checked by 71 azimuth observations in Sagaing district and 56 in Shwebo district. Two stations of the Great Trigonometrical Survey were connected with the traverse work in Sagaing district, *viz.*, Mozataung in the south and Mingun in the north, which furnished checks to the linear measurements. The positions of 103 conspicuous objects, chiefly masonry pagodas, have been connected with the traverse lines by theodolite observations.

213. The theodolite at every station was set up in the magnetic meridian; by doing this, not only can any large angular error at once be discovered, but a close approximation to the magnetic variation at each village at the time of survey can be obtained. The magnetic readings, which are taken with greater accuracy at each of the azimuth stations, vary considerably in the four districts of Kyaukse, Mandalay, Meiktila and Sagaing.

Thus in Kyaukse they varied from 4° 54′ to 1° 25′; on Mandalay from 4° 57′ to 1° 30′; in Meiktila from 3° 21′ to 1° 32′; and in Sagaing from 3° 50′ to 1° 32′. With a view to ascertaining how much of this is due to local attraction and how much to instrumental errors, the magnetic variation has been determined with each instrument when erected on the same spot, and the differences from the

mean have been noted. It is intended to apply these to the observations made during the coming season.

214. The total out-turn of work for the season is shown in the following table :—

Districts.	Cadastral Survey, 16 inches = 1 mile.			Traverse Survey.		Topographical Survey 1 inch = 1 mile.
	No. of villages.	No. of fields, etc.	Area in square miles.	No. of village blocks.	Area in square miles.	Area in square miles.
Sagaing	1,150	1,001,010	1,818	691	1,219	...
Shwebo	...	...	...	364	800	...
Upper Chindwin . .	...	...	...	...	...	106
Total .	1,150	1,001,010	1,818	1,055	2,019	106

The cadastral area, *viz.*, 1,818 square miles, excludes all rivers; the high banks of these have been surveyed by the plane-table throughout, as well as all islands, cultivated or otherwise. The small groups of hills lying within the area surveyed on the 16-inch scale have been surveyed on the 2-inch scale.

The total number of items surveyed was 1,001,010, the average size being about 1·16 acre, but if all large blocks of jungle, etc., are omitted, the average size of the "field" is about 0·64 of an acre. It is impossible, till a statistical statement has been prepared, to say what proportion the cultivated area bears to the uncultivated, but judging from results already obtained, it will probably be about 40 per cent. The statistical statements for districts previously surveyed have now been prepared, and the results are as follows:—

Kyaukse,	under crops and fallow	. . .	59%	of area surveyed.
Mandalay,	ditto	ditto . . .	46%	ditto.
Meiktila,	ditto	ditto . . .	55%	ditto.

This should, of course, be considered when comparisons of costs are made. The uncultivated portions are covered with thorny scrub, and when near hills are broken by numerous ravines.

215. The Irrawaddy, Chindwin and Mu rivers, which flow through or on the boundaries of Sagaing district, have usually high firm banks and seldom overflow. But the water of the Irrawaddy, when the river is full, flows up the beds of water-courses that fall into it from the hills, and fills large depressions, thus forming little lakes, or *ins*, round which rice is raised in large quantities. Advantage is taken of the slopes of hills and downs to make small dams to collect the rainfall, and from the tanks or *kans* so formed, water is gradually let off over the neighbouring low lands for irrigation. This method might be extensively enlarged when the population increases. At present the bulk of the crops are cotton, sesamum and *jawar*, not needing irrigation. A Chinaman collects large quantities of cotton at Ywathitgyi, on the Irrawaddy, chiefly for the Chinese market, *vid* Bhamo.

216. The average cost of the cadastral survey, including the permanent marking of stations, traverse, detail survey and mapping, as well as tracings and area statements for the Settlement Department, was R141-4 per square mile, or As. 3-6 per acre, as against As. 4-11 per acre in Mandalay last season and As. 8-5 per acre in Kyaukse in 1889-90. This reduction in the cost-rate is due to the large area surveyed and to the larger employment of local labour. The employment of village coolies in place of *khalásis* imported from India has effected a saving of nearly R21,000, due to not having to pay the passages of *khalásis* to and from India, and to the difference between their regular monthly pay and the amount actually paid for local labour. It is possible that a further saving may be effected next season by extending the employment of local men; but as other departments pay higher wages, and a better season for crops may make the people less inclined to work for wages, it is not safe to trust entirely to local labour.

217. Regarding the employment of Burmans as sub-surveyors and *amins*, Mr. Scott reports as follows:—

"It is to be regretted that the employment of educated Burmans as sub-surveyors and *amins* cannot also be largely increased, but there is too much uncertainty about them to allow of a complete reliance being placed on them."

Four Burman surveyors were employed throughout the season; the out-turn of one of them was as good as that of the best of the Indians, and two others did well, but the fourth was useless. Thirty-two Burman *amins* were employed, two with each Indian squad, and on the whole did well, though their out-turn was not so large as that of most of the Indians. A large number of Burmans are now employed in the mapping, tracing, and area estimating sections.

218. The traverse work in Sagaing was completed by the beginning of April, and the camp was transferred to Shwebo. The cadastral survey of the entire district was completed by the middle of June, and tracings and area statements of about 800 villages are now ready for submission to the Settlement Officer: the rest will be ready by the close of the recess season. Three thousand linear miles of check survey were run in field books, and 1,350 linear miles on plane-tables while work was in progress, to test the accuracy of the survey, and the work proved to be very good. Every village was checked by a final field book *partal* before being passed.

219. The health of the party in Sagaing was exceptionally good; not a single death occurred. In the coal tract one *tindal* died. The hospital assistant in Sagaing, Gunga Churn Guha, performed some skilful operations for broken limbs, and the dispensary was highly patronised.

220. A detachment under Mr. Newland was sent to survey a tract of coal-bearing country in the Upper Chindwin district, and to demarcate a block for the Buckland Syndicate. As the area at first proposed for survey was very large, the establishment sent was a strong one: this area was subsequently reduced to 106 square miles; but as the country was a mass of hills rising to three thousand feet, quite uninhabited and covered with dense forest, the *khalásis*, in addition to jungle-cutting, had to carry their own supplies by relays across the hills from the Chindwin river, and thus a smaller party might have failed to do the work required. Mr. Newland was prostrated by fever shortly after arrival on the ground, and Mr. Walsh was sent to help him: he also was taken seriously ill. However, both recovered for the time, and the work was completed by the middle of March. The triangulation was based on four points of the Kubo and Chindwin Valleys Series. The Deputy Superintendent visited the place in January, and spent a week in placing the work on a proper footing. Unfortunately Mr. Newland died of heart disease on the 16th March. In him the Department has lost a most experienced, devoted and trustworthy officer.

221. The relations with the Civil authorities were cordial throughout the season, and those between the survey employés and villagers were, as a rule, most friendly. An extract from Mr. Scott's narrative report on the country surveyed will be found in the appendix.

222. The programme for next year comprises the cadastral survey of all open country in Shwebo district, probably 1,200 to 1,400 square miles, the traverse of Yeu district in advance, and the laying down of a small section of disputed boundary between Manipur and Burma.

223. On the 22nd August 1892, the Deputy Surveyor-General met the Chief Commissioner at the survey office at Mandalay, and inspected the maps and discussed the future programme of the party with him. A detailed inspection was afterwards made by the Deputy Surveyor-General on the 22nd and 23rd August, when everything was found in excellent order. The large out-turn and low cost-rate testify to the good management and energy of Mr. Scott.

224. Mr. Gilbert-Cooper held charge of the traverse camp for a time; he was also sent to run a series of check lines across the Ava sub-division, after which he was instructed in the various computations required in a cadastral party. He is a promising assistant.*

* Mr. Scott reports thus of his assistants: "Mr. Connor, who held charge of the cadastral camp throughout the season, and Mr. Smart, who held charge of the traverse camp after Mr. Gilbert-Cooper's departure, both did excellent work. Messrs Serrao, Baker and Powell all worked with zeal and ability, and aided largely in the progress of the work. Mr. Walsh has been employed chiefly on hill work, and has, as usual, been most willing to perform any work allotted to him, however arduous."

Of the natives, he selects the following as specially deserving of notice, *viz.*, Bhugobutty Charan Chuckrabutty, Pandit Kedar Nath, Gafur Bux, Masiuddir, Alimuddin, Moung Pho Tun, Abdul Hassan, Rafartulla, Rangbehari Lall and Mahomed Shaffi.

WESTERN DUARS, BENGAL.

No 4 Party.

225. This party has been employed on cadastral and topographical operations in the Western Duars in continuation of the work of former seasons, the latter comprising the survey of reserved forests on the 4-inch scale and of the waste lands on the 2-inch scale. The re-laying of the Jalpaiguri-Bhutan boundary was also continued and completed.

Personnel.

Captain G. B. Hodgson, S.C., Deputy Superintendent, 2nd grade, in charge.
Mr. H. T. Hanby, Extra Assistant Superintendent, 2nd grade.
„ W. H. Penrose, Sub-Assistant Superintendent, 1st grade.
„ G. T. Hall, Sub-Assistant Superintendent, 1st grade.
„ G. A. Knight, Sub-Assistant Superintendent, 1st grade.
„ L. F. Berkeley, Sub-Assistant Superintendent, 1st grade.
„ P. C. H. Smart, Sub-Assistant Superintendent, 1st grade.
„ C. G. S. Wood, Sub-Assistant Superintendent, 2nd grade.
„ P. K. Vaughan, Sub-Assistant Superintendent, 3rd grade, from 23rd November 1891.
43 sub-surveyors and others.

Temporary Establishment.

84 field surveyors, inspectors, etc.
62 computers, draftsmen, etc.

Cadastral Survey.

226. The cadastral operations consisted principally in the preparation of the records of the former year's survey for the Settlement Department, the work being considerably in arrears, as explained in former reports. A few detached plots of land were surveyed cadastrally, which had been omitted in former seasons or which had recently been allotted.

227. The divisions into which the lands are separated was given in para. 204 of the General Report for 1890-91, and is again quoted as it explains the "unit of the map" in the Duars:—

"The only territorial divisions bearing definite names in the Western Duars 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*."

228. It was anticipated that only 5 or 6 square miles of the cadastral survey of some *jots*, which had been omitted in previous seasons for various reasons, remained for survey; but as the work progressed it was found that new *jots* had been formed out of the jungle, so that the area for survey gradually increased, and amounted in the end to 22·74 square miles, which were completed and the details of which are tabulated below:—

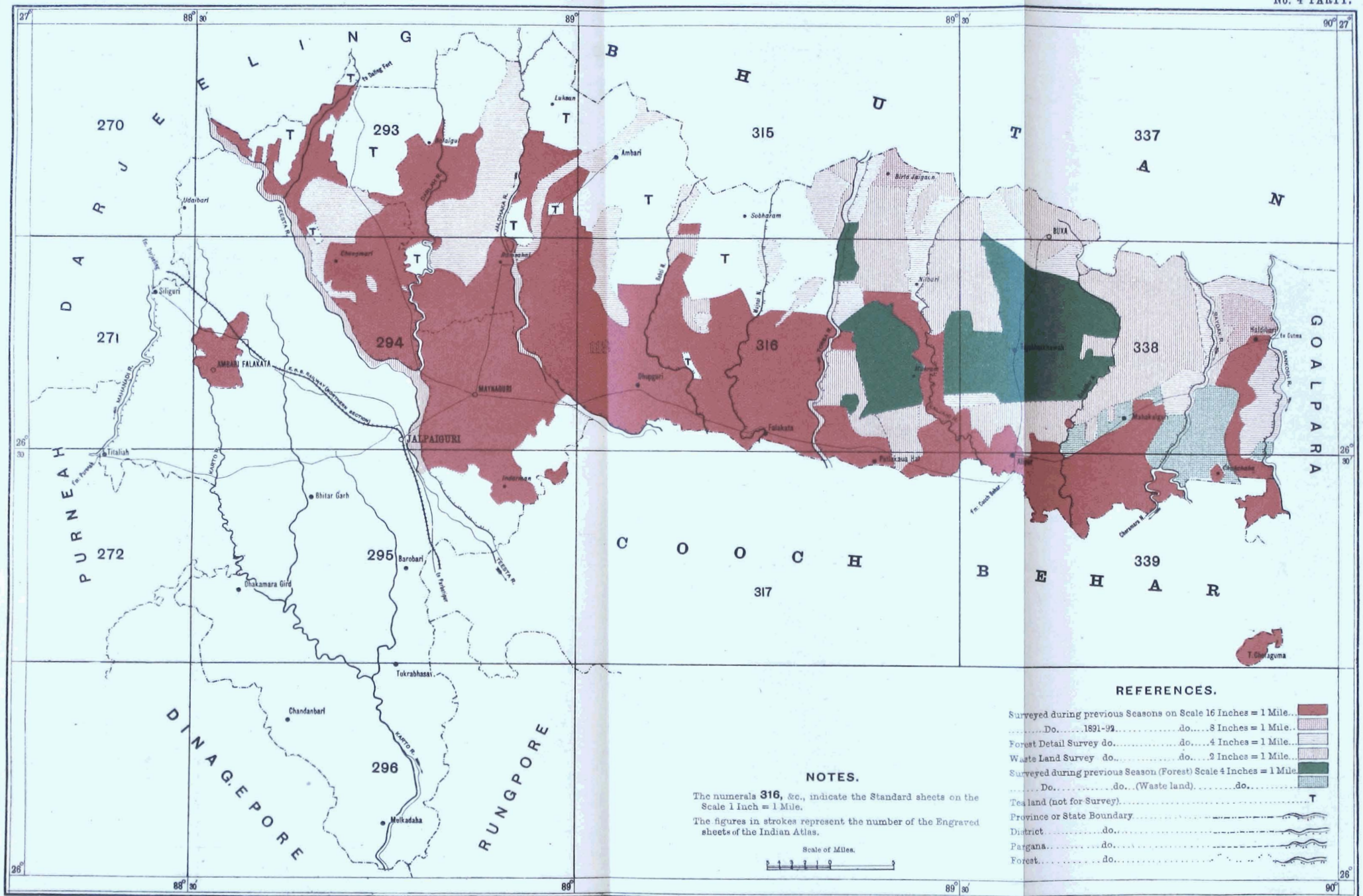
Parganas.	Cadastral Survey, 16 inches=1 mile.			
	No. of *chaks*.	No. of *jots*.	No. of fields proper.	Area in square miles.
South Mainaguri	2	4	214	0 35
Chengmari	7	17	916	1·47
North Mainaguri	12	39	940	2 37
Moraghat	10	29	446	1·28
Lakhipur	7	28	535	1·48
Madari, West	4	55	825	5·55
Do., East	17	23	1,095	6·21
Chakwaheti	...	25	524	3·11
Buxa	8	8	302	0·92
Total	67	228	5,797	22·74

The average size of fields in district Jalpaiguri has this season been found to be 2·51 acres.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN THE WESTERN DOOARS (DISTRICT 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 sheets of the Indian Atlas.

Scale of Miles.

REFERENCES.

Surveyed during previous Seasons on Scale 16 Inches = 1 Mile	
Do. 1891-92 do. 8 Inches = 1 Mile	
Forest Detail Survey do. do. 4 Inches = 1 Mile	
Waste Land Survey do. do. 2 Inches = 1 Mile	
Surveyed during previous Season (Forest) Scale 4 Inches = 1 Mile	
Do. do. (Waste land). do.	
Tea land (not for Survey)	T
Province or State Boundary	
District do.	
Pargana do.	
Forest do.	

Reg. No. 925, Bengal & S. I. D.—Jan. 93—2,252.

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

229. Although the area is so small it was very scattered, and thus the cost is high, for there was great loss of time in travelling about and tracing out the boundaries of these *jots*, which for the most part lie in high grass and necessitate heavy line clearing, and the boundaries of which were not demarcated. A few *jots* in *pargana* South Mainaguri are situated in the sands of the river Tista, and had no existence as cultivated *jots* when that *pargana* was surveyed in season 1888-89. The small area of detail survey was checked by 22½ linear miles of independent *partal* and by 24½ linear miles of *partal* run on the field sheets by inspectors. Only 5·33 square miles of the cadastral area had to be traversed, as the rest of it lay within the limits of the old traverses.

230. The cadastral section office was located at Jalpaiguri throughout the field season, as its principal work was the completion of the records of the cadastral survey of previous seasons, which had to be furnished to the Settlement Officer. These arrears consisted of 4,919 *jots* and waste land blocks. Some anxiety was felt whether this large amount of work would be accomplished, for the physical condition of the establishment was far from satisfactory, as the men were weakened from constant illness caused by recessing in a feverish place like Jalpaiguri, and there was no possibility of filling up casualties. By great efforts however all the records, inclusive of those of the current season, were sent in to the Settlement Officer by the 20th May, and the party quitted Jalpaiguri by the 25th May 1892.

231. The cost-rate over the whole of the cadastral area of 782 square miles surveyed in the Jalpaiguri district between the years 1888–92, including traverse, survey of fields, mapping and writing of record of rights, is ₹458 per square mile, or annas 11-7 per acre; the average size of the field is 0·68. The most important among the numerous causes which led to this high rate are the excessive unhealthiness of the district and the physical difficulties of working in a country the greater part of which is covered with dense forest. Some of the other causes were the great difficulty in making a comparison between the old and the new boundaries owing to the unsystematic way in which the old records had been kept, the absence of definite names of localities, which caused great delay in hunting up the positions of outlying *jots*, and the unwillingness of the inhabitants to render any assistance to the surveyors.

232. Mr. Hanby complains that allotments of land continued to be made during the progress of the survey, and the demarcation *amins*, paying no attention to what had been surveyed, fixed points wrongly on the common boundaries, and thus caused much unnecessary trouble when the new *jots* came under survey. This was noticed in every *taluk*, but more especially in *taluks* Khuriar Bande and Dhupjhora of *pargana* Chengmari and Gairkhuta of *pargana* Moraghat.

Topographical Surveys.

233. The topographical programme comprised the completion of the survey of the reserved forests of the Western Duars, on the 4-inch scale, and of all arable and non-arable waste lands, on the 2-inch scale, in the area originally allotted to the party, which had not been surveyed on the 16-inch scale, and of which a cadastral survey was not considered desirable. In addition, the relaying of the Bhutan boundary was to be completed, and the survey on the 8-inch scale of two blocks of tea land aggregating 10,000 acres.

The final orders of the Government of Bengal on the proposed season's operations were conveyed in letter No. 470TR, dated 28th September 1891, from the Under-Secretary, Revenue Department. According to these orders the 1-inch scale was to be employed for the waste lands, but this was subsequently cancelled and the adoption of the 2-inch scale sanctioned. Under the authority of the former letter quoted above, also, the classification of growths and soils in the forests was discontinued.

234. Recess work at Hazaribagh closed on the 13th November 1891, and the party re-assembled on the 25th idem at Salsalabari, five miles to the east of Alipore, the head-quarters of the *tahsil* of that name. Considerable delay in commencing field work was caused by the late arrival of the *khalásis* temporarily entertained at Hazaribagh, who on their way to Jalpaiguri halted for a week at Purnea and sent on word demanding a further advance of money

beyond what they had already received on starting. It was not, therefore, till the 5th December that field work actually commenced.

235. There was no triangulation done during the present season, and over the area surveyed topographically, the only traverse work was the remeasuring of portions of two main circuits enclosing the cantonment of Buxa and extending from the northern boundary of the Buxa forest to the boundary of Bhutan, which had been surveyed during the previous season but had not proved mathematically. The area of traverse survey which has been added is 22 square miles. The linear error is extremely large even now; but this is due partly to the mountainous nature of the country in which the work was carried on, and partly to the large correction already applied in the adjoining traverse circuits. The traversing was done with the subtense bar, chain measurements being supplemented wherever practicable.

236. Detail survey was commenced in the eastern half of the district, the party being divided into four sections, each under an European assistant, to which the whole area still remaining unsurveyed between the Torsa and Sankosh rivers was apportioned off: it was arranged that, as each section completed the area allotted to it, the men should be moved across the Torsa river into the western half of the district, where several larger reserved forests still remained for survey. Thus, from the very commencement, the party was scattered over a considerable area of country with large tracts intervening which had either been surveyed in former seasons or were not for survey. This entailed a large amount of marching and consequent loss of time, a serious consideration in such a short field season as is practicable in the Duars. Each assistant had to superintend whatever work fell into his block, whether on the 2-inch, 4-inch or 8-inch scale. Each was provided with an elephant, which not only enabled him to move about more rapidly than is possible on foot, but proved useful in other ways, and as the assistants did not take up any plane-tabling themselves, whenever they were not actually checking a man's work they accompanied one or other of the plane-tablers and kept them up to the mark. The large amount of supervision thus exercised has insured a far greater degree of accuracy than would have been attainable otherwise in a survey of such a jungle-clad country, where the fear of wild animals and the very laborious nature of the work, added to the terrors of a notoriously unhealthy district, rendered the work intensely distasteful to the majority of the men.

237. The area of detail survey on the 4-inch scale of the reserved forests done during the season amounted to 327 square miles.

238. The area of waste land surveyed on the 2-inch scale during the season is 337·17 square miles, the larger part of which lies in *parganas* East Madari, Chakwaheti, Buxa, Bhatibari and Bhalka, with small scattered plots in *parganas* North Mainaguri, Lakhipur, and West Madari. Of this area, the Tista river accounts for 36·41 square miles. The other large rivers in the district whose beds had not been previously surveyed on the 16-inch or other scales are the Jaldhaka, Torsa, Raydak and Sankosh, and, with the exception of the Sankosh, the greater part of all these were surveyed this year either on the 2-inch or 4-inch scales, the latter scale being employed for such portions of rivers as fell into the various forest reserves.

239. A theodolite traverse has only been run along one bank, the inner or Western Duars bank, of both the Tista and Sankosh rivers, and the survey of the Tista river, which was done entirely on the 2-inch scale, was carried out by running a plane-table traverse along the west bank, which was checked by interpolation, various objects whose positions had been fixed from the traverse stations on the east bank being used for intersections. The bed of the Sankosh river has not been surveyed, as the river is not fordable anywhere in the portion adjoining the Western Duars, and it is so wide in places, and there is so much jungle along the east bank, that it would have taken a considerable time to accomplish the survey of it, and it was therefore not considered advisable to take it up.

240. The area of tea lands surveyed on the 8-inch scale amounts to 17·52 square miles, and was carried out for the tea land survey office, Jalpaiguri. The survey of five plots of waste land on the 16-inch scale was originally ordered, but as so long a time had elapsed since the request was made for the survey of these plots, a reference was made to the Deputy Commissioner, Jalpaiguri,

before the commencement of the field season, as to whether the survey was still required, and, if so, whether the 8-inch scale on which the majority of the tea land maps are drawn would suffice. He intimated that the 8-inch scale would suffice, and that the survey of only two plots was required—one of 4,000 acres, called the Jaigaon Tea estate, situated between the North Borajhar and Gaburbasra forest reserves and adjoining Bhutan; and the other 6,000 acres to the south of and adjoining the Dhumpara forest in *taluk* Haldibari Jhar, *pargana* Bhalka. No boundary marks had been erected by the local authorities, and the positions of the boundaries had to be determined so as to include as nearly as possible the areas applied for. This was done in Jaigaon with a theodolite traverse, and large earthen mounds were erected along the boundaries. In the Jaigaon grant the Company had been given preliminary possession; that is to say, had been allowed to enter and commence opening up the grant before the survey had been carried out, the usual procedure being to survey and mark out the land before giving possession.

241. The reason why the survey of these plots was not carried out in season 1889-90 was because the traverse survey of the district had not approached sufficiently close to the localities to enable it to be taken up, and at the commencement of the field season of 1890-91 information was received from the Settlement Officer that these plots would not be given out for tea cultivation; so nothing further was done that season. On the 24th June 1891, the Deputy Commissioner wrote, asking why the survey of Jaigaon had not been done, which led to the survey of these plots being taken up during the present season. In February 1892, information was received from the Deputy Commissioner that he would arrange to carry out the survey of the Jaigaon plot, and that there was no necessity to take up the survey of the other block, as the applicants had not paid the survey fees, and it was thought that they no longer wished to take up the land. By that time, however, the surveys of both blocks on the 8-inch scale had been almost completed, so they were carried through, though no boundaries were determined or marked for the plot in Haldibari Jhar.

242. As the work progressed very slowly at first, and fears were entertained that the district would not be completed this season, orders were issued to the detail surveyors that only the main features were to be accurately surveyed both in the forests and waste lands, and the smaller features sketched in approximately and shown with dotted lines. This however was found impossible, owing to the dense grass and tree jungle which covered almost the entire area under survey this year, and utterly precluded the possibility of any "sketching," so that all the details that have been mapped are as accurate as the scales and nature of the country admit.

243. Many obstacles to the survey were met with. Several fires occurred in the forests this year during the progress of the survey, but enquiries made on the spot in each case at the time of the occurrence proved that the subsurveyors had no hand in originating them. In the waste lands the grass is burnt annually, though usually not till about February. This season, owing to a scanty rainfall, the inhabitants began burning the grass in December, and though this slightly increased the range of vision and disclosed some of the smaller features which would otherwise have been lost, it did not have much effect on the rate of progress, as it is almost as difficult to force a way through it on foot after it is burnt as before, the thick succulent stems of the giant grass, often as thick as a man's finger, only partially yielding to the destroying element. Along the edges of the water-courses it is generally found that this grass does not get burnt at all, and though its green colour betrays the presence of a stream, it effectually conceals its actual proportions. The country is intersected with innumerable streams, all more or less fringed with this impenetrable grass, most of which have water in them for the best part of the year and soft muddy bottoms, which makes the crossing them most unpleasant at all times, and adds to the dangers and difficulties of survey work in the Western Duars. In the forests where the tree growth is large, this elephant grass is not met with, but a tangled mass of creepers and undergrowth of other sorts supplies its place, and renders a survey with any pretentions to accuracy of detail very laborious and slow.

The tracts that came under survey this year are for the most part uninhabited, and are consequently the haunt of the wild animals that abound in the

Western Duars—elephants, tigers, leopards, bears, buffaloes, bison, and several varieties of deer. These animals, however, were not often encountered by the sub-surveyors and their squads, who kept together as much as possible and took good care to make a considerable amount of noise over their work, and only one casualty occurred: a *khalási* who had got separated from his comrades was attacked by a buffalo and gored to death in the North Borajhar forest.

244. The cost-rate of the 4-inch forest survey, including mapping, is R129·1 per square mile, while that of the 2-inch scale is R67·9. Last season the cost of the 4-inch forest survey was R90·9 per square mile, and the cause of the increased cost this season is that in the forests surveyed this year there were comparatively few fire lines, and the reserves lay at great distances apart, whereas the work of last season lay principally in the Buxa forest in one compact block, and there was therefore little or no time lost in marching, and the forest was well provided with fire lines.

245. In addition to the topographical surveys above reported on, two assistants, Messrs. Hall and Knight, were employed throughout the field season in re-laying the Jalpaiguri-Bhutan boundary in accordance with instructions conveyed in letter No. 488P., dated 4th February 1892, from the Chief Secretary to the Government of Bengal to the Secretary to the Government of India, Foreign Department. Each assistant was instructed to erect intermediate marks between the existing cairns of stones which mark the boundary, and to prepare a careful map of the same on the 4-inch scale, giving enough of the surrounding details on each side of the boundary to enable the positions of the marks to be readily identified. The positions of these intermediate marks have been determined with the plane-table, and not with the theodolite. Such portions of the boundary as mark the limits of forest reserves were surveyed in the ordinary course of the forest survey; numbered wooden posts are erected at short intervals therein, and nothing was required to be done in such portions.

The survey on the 4-inch scale has been done of 75·93 linear miles of the boundary, comprising an area of 25 square miles.

A special report on the boundary survey has been submitted to the Government of Bengal, and a copy thereof, with a vellum trace of the map, was sent to the Deputy Commissioner of Jalpaiguri for information.

246. A good deal of sickness was experienced during both the field and recess seasons, though the close supervision that was exercised by the assistants probably accounted for there being a good deal less sickness than during the previous seasons; but the present was undoubtedly a less unhealthy one than usual, owing to the comparatively slight rainfall of 1891. At the commencement of April the rains set in, when 180 square miles, chiefly of forests, still remained to be surveyed: sickness among the sub-surveyors did not increase, though the wretchedly clad *khalásis* suffered considerably, and the survey was almost accomplished by the end of the month. There were 21 deaths among the *khalásis*—under 4 per cent.—of which eight occurred on the road from Hazaribagh to Jalpaiguri. There were also 28 desertions among the *khalásis*, and two sub-surveyors absconded.

247. The field work of the topographical section closed on the 5th May, and recess office was opened on the 17th idem at Hazaribagh, when the final examination of the 16-inch cadastral sheets was resumed; and also the preparation of standard maps on the 2-inch scale for reduction to one-half, and special forest maps on the 4-inch scale for reproduction to scale.

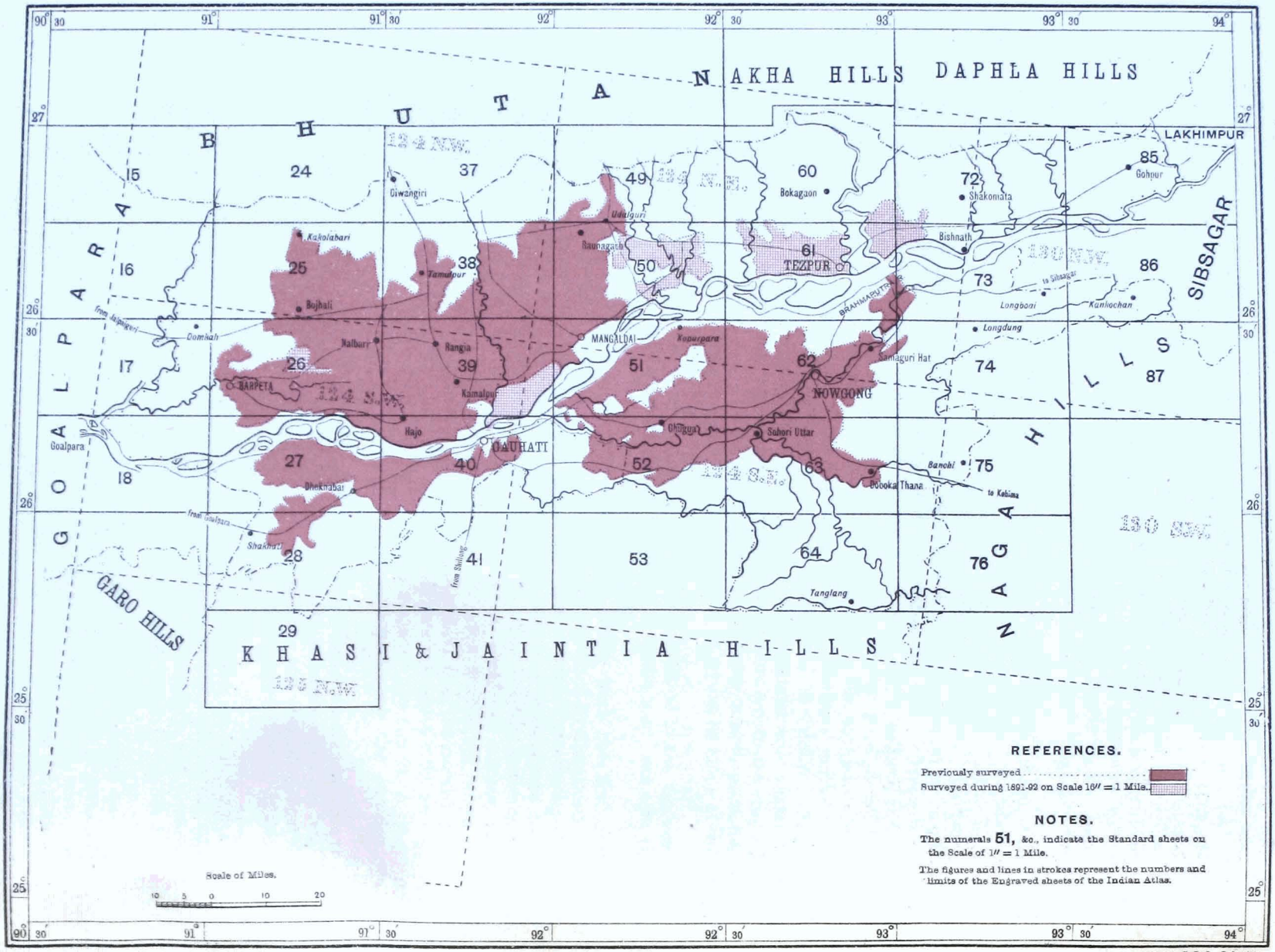
248. The season's work has been mapped on 159 sheets, of which 17 are on the 8-inch scale, being special work for the Jalpaiguri tea land survey, 91 sheets are on the 4-inch scale (78 forest, 12 Bhutan boundary, and 1 waste land commenced last season), and 51 sheets, consisting of waste lands, on the 2-inch scale.

The 2-inch mapping of the district is comprised in 36 standard quarter sheets, all of which have been projected and plotted and margins drawn, but are all in an incomplete state. Five sheets have been outlined in ink, with the exception of the portions known as tea lands, which do not fall into the present survey, of which details are to be entered from maps received from the Jalpaiguri tea land survey. In two of these five sheets the tea land covers very small portions of the sheets. Nine sheets are completed in outline in pencil, with the exception of the tea lands which fall into and cover a considerable

ASSAM SURVEY.

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

No. 6, PARTY.



REFERENCES.

Previously surveyed

Surveyed during 1891-92 on Scale 16″ = 1 Mile.

NOTES.

The numerals **51**, &c., indicate the Standard sheets on the Scale of 1″ = 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 20

Reg. No. 369, S. I. D.—Mar. 95.—550.

Photo. S. I. O., Calcutta.

area of three of them. Six sheets are only partly pentagraphed, but four of these are partly inked in as well. One sheet is plotted only.

The 4-inch mapping of the forests was taken up first: of these, there are 48 standard sheets. All have been outlined in ink, and borders and headings completed. The examination of all but four has been completed, as far as can be done in the present state of the maps.

249. When the forest survey was commenced in season 1890-91, instructions were received from the Forest Department that all streams which formed the boundaries of reserves were to be included in the reserves. As however such streams had already been included by the cadastral surveyor in the areas of the adjoining *jots*, a revision of a large number of the area books and of the offset entries in the traverse volumes has been necessitated. It has not been found possible as yet to take up this revision; but it will be effected by the field office during the ensuing cold weather, a note being made in the area books that a certain area has been transferred to the adjoining forest, and in the traverse volumes the offset entries will be altered.

250. It had been decided that the details of the tea lands which had been surveyed under the Revenue authorities should be incorporated in the 1-inch standard sheets. A large number of the sheets which are on the 8-inch scale have been reduced by pentagraph, but a comparison of these with the work by this party shows such discrepancies that the work was stopped; whether any use can be made of these maps of the tea lands has yet to be decided. Plotted copies of the 8-inch sheets—three in number—of the Jaigaon tea estate were prepared for the Deputy Commissioner and despatched in September.

251. The final examination of the 16-inch cadastral sheets was carried on during the recess, but was not quite completed; the remaining sheets, 121 in number, will be completed shortly.

252. Having completed the survey of the Western Duars, the party has been transferred to commence the cadastral survey of Northern Bihar.*

ASSAM.

No. 6 Party.

253. This party, of the strength indicated in the margin, left recess quarters at Shillong on the 25th October 1891 for Tezpur, where the field offices were established. Field operations were continued in the districts of Kamrup, Darrang, Sibsagar and Lakhimpur, of the Assam valley, and in the district of Sylhet. The party continued in the field till the 10th June 1892, when it returned to recess quarters. Mr. Barrett continued in charge throughout the year, with the exception of 3 months during the recess season, when he obtained privilege leave, and Mr. O'Donel, the senior Extra Assistant Superintendent, acted for him.

Personnel.

Mr. E. C. Barrett, Superintendent, 2nd grade, in charge up to 27th June 1892.
„ J. H. O'Donel, Extra Assistant Superintendent, 3rd grade, in charge from 27th June 1892.
„ C. W. Wilson, Extra Assistant Superintendent, 4th grade.
„ J. Smith, Sub-Assistant Superintendent, 2nd grade.
23 sub surveyors and others.

Temporary Establishment.

81 inspectors, draftsmen, computers, etc.
34 field surveyors (imported).
112 *mandals* and candidates (local).

254. Mr. Smith, Sub-Assistant Superintendent, assisted by 6 sub-surveyors and inspectors, on the 1st October opened a survey class at Tezpur for the instruction of the *mandals* (village headmen) intended for employment in the survey of the fields. One hundred and six *mandals* went through the course, of whom 99 qualified as field surveyors, 80 being retained for actual work. Besides the *mandals*, 40 local men were trained in the survey class. In addition to the local men trained under the direct supervision of Mr. Smith, Messrs. Medlicott, Duncan, French, Nicholls, and Reid, of the Civil Service, 3 Sub-Deputy Collectors, 2 *tahsildars*, 1 *kanungo*, 11 *tahsil moharrirs*, 2 Government surveyors, 6 *mandals*, 2 school-masters, 4 clerks, 4 *mauzadars*, and 73 local men were placed with

* Captain Hodgson commends the effortsof Messrs. Hanby, Hall, Berkeley, Smart and Wood; also Irfanali, Peari Lal, Ramjas Misir, Wazarat Husein, Nila-dhar, Patandin, Hyat Mohamed I, Hyat Mohamed II, Mahadeo Ram Azimulla, Mahabir Pershad and Dalmir Khan.

amins, and received practical instruction in field surveying, making, with the 146 *mandals* and candidates referred to above, a total of 5 officers and 254 local men, which is considerably in excess of the number trained in any pevious year.

255. Cadastral survey in the Assam valley was carried on as heretofore by imported and local agencies, 29 Hindustani *amins* and 102 local men being employed during the year. The Hindustanis, who were as a rule employed on the more difficult descriptions of survey, were each attended by a deputy *mandal*, whose duty was to write up in Bengali the village record locally known as the *dag chitta*. In Sylhet, 13 Bengali *amins* were employed in the field-to-field survey and 2 Hindustani *amins* and 2 sub-surveyors in the survey of grants. The *mandals*, who are salaried Government servants, received pay for their survey work at one-third the contract rates allowed to Hindustani *amins*, while all other local men received remuneration at two-thirds of those rates. The average area surveyed daily by each of the different agencies employed was—

In the Assam Valley.

By Hindustani *amins*	23·49
„ *mandals* (new)	10·24
„ candidates (old)	22·60
„ candidates (new)	12·41

In Sylhet.

By Bengali *amins*	11·57
„ local *amins*	10·41
„ Hindustani *amins* and sub-surveyors	41·19

256. The boundaries of a few of the grants were found marked by prisms and masonry pillars, but as a rule there had been no previous attempt at demarcation of any kind. In the Assam valley, where new villages were formed by the survey, stone prisms measuring 3′ × 1′ × 1′ (when available) were placed at village tri-junctions, but owing to the local administration not having been able to procure prisms from Calcutta in time, the marking of about 38 per cent. of the tri-junction points had to be left to be done by the Settlement Department. In the Jaintia *parganas* of Sylhet all village tri-junctions had been marked by blocks of stone when the last survey was effected, but it was found that quite 45 per cent. of these stones had disappeared; all the lost marks have been replaced by stone prisms of similar dimensions to those used in the Assam valley. Branches of *simal* (silk-cotton) and other quick-growing trees have been planted at an uniform distance of 5 feet to the magnetic north of all theodolite stations in the Assam valley and Sylhet: mounds of earth, 4 feet high and 6 feet in diameter, have been thrown up around the boughs, but the experience of the past two years has shown that these should be protected by bamboo fencing, otherwise the mounds are liable to be destroyed by cattle or washed away during the rains. It has now been arranged that in future all traverse stations shall be protected by mounds heaped up around several boughs and encased in bamboo fencing, the whole to be of a certain fixed size. These are to be erected in the first instance by the traverse surveyors and the cadastral *amin*, who during the field-to-field survey will report whether the orders have been carried out, and, if not, will call attention to the deficient marks, or shall, if possible, have them repaired before he leaves the village.

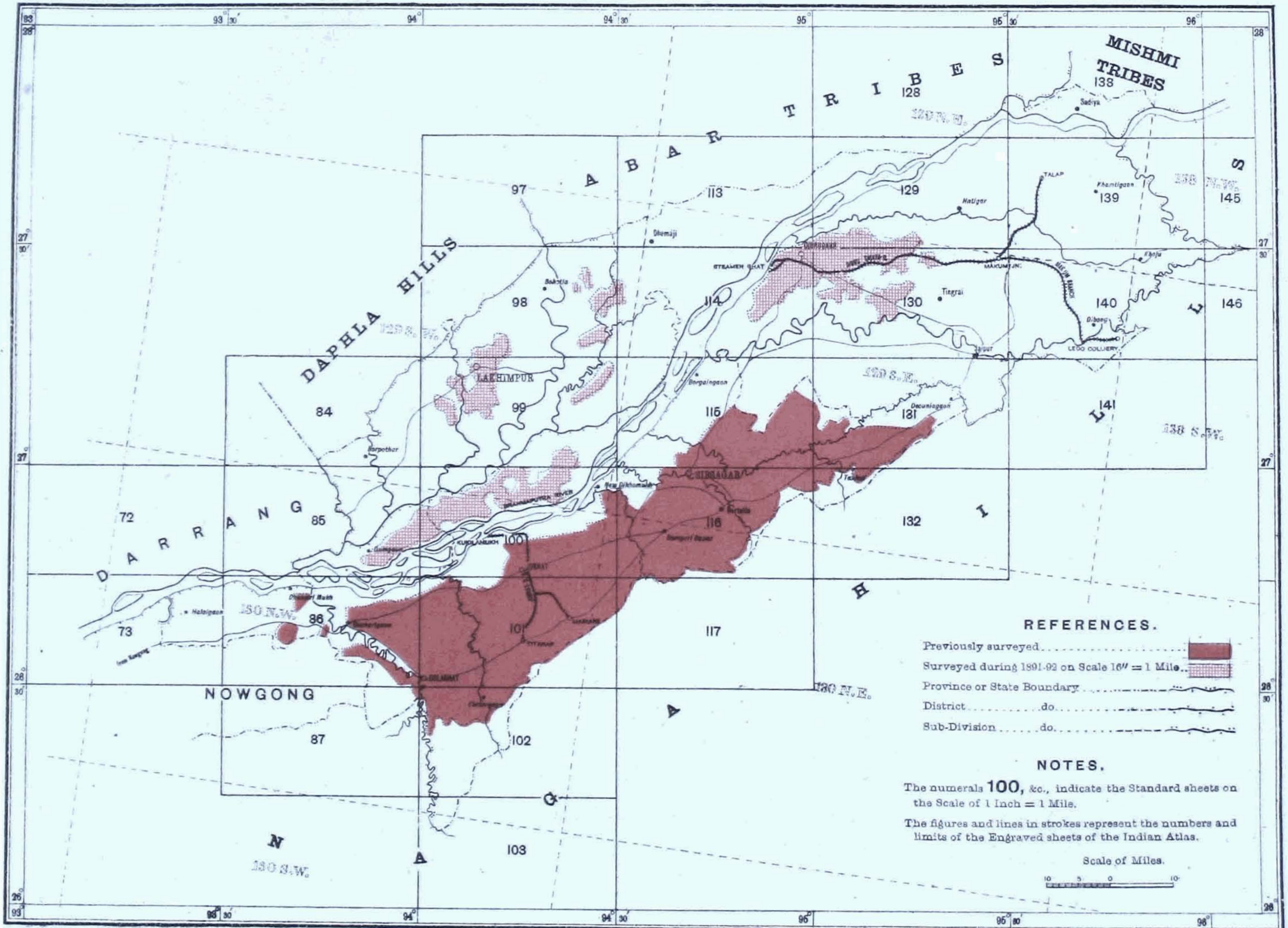
257. The season's out-turn of traverse and cadastral survey is given in the following statement:—

Districts.	Traverse Survey.			Cadastral Survey, 16 inches = 1 mile.		
	Number of *mauzas*.	Number of villages.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Kamrup	...	...	...	31	7,757	26·92
Darrang	4	78	81·18	326	83,440	310·08
Sibsagar	2	140	149·88	140	25,123	150·21
Lakhimpur	23	318	269·24	319	96,704	269·25
Sylhet	17	418	347 00	77	14,816	71·69
Total	46	954	847·30	893	227,840	828·15

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICTS SIBSAGAR & LAKHIMPUR.

No. 6 PARTY.



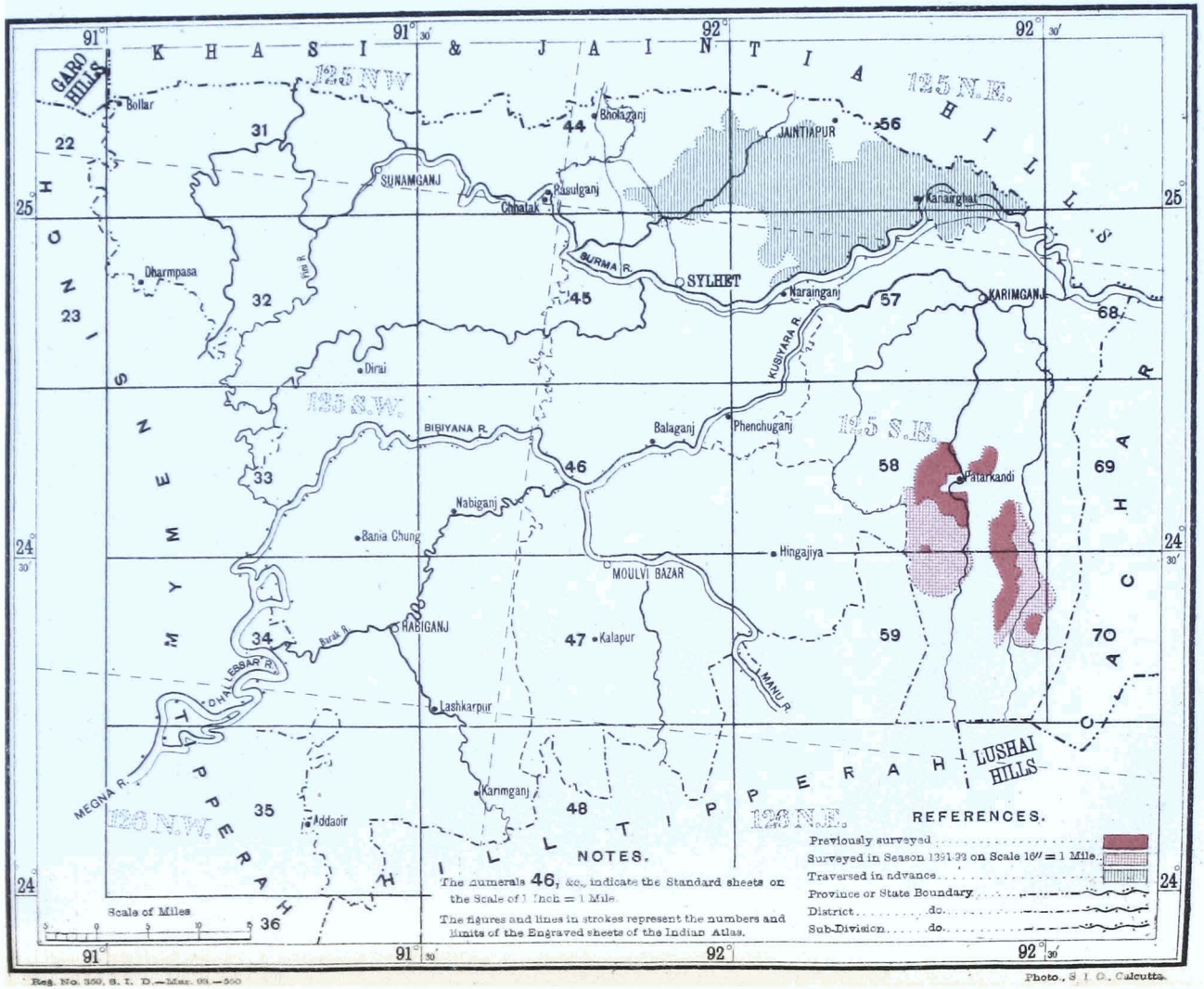
Reg. No. 419, S. I. D.—Mar. 93—550.

Photo. S I.O., Calcutta.

ASSAM SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT SYLHET.

No. 6 PARTY.



NOTES.

The numerals 46, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

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

REFERENCES.

- Previously surveyed
- Surveyed in Season 1891-92 on Scale 16″ = 1 Mile
- Traversed in advance
- Province or State Boundary
- District ..... do.
- Sub-Division ..... do.

Reg. No. 350, S. I. D.—Mar. 93.—500

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

258. In addition to the area completed on the scale of 16 inches = 1 mile, 9 islands in the Brahmaputra and the portions lying between the area cadastrally surveyed last year in district Kamrup and the river banks, measuring 23·5 square miles, have been surveyed topographically on the scale of 2 inches = 1 mile.

259. At the request of the Chief Commissioner, the town and cantonments of Dibrugarh have been surveyed on the scale of 32 inches = 1 mile.

260. The area surveyed contains the following grants and other estates :—

Districts.	Grants, Fee simple.		Grants, 30-year lease.		*Lakhiraj* (rent-free).		*Nisf-khiraj* (half rent).		*Ilam* (temporarily settled).	
	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.	No.	Area in acres.
Kamrup	...	...	...	...	...	...	37	884·84	...	...
Darrang	7	2,276·72	1	271·56	6	164·31	61	21,94·97	...	...
Sibsagar	1	516·15	..	...	24	27,497·56	2	23·47	...	...
Lakhimpur	25	16,697·85	12	3,635·90	11	186·79	47	1,070·59	...	...
Sylhet	...	...	29	17,689·89	...	...	...	...	1	1,327·23
Total.	33	19,490·70	42	21,597·35	41	27,848·66	147	4,173·87	1	1,327·23

261. Heavy rains set in over the Assam valley and Sylhet towards the close of March 1892, and almost paralyzed field operations. During the week ending the 2nd of April, no less than 61·54 inches of rain fell in the hills immediately adjoining the Jaintia *parganas*, the result of which was that the country was flooded and the work completely stopped. The rain continued almost without intermission till about the 15th of May, when a break occurred which enabled the men to resume field work. The rainfall in the hills for the seven weeks ending the 14th of May was 166 inches against a fall of 25 inches recorded during the same period last year. In the plains of Sylhet and in the Assam valley, the rainfall during April and May was almost twice as heavy as last year.

262. The cadastral survey in the Assam valley has been tested by 2,078 linear miles of check survey, which gives an average of $2\frac{3}{4}$ linear miles to the square mile surveyed. In Sylhet, 60·78 linear miles of check survey was run, which is equal to 1 linear mile of check to the square mile of survey. Village sites were tested by the re-survey of a portion of each site. The entries in the village records of 48,539 fields were examined on the ground by European and native officers. Two Sub-Deputy Collectors and 1,141 *munsarims* of the Settlement Department were also occupied throughout the field season in testing the accuracy of the entries in the records. The rectangular co-ordinates of 14 Great Trigonometrical Survey stations have been used for the correction of the traverse distances, and the angular work has been checked by observations for azimuth taken at 115 stations.

263. The average cost of the cadastral survey, including traverse, detail survey, mapping, completion of records and statistics, amounts to R108·6 per square mile in the Assam valley and R97·8 per square mile in Sylhet.

264. The season's out-turn has been mapped on 1,001 sheets. Tracings of the maps and the village records of the area completed in the Assam valley have been forwarded to the Settlement Officer. The tracings and records of the area surveyed in *pargana* Pratabgarh (Sylhet) have been sent to the *tahsildar* of Patharkandi.

265. The revision of the work of season 1890-91 was undertaken by 7 field surveyors, each of whom was attended by a Settlement *munsarim*. The number of objections raised by the *rayats* was 3,961 against 5,434 in 1890-91 and 10,409 in 1889-90.

266. The field season was, on the whole, fairly healthy; fever and bowel complaints were prevalent during April and May after the rains had set in. Mr. Wilson was obliged to take sick leave from the 22nd April till the close of the field season owing to an attack of fever. An *amin* and a cadastral office hand died of fever and dysentery in May, and a sub-surveyor died of dysentery in September.

267. Mr. Barrett expresses his indebtedness to the Deputy Commissioners of the five districts in which survey operations were carried on, and also to the Sub-Divisional Officers of Karimganj and North Lakhimpur, for the effectual manner in which they furthered survey operations. The relations between the Survey and Settlement were most cordial throughout the year.

268. The Deputy Surveyor-General visited Shillong in September 1892, when he inspected the office of the party, examining the cadastral sheets, traverse computations and all other office records, all of which were found to be satisfactory. For the sake of economy the European supervision of the party has been reduced to a minimum, if not somewhat below what is necessary for an efficient check on the work. To counteract this as much as possible, orders were given to run a greater number of *partal* lines between points given to the inspectors, the results of which being recorded in a field-book can be plotted and compared by the Superintendent in office; the completed sheet is kept under lock and key in the office, which prevents any possible collusion between the inspector and the *amin*. This forms as good a check as a *partal* run by a European assistant. The Deputy Surveyor-General also interviewed the Director of Land Records and the Chief Commissioner, when the programme for 1892-93 was discussed and arranged, and certain minor points connected with the junction lines of sheets, the erection and inspection of traverse stations and the more rapid supply of area statements, were discussed and arranged for the future.*

AMHERST, TAVOY AND MERGUI DISTRICTS, LOWER BURMA.

No. 7 Party.

269. This party was employed during the season in the Amherst, Tavoy and Mergui districts, work having been carried into the two last-named localities in accordance with the decision arrived at in the conference held at Rangoon on 25th April 1891, as mentioned in paragraph 289 of the Annual Report for 1890-91. The area of the operations was thus very extensive, and necessitated the sub-division of the party into two sections, one of which, under Mr. Wood's immediate superintendence, continued the work in Amherst, whilst the other, under Mr. Littlewood, commenced the survey of the cultivated portions of Tavoy and Mergui.

Personnel.

Mr. C. Wood, Officiating Deputy Superintendent, 2nd grade, in charge.
" H. R. Littlewood, Officiating Assistant Superintendent, 1st grade, from 25th November 1891.
" R. B. Smart, Extra Assistant Superintendent, 3rd grade, from 1st November 1891.
" G. W. Jarbo, Extra Assistant Superintendent, 4th grade.
" J. Murphy, Sub-Assistant Superintendent, 1st grade, from 14th November 1891.
" M. Gastaud, Sub-Assistant Superintendent, 1st grade, from 30th October 1891.
" F. B. Powell, Sub-Assistant Superintendent, 2nd grade.
" W. H. Biggie, Sub-Assistant Superintendent, 3rd grade, from 31st December 1891.
22 surveyors and others.

Temporary Establishment.

69 inspectors, draftsmen, computers, etc.
110 field surveyors.

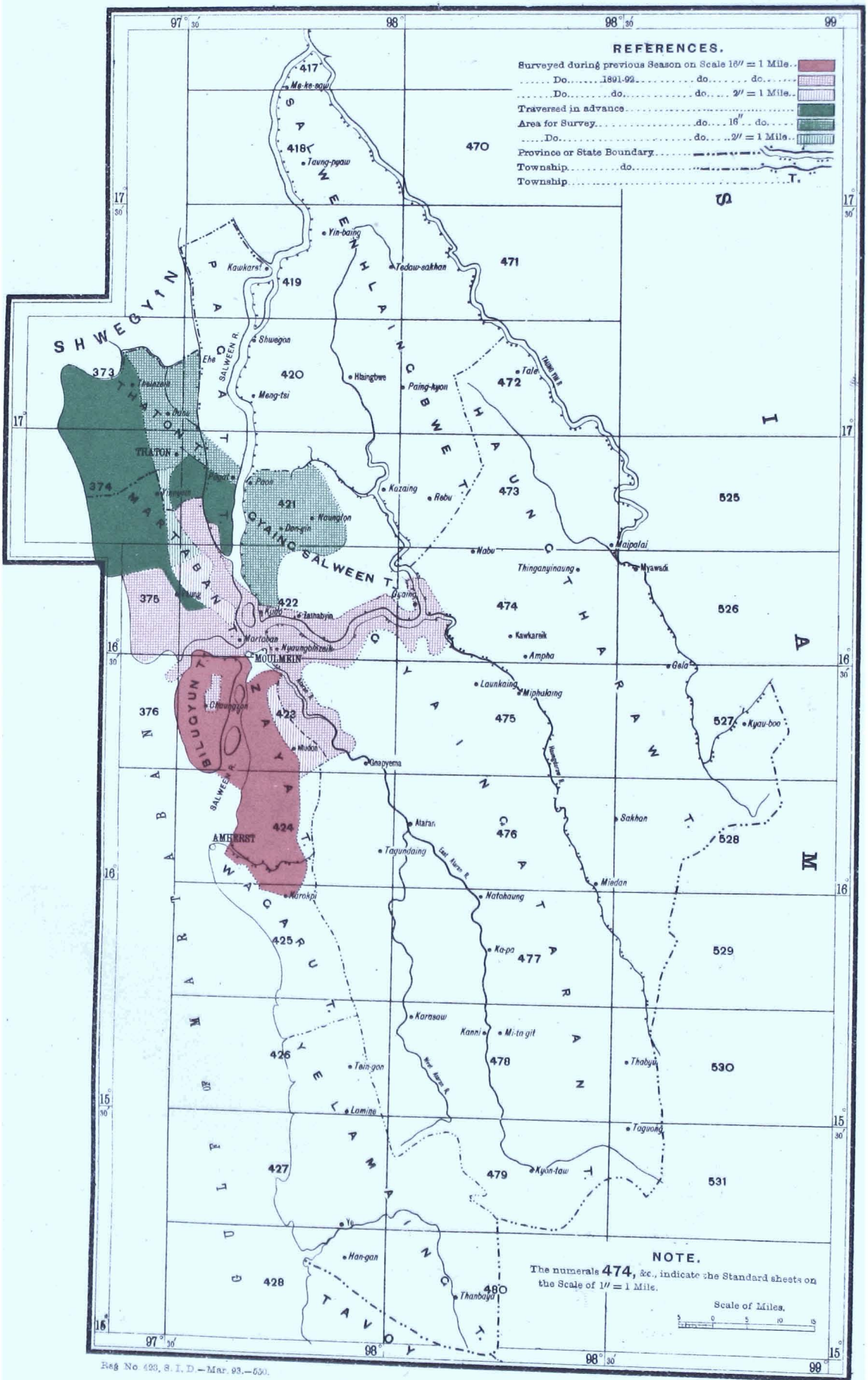
270. As no advance boundary survey had been executed in these last-named districts, it was necessary for the traverse surveyors to commence work as early in the season as practicable. Accordingly, two surveyors were sent on to Tavoy on the 10th October 1892, and the main body of the traverse squads left Rangoon on the 22nd idem by the Government

*Mr. Barrett again writes, in the highest possible terms, of his senior assistant, Mr. J. H. O'Donel. Messrs. Wilson and Smith are reported to have done good work during the recess. The under-noted members of the native establishment are considered deserving of special mention: Sakhawat Hossein, Khurshed Hossein, Khairuddin, Janardan Rao, and Chatterpul Singh, sub-surveyors; Gholam Hyder Khan, draftsman; Krishnaji Mahadeo Raj, computer; and Babu Sitanath Chuckerbutty and Jhuni Lal, of the cadastral establishment.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT AMHERST.

No. 7 PARTY.



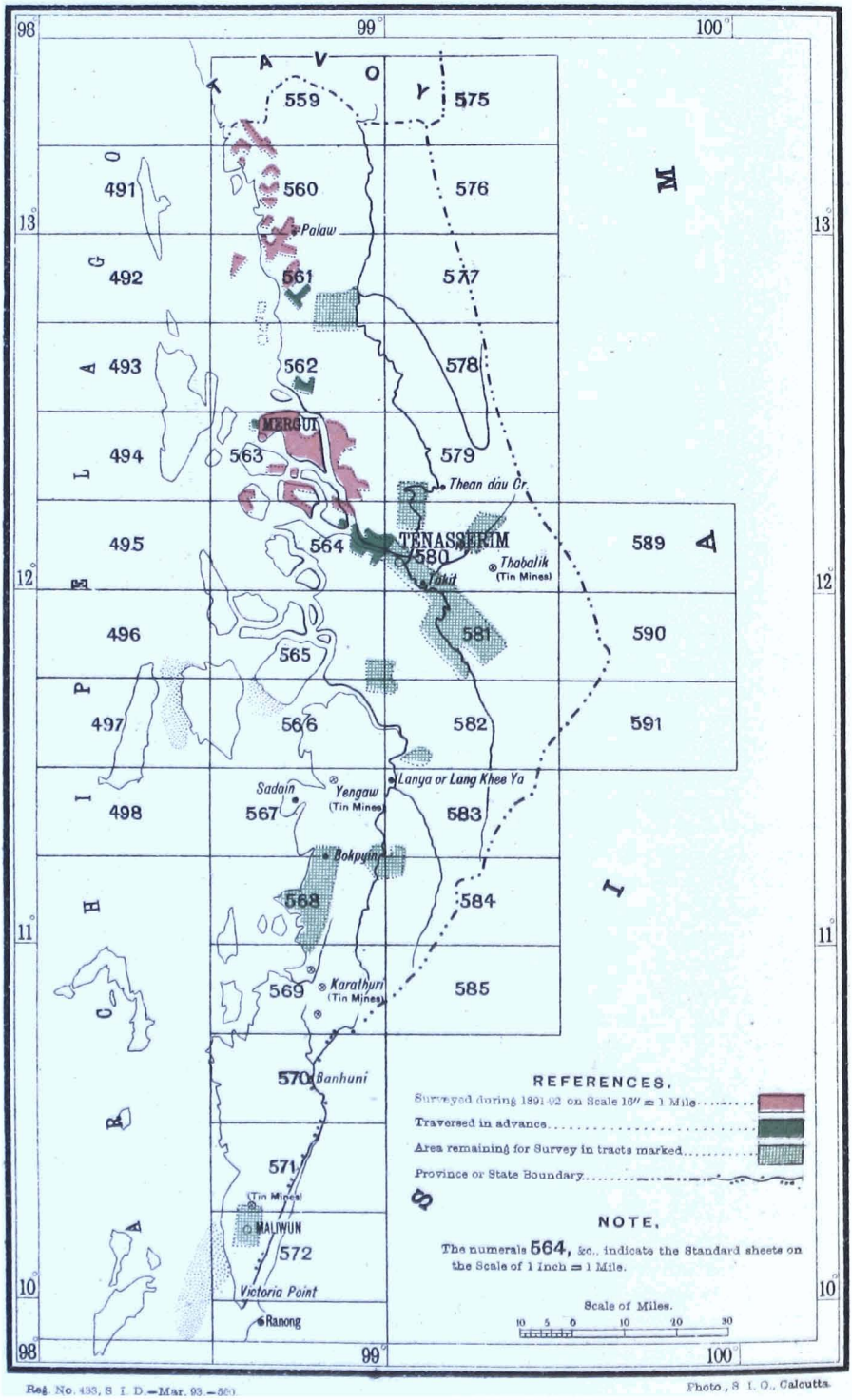
Reg No 429, S. I. D.—Mar. 93.—550.

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

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT MERGUI.

No. 7 PARTY.



Reg. No. 433, S. I. D.—Mar. 93.—560.

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

steamer "Mayo": the traverse section for Amherst took the field in the last week of October. The greater part of the cadastral section left Rangoon for Amherst on the 3rd December; a small squad under Mr. Littlewood was, however, sent forward on the 30th November to Tavoy. The remainder of the cadastral establishment for Tavoy and Mergui joined a month later, having been kept at work at Moulmein until the boundary survey had made sufficient progress. Owing to the early setting in of the rains, the Amherst sections returned to recess quarters on the 24th May; the Tavoy and Mergui sections, however, kept out till the end of the month, and arrived in Rangoon on the 6th June by the Government steamer "Dalhousie."

271. The work of the season comprised the following operations:—

In Amherst, (i) the traverse survey of 423 square miles in the Martaban, Thaton and Pagat townships; (ii) the cadastral survey on the 16-inch scale of 550 square miles in the Gyaing-Ataran, Gyaing-Salween, Haung-tha-raw, Bilugyun and Martaban townships; and (iii) the topographical survey, on the 2-inch scale, of 106 square miles in the Zaya, Bilugyun and Martaban hills.

In Tavoy, the traverse or boundary survey of 408 square miles and the cadastral survey of 310 square miles in the four townships of the district, on the 16-inch scale.

In Mergui, the boundary survey of 187 square miles in the Mergui, Palaw and Tenasserim townships, of which area 150 square miles were cadastrally surveyed, on the 16-inch scale, in the two first-named townships.

272. It was at first thought possible that the survey of the cultivated tracts in Tavoy and Mergui could be finished in one season to admit of revised assessments coming into force in 1892-93; but the extent of ground to be brought under survey was found to be much larger than was expected; and notwithstanding every endeavour to push the work on, a considerable area (about 130 square miles in Tavoy and about 100 in Mergui) still remains for completion in 1892-93.

273. Settlement operations were also carried on during the season by a *myook* and his staff of holding-markers, etc., working under the direction of this party. In order to admit of this work proceeding as nearly as possible *pari passu* with the detail survey, tracings were supplied almost immediately after the sheets received from the field surveyors had been examined, and no time whatever was lost in revising the same after the holding-markers had gone over the ground. The demarcation in gardens having originally been very defective, a good deal of revision work had to be done in consequence. Nevertheless, complete settlement registers were prepared for 167 *kwins* in Tavoy and 56 in Mergui (leaving only the classification of gardens to be taken up hereafter by the Settlement Officer of the Tenasserim division); and the demarcation of holdings was further completed in 14 *kwins* of the former and 73 of the latter district. The *kwin* demarcation in the Amherst district was all that could be desired, but not so in Tavoy and Mergui, where in many instances it was confined to the fixing of stakes at intervals along the edge of cultivation—an undertaking obviously superfluous, as those limits are visible on the ground without any demarcation. Possibly this may be due to the circumstance that whereas in Thongwa, Amherst, and other parts of Lower Burma a *kwin* is understood as the local equivalent of the Indian *mauza* (village), in Tavoy and Mergui it is evidently taken as the equivalent of *purwa* (hamlet), and so is practically applied to each detached patch of cultivation.

274. All the traverse stations were marked in the usual way and measures taken, as detailed in paragraph 283 of the Report for 1889-90, for their protection. No difficulty worth mentioning was experienced in getting the *ywathugyis* (revenue officials of *kwins*) to take over the custody of the station marks. The angular results of the season's traverse survey have been checked by star observations for azimuth at 235 stations, and the linear results were checked by connection with 20 stations of the trigonometrical and 2 of the topographical surveys: in both cases, the smallness of the corrections required (*viz.*, 4 seconds per angle and $6\frac{1}{2}$ feet per mile) shows that the work was satisfactorily done. The detail survey on the 2-inch scale was tested by *in situ* fixings and by connection with the traverse stations; while that on the 16-inch scale was checked by 1,948 miles of chain measurements, of which 340 miles were run by Europeans.

275. The following statement shows the out-turn of the season's work, both as regards traverse and detail survey :—

District.	Traverse Survey.		Cadastral Survey, 16 inches=1 mile.				Topographical Survey, 2 inches=1 mil.
					Area in square miles.		Area in square miles.
	No. of *kwins.*	Area in square miles.	No. of *kwins.*	No. of fields.	Cultivation.	Jungle and waste, including water.	
Amherst . .	241	423	382	480,000	284	266	106
Tavoy . .	388	408	342	350,000	185	125	...
Mergui . .	214	187	157		50	100	...
Total .	843	1,108	881	830,000	519	491	106

276. It will be seen that the cultivation practically comprises one-half the total area surveyed, both in the Amherst and in the Tavoy-*cum*-Mergui districts. The average size of the fields this year, reckoned on cultivation only, in Amherst is 0·38 of an acre, while in Tavoy and Mergui taken together it is 0·54 of an acre. Reckoning that the expenditure in surveying 4 square miles of jungle is equal to that of 1 square mile of cultivation, the cost per square mile of cultivation for Amherst is ₹186¼ and for Tavoy and Mergui ₹216¾: the similarly worked out figure for the year 1890-91 (average size of field = 0·64) is ₹198¼. So that, notwithstanding the very many difficulties and increased expenses incident to work in Tavoy and Mergui, the detail survey in these districts has only cost about 6 pies per acre more than under nearly the same conditions as to size of field in 1890-91 ; while the work in Amherst has cost about 3½ pies per acre less than before, notwithstanding the small average size of the field dealt with this year.

277 The season's cadastral survey on the 16-inch scale is mapped on 1,623 sheets, and the 2-inch mapping enters into 3 of the standard 1-inch sheets. Of the sheets of the previous seasons, the whole of those appertaining to Thongwa (*i.e.*, 943 sheets) have, during the year under report, been sent to Calcutta for printing, while the 550 sheets appertaining to Amherst have been retained till next spring, pending the completion of the settlement operations now in progress in that district. The fair drawing on the 2-inch scale of the Thongwa survey, for reduction to half scale, has been all but completed, and the sheets are in course of publication at Calcutta : the little drawing that still remains to be done will be completed as soon as prints of the 16-inch work are available ; and in the meantime the 2-inch scale drawing of the Amherst survey is being pushed on.

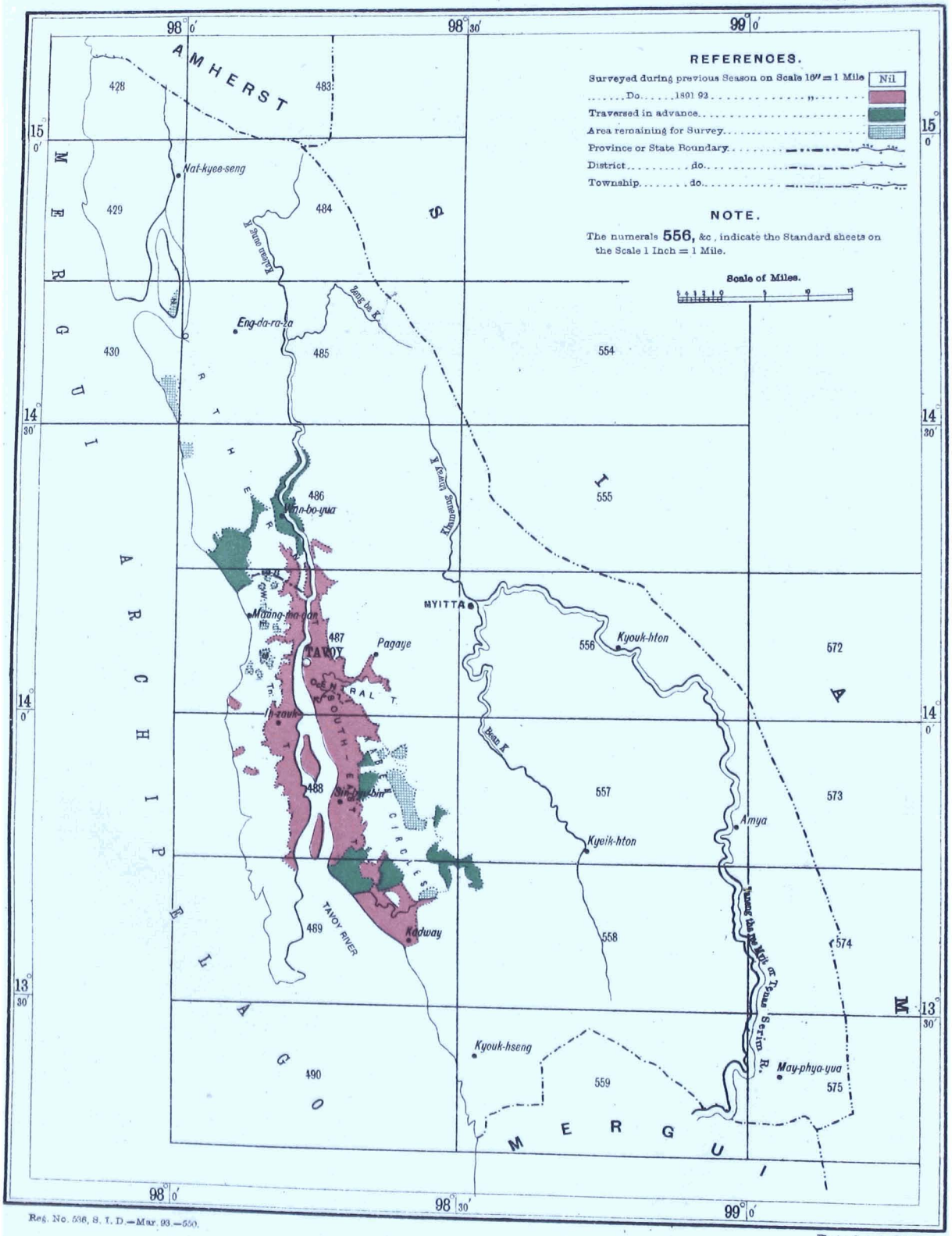
278. The records of the present season's work have been indexed and bound. The field books and traverse computations of the entire Thongwa survey have been lodged in the Calcutta office, and the volumes of area statements will shortly be forwarded.

279. The scheme for the employment of Burmans and Karens as field surveyors has worked satisfactorily during the year. Of the 20 men who qualified for a certificate and deferred pay in 1890-91, only nine returned to this party last November ; 24 others have this year similarly qualified and been given their certificates and deferred pay. The average monthly earnings of this field season are ₹35-11 against ₹39-11 of the year before : this is due entirely to the more intricate character of the work and the slower rate of progress in consequence ; but as the field season was somewhat longer than usual, the total earnings have exceeded those of any previous year. The average out-turn of the Burman has this year again been found to be four-sevenths of that of the Hindustani ; and though they are both paid at the same rates for the actual out-turn of work, yet

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT TAVOY.

No. 7 PARTY.



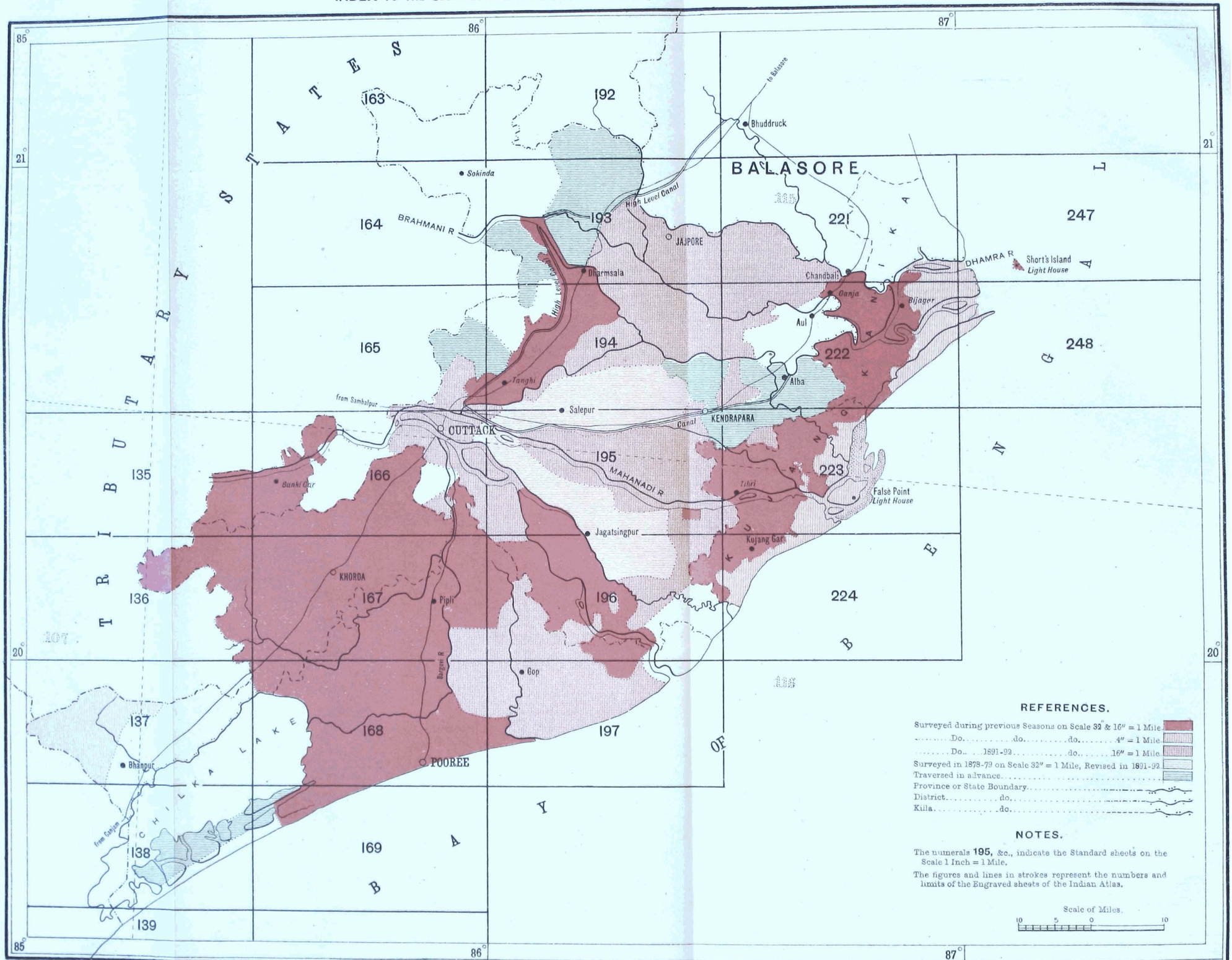
Reg. No. 536, S. I. D.—Mar. 93.—550.

Photo. S. I. O., Calcutta.

BENGAL SURVEY.

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

No. 8 PARTY.



REFERENCES.

Surveyed during previous Seasons on Scale 32″ & 16″ = 1 Mile.
.....Do.....do.....do.....4″ = 1 Mile.
.....Do.....1891-92.....do.....16″ = 1 Mile.
Surveyed in 1878-79 on Scale 32″ = 1 Mile, Revised in 1891-92.
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. 461, Bengal & S. I. D.—Jan. 93—2,333.

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

as in each case the expense of 4 *khalâsis* at ₹10 each per mensem is incurred during the time the surveyors are at work, it is evident that the Burmans' cost-rate must be higher than that of the Hindustanis without taking into account the extra expense of the European supervision due to the longer time occupied in completing a given area. The loss on each Burman employed is on account of this at least ₹100 per season, after deducting the cost of passages for Hindustanis. As a set-off against this must be taken the advantage of leaving a trained staff of men to fill the appointments of *teiksayes*, *thugyis*, etc. At the close of the field season the number of Burmans on the rolls under this scheme and their length of service were as below:—

Of 2 years' service	7 men.
„ 3 „ „	10 „
„ 4 „ „	13 „
„ 5 „ „	24 „

280. The party was inspected in August at Rangoon 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 records of the party.

281. During the ensuing season, it is intended to complete the cadastral survey operations in Tavoy, Mergui, and Amherst up to the limits hitherto assigned for survey, and to carry the advance boundary survey operations into the adjoining district of Shwegyin. It is also intended to execute, on the scale of 64 inches = 1 mile, a survey of the town lands of Thaton, which has been urgently applied for by the Municipality in connection with their contemplated scheme for water-works. A large scale survey (not less than 64 inches = 1 mile) of the town and lands of Moulmein has also been asked for by the Financial Commissioner, as he says, "it is found that large areas of assessed or assessable land fall within the municipal limits, and there are some thousands of revenue-paying grants of peculiar tenure which it is very advisable to locate on accurate maps * * * if possible by the end of next April." Lastly, it is contemplated to execute a topographical survey, on the scale of 1 inch = 1 mile, of the country to the east and south of Mergui, including the coal field near the Tenasserim river. It will be seen that the programme is a very varied one, and it will need the best efforts of every member of the party to ensure its completion.*

DISTRICTS PURI, CUTTACK AND BALASORE, ORISSA.

No. 8 Party.

282. Survey operations in Orissa were resumed early in December 1891 under the charge of Lieutenant-Colonel J. E. Sandeman up to 12th January 1892, from which date Lieutenant-Colonel Sandeman being placed on special duty, pending appointment as Director of Bengal Surveys, the charge of the party devolved on Lieutenant Crichton.

The establishment, of the strength given below, was divided into five sections (two for traverse and three for cadastral operations), and was employed in districts Puri, Cuttack, and Balasore:—

Personnel.

Lieutenant-Colonel J. E. Sandeman, s.c., Deputy Superintendent, 1st grade, in charge from 28th November 1891 to 12th January 1892.

Lieutenant R. T. Crichton, s.c., Officiating Deputy Superintendent, 4th grade, in charge from 11th November 1891 to 28th November 1891 and from 12th January 1892 to 30th September 1892

Mr. H. R. Littlewood, Officiating Assistant Superintendent, 1st grade, in charge from 1st October 1891 to 3rd November 1891.

„ R. C. Ewing, Extra Assistant Superintendent, 4th grade, in charge from 3rd November to 11th November 1891.

Puri and Cuttack Cadastral Section.

Mr. R. C. Ewing, Extra Assistant Superintendent, 4th grade.

Mr. C. S. Gasper, Sub-Assistant Superintendent, 2nd grade.

2 computers and draftsmen.

Temporary Establishment.

198 computers, draftsmen and *muharrirs*.

28 inspectors.

262 field-surveyors and *khanapuri amins*.

* The Executive Officer speaks very highly of Mr. Littlewood for the able manner in which he managed the detail survey in Tavoy and Mergui under exceptional difficulties. Messrs. Jarbo and Powell are also commended, especially the former, for their energy in the prosecution of the traverse work of these districts in the face of many disadvantages. Mr. Smart is mentioned as unsparing in his efforts to achieve a successful season's work and to be deserving of much credit for his out-turn. Mr. Murphy is said to have afforded valuable help; and Messrs. Gastaud and Biggie are also well reported on. Of the native establishment, the following have been especially mentioned, *viz.*, Nand Lall Chatterjee, Shoshi Bhusan Ghosal, Preonath Banerjee, Dindyal, Faiz Buksh, Sheodat, C. Abrew, Hidayatoola, Nasib Beg, Mahomed Umar, Mohamed Ali, Mahbub Ali, Mahtab Khan, Karim Buksh, Maung Hpo Kah, Dokhine, Pasand Khan and Jukhan Khan.

CUTTACK CADASTRAL SECTION.

Mr. S. O. Madras, Extra Assistant Superintendent, 4th grade.
2 computers and draftsmen.

Temporary Establishment.

Mr. A. H. Pyster, Supervisor.
97 computers, draftsmen, and *muharrirs.*
32 inspectors.
505 field-surveyors and *khanapuri amins.*

CUTTACK CADASTRAL SECTION.

Mr. A. W. Smart, Sub-Assistant Superintendent, 1st grade.
Mr. E. F. Berkeley, Sub-Assistant Superintendent, 1st grade.
Babu Nilmoni Chatterji, Sub-Assistant Superintendent, 3rd grade.
2 computers and draftsmen.

Temporary Establishment.

200 computers, draftsmen, and *muharrirs.*
25 inspectors.
355 field-surveyors and *khanapuri amins.*

PURI AND CUTTACK TRAVERSE SECTION.

Mr. G. Vander Beek, Sub-Assistant Superintendent, 1st grade.
Mr. J. P. Barker, Sub-Assistant Superintendent, 1st grade.
10 sub-surveyors, computers, etc.

Temporary Establishment.

30 sub-surveyors, computers, etc.

CUTTACK AND BALASORE TRAVERSE SECTION.

Mr. G. Campbell, Extra Assistant Superintendent, 4th grade, up to 12th June 1892.
Mr. C. S. Kraal, Sub-Assistant Superintendent, 1st grade.
11 sub-surveyors, computers, etc.

Temporary Establishment.

32 sub-surveyors, computers, etc.

Survey of Puri District.

283. The traverse section commenced field work on the 27th November 1891, and completed the traverse of the district by February 1892. The number of linear miles traversed amounted to 756. Progress was slow owing to the line-clearing work being very heavy.

284. The area traversed includes some unnecessary work done in the early part of the season in *parganas* Bajarkot, Mallud and Parikud, south-east of the Chilka lake. The survey of these *parganas* was notified in the *Calcutta Gazette* of the 26th November 1890, and this notification was not cancelled until the 15th December 1891, before the receipt of which order an area of 41 square miles of traversing in these *parganas* had been completed.

285. The traverses were connected with 13 stations of the Great Trigonometrical Survey and the chain measurements checked thereby. The angular work was checked by observations for azimuth at 32 stations.

286. The cost-rate of the traverse survey was R51-6-5 per square mile, and that of the stone embedding was R7 per square mile.

287. The cadastral section under Mr. Ewing commenced work on the 3rd December 1891, and completed the area assigned to it on the 1st May 1892. A portion of the section was moved into the Cuttack district in March to commence the area allotted to it there. The area cadastrally surveyed comprises the tract traversed in advance last season, and the 126 square miles traversed this season.

288. The following table gives the out-turn of the traverse and cadastral survey for the season in district Puri :—

DISTRICT.	TRAVERSE SURVEY.				CADASTRAL SURVEY, 16 INCHES = 1 MILE.		
	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Puri . .	278	130	3,905	167	612	451,111	307

The average size of the field calculated on the entire area was 0·43 of an acre.

289. The detail survey was tested by 722 linear miles of check survey, 288 miles being done by Europeans and 434 miles by native inspectors, thus giving an average of 2·3 linear miles of test work to each square mile of survey.

290. The *khanapuri* or record of rights was completed for the entire area cadastrally surveyed and the records handed over to the Settlement Department. Five thousand six hundred and forty-six *khasra* entries were checked by

Europeans of the Survey Department and 6,294 entries by officers of the Settlement Department attached to the camp, as well as 150,782 entries by native inspectors; which gives a percentage of 36 of the total numbers of the *khasra* entries.

All boundary disputes were settled as they came up either by the Survey Officer or the Assistant Settlement Officer.

291. Work was carried on with considerable difficulty in this district. In the *parganas* on the sea-coast the water is brackish and unwholesome; there is a considerable amount of scrub jungle, and the cyclone of 5th November 1891 had destroyed a considerable proportion of the standing crops. Special inducements had to be held out to the *amins* to work in these *parganas*.

292. The area cadastrally surveyed during the season has been mapped on 777 sheets. Of the topographical maps on the 2-inch scale, compiled from the 16-inch plans, six standard sheets of this district have been completed: after examination they will be sent to Calcutta, and it is hoped that the remaining 8 sheets will be completed by the end of November 1892.

293. The cost-rate of the cadastral survey was R109-13 per square mile; that of the *khanapuri* amounted to R30 per square mile.

Survey of Cuttack District.

294. The two traverse sections, under Mr. G. Campbell and Mr. G. Vander Beek, commenced work in this district on the 28th and 27th November 1891, respectively, and returned to recess quarters on the 30th and 21st June 1892. The first section carried on operations in the Jajpur sub-division, and the approximate area assigned to it was 406 square miles of the Cuttack district. The remainder of the district, *viz.*, 815 square miles, was given to the second section, and both areas were completed.

295. The total area traversed amounted to 1,251 square miles, the number of linear miles being 5,901. The traverse work was connected with fort Barabati, a station of the Great Trigonometrical Survey (the origin of the Orissa survey), and about 196 stations of the main circuit of the irrigation survey of 1878-79 were identified and incorporated in the season's work. The angular work was checked by observations for azimuth at 166 stations.

Permanent marks were embedded at all the traverse stations. These consist of 2,593 large stones, 4,664 smaller stones, 26,147 clay cylinders, and 115 country stones.

296. The cost-rate of the traverse survey was R 32-5 per square mile; that of the stone embedding was R5-14 per square mile.

297. The two cadastral sections under Messrs. S. O. Madras and A. W. Smart were employed throughout the season in this district; and a portion of the section under Mr. Ewing commenced work in March 1892 in *parganas* Sailo, Bakrabad and the *parganas* around Cuttack city, where it was joined in May by the remainder of the section from the Puri district. Mr. Madras' area lay principally in the fork formed by the Kendrapara and Taldanda canals, and Mr. Smart's in the Jajpur sub-division.

298. The following table gives the out-turn of traverse and cadastral survey for the season in district Cuttack:—

District.	Traverse Survey.				Cadastral Survey, 16 inches = 1 mile.		
	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.	Number of villages.	Number of fields.	Area in square miles.
Cuttack .	2,388	1,604	33,519	1,251	2,233	1,922,884	1,095

The average size of the field calculated on the entire area cadastrally surveyed was 0·36 of an acre.

299. The detail survey was checked by 4,615 linear miles of test survey, 1,394 miles being done by Europeans and 3,221 miles by native inspectors, thus

giving an average of 4·2 linear miles of check work to each square mile of survey.

300. Heavy floods interfered to a very serious extent with the work in this district. On the 8th, 9th and 10th June, owing to a cyclonic disturbance, there was very heavy rain, more particularly in the north of the district. Messrs. Smart's and Campbell's camps were on the bank of an old bed of the Byturni river, which is usually quite dry; but on the morning of the 11th, the Byturni overflowed and sent a rushing torrent down this old bed, which also overflowed, and in a few hours there were over three feet of water in the camp, and every prospect of its rising higher, which would probably have resulted in the total destruction of the maps and records of the current season's work and all other Government property, representing probably something over three lakhs of rupees value. It was entirely owing to the energy and presence of mind displayed by Mr. Smart that such a catastrophe was averted. Mr. Smart sent immediately for some country-boats, by means of which all the Government property was transported to the high *bund* surrounding the Jajpur town. The gravity of the situation is borne out by the fact that boats of 500 maunds capacity were rowed into the centre of the encampment.

301. The area cadastrally surveyed comprised 298 square miles traversed in advance during last season and 797 square miles of the 1,252 square miles traversed this season, thus leaving 455 square miles traversed in advance for next season, which will be completed in detail and *khanapuri*, and the records handed over to the Settlement Department, by the end of March 1893.

302. With regard to the record writing, of the 1,095 square miles cadastrally surveyed, 781 square miles, comprising 1,519 villages, 1,252,334 fields have been completed in *khanapuri*, and the records of 225 square miles have been handed over to the Settlement Department. The records of the remaining 556 square miles are being completed, and will be all handed over by the 31st October 1892. The 314 square miles which have been cadastrally surveyed this season, but of which the *khasra* entries have not been made, will be completed early next season, and the records handed over by 31st January 1893.

303. Thirty thousand five hundred and fifty-four *khasra* entries were checked by Europeans of the Survey Department, 29,146 entries by Assistant Settlement Officers and 230,389 entries by native inspectors, giving a percentage of 23 of the total number of *khasra* entries.

304. The cost-rate of the cadastal survey in this district amounted to R88-13 per square mile; that of the *khanapuri* was R35-13 per square mile.

Revision of Irrigation Survey of 1878-79 in Cuttack District.

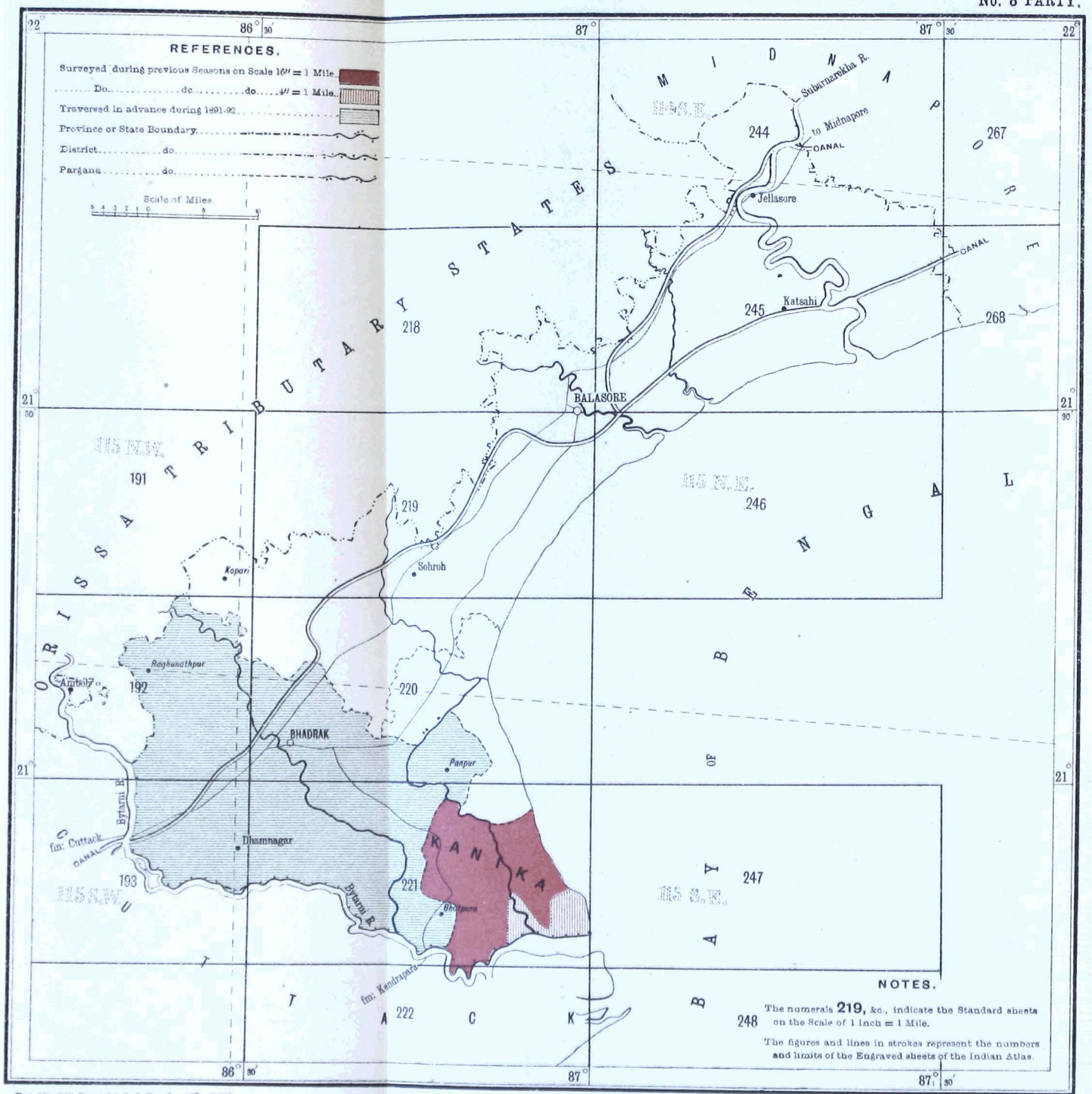
305. This work was commenced concurrently with the ordinary detail survey by Messrs. S. O. Madras and R. C. Ewing. The original orders were that only the correction of the maps was to be done by the Survey Department and that the *khanapuri* would be undertaken by the Settlement, and it was not until the survey of 130 square miles had been corrected (of none of which had the *khanapuri* been done) that it was decided that the Survey Department should do the *khanapuri* as well. This necessitated going over the ground again and caused no little waste of time, and the work was not completed until the end of July 1892.

306. This revision consisted in bringing up the maps to date and doing the *khanapuri* of 364 square miles, surveyed in 1878-79 for the Irrigation Department. The old survey was on the 32-inch scale, and the original unit of survey was the *kitta* (each *kitta* having a number and its area extracted), and there was no distinction made on the map by which the "field" or occupancy of the cultivator could be recognised; nor had the houses in the villages been separated from the fields or compounds. The revision procedure adopted was to give the *khanapuri amin* the map, and he, while he did the *khanapuri*, ascertained which lines on the map denoted the boundaries of a "field" and which the *kittas*; the latter he scored across in red ink and gave a number to the "field." On the traces the *kittas* have been, and on the fair maps will be, shown by dotted lines. In cases where the "field" had not altered since the former survey, the area was obtained by the simple addition of the areas of the *kittas* contained in it, as given in the area statement of the former survey.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY OF ORISSA, DIST. BALASORE

No. 8 PARTY.



Reg. No 379, Bengal & S. I. D.—Jan. 93.—2,252.

Photo., S. I. O., Calcutta

Where there were differences—and there were many owing to distributary canals having been cut and the other changes which must be expected in a period of fourteen years—areas had to be re-extracted.

307. When this work was first started, it was not anticipated that it would be so difficult or expensive, but the amount of labour and length of time expended in its completion prove that it is little less arduous than entirely fresh work. It was found necessary to pay the *amins* for the actual correcting of the maps R1-8 per 100 acres, *i.e.*, half of what was paid for entirely fresh survey, and all other items, such as cooly hire, *khanapuri* records, supervision, etc., were of course just as costly as in fresh work.

308. The *khanapuri* of the entire area surveyed in detail was also completed and the records handed over to the Settlement Department.

309. The revised area of 364 square miles is mapped on 2,021 sheets. The average size of the field is 0·27 of an acre. The detail survey was checked by Europeans and inspectors, while engaged in checking the *khanapuri*, by measurements to the corners of fields. The *khanapuri* was checked by the testing of 15,538 *khasra* entries by European officers, 38,397 entries by Assistant Settlement Officers, and 172,958 entries by native inspectors, giving a percentage of 27 of the total number of *khasra* entries.

310. The total expenditure on this work has been R23,146, or R63-9-7 per square mile, but it is estimated that a further sum of R6,000 will have to be expended to complete the final records, etc.

Survey of Balasore District.

311. The operations in this district were confined to traverse work. The traverse section under Mr. G. Campbell on completion of its area in the Cuttack district commenced work in Balasore in March and closed work at the end of June 1892.

The following table gives the particulars of the area traversed :—

District.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Balasore	1,072	963	13,938	588

312. The number of linear miles traversed was 2,905 : connection was made with one station of the Great Trigonometrical Survey to test the chain measurements, and the angular work was checked by observations for azimuth at 71 stations. Permanent marks have been embedded at all the traverse stations, and consist of 1,380 large tri-junction stones, 1,880 smaller stones, and 10,678 clay cylinders.

313. Some opposition was met with in this district, owing to the delay in the publication of the Government notification of survey, and there was a good deal of cholera in the district towards the close of the field season. There is believed to be an area of 1,100 square miles remaining to be traversed in the Balasore district. This will be completed next season.

314. There was, at the close of the field season, an area of 750 square miles undemarcated. It was decided that the Survey Department should demarcate this. This work has been commenced, and it is hoped that it will be completed by November 1892.

315. The cost-rate of the traverse survey was R17-11 per square mile; that of the stone embedding was R6-8 per square mile.

General remarks applicable to the three districts.

316. The unit of traverse survey was the "existing" *mauza*, *i.e.*, the *mauza* as pointed out by the people on the ground, and in contradistinction to the *mauza* of the former revenue survey.

All traverse work was plotted roughly on the 4-inch scale, and comparisons were made with the old 4-inch village maps of the former survey, and wherever

any differences appeared, they were noted for the information of the Settlement Department.

All *tahsil alahida* blocks over 50 acres in area were also traversed round, but not plotted separately, *i.e.*, they were plotted and surveyed with the village in which they lay.

317. The demarcation was done by the Settlement Department, and consisted of erecting bamboo sticks with small earthen mounds at their bases at the tri-junctions and salient points on the village boundaries. A large number of these marks were not forthcoming at the time of traverse survey, which delayed the sub-surveyors and line-cutters not a little. These marks had probably been washed away by some of the numerous floods to which the Orissa division is subject.

318. Permanent marks of the same description as used in former seasons were obtained from a contractor at the rates of ₹56-4 per 100 for large stones for tri-junction of boundaries and ₹37-8 for the smaller stones. These rates included carriage to any centres that might be named to the contractor. Baked clay cylinders are obtainable almost anywhere in the district at an average rate of ₹4 per 100. At the commencement of the season, the smaller stones were embedded at the satellite stations of each tri-junction; but early in the season orders were given that these smaller stones should be embedded at stations at intervals of about 40 chains, taking care that each stone should be placed in such a manner that the stations in advance and behind it might be visible. The object of this procedure was to place the smallest number of stones compatible with the necessity of being able to relay the boundary with a plane-table in the event of the cylinders having been destroyed.

319. The 16-inch scale was found generally large enough for the survey, except for the village sites, which are very close and among which the fields are very diminutive, and as each house had to be shown separately, it was generally found necessary to make an enlargement on the 32-inch scale of these portions on the margin of the sheet. The survey of the village sites is in Orissa a difficult matter, as the majority of the villages are surrounded by bamboos, palms, etc., and at a little distance present more the appearance of a dense wood than a village: this often necessitated having theodolite stations running close round the sites.

320. The unit of cadastral survey was the "field;" *kittas* (interior sub-divisions of fields for purposes of irrigation and agriculture) were not measured or mapped (except in the revision area, where they were shown at the request of the Irrigation Department), but the total number of *kittas* contained in a holding were noted in the *khasra*.

321. Lieutenant Crichton reports that the expense and delays in work in Orissa are primarily due to the nature of the inhabitants of the country. The Uriyah will do no more work than he is absolutely obliged to do in order to obtain a bare living. It is only by the closest supervision and constant coercion that the Uriyah *amin* can be prevailed upon to produce a moderate daily out-turn of work. As a surveyor his laziness makes him practically useless; his rate of work has been proved to be this season one-fifth of that of an up-country *amin*; his drawing is most clumsy, and a map which has been in the hands of an Uriyah *amin* is returned in a dirty and very often torn state to the camp office. Another cause of expense in Orissa is no labour being given free by the villagers (as is the case in the Upper Provinces). Each cooly had to be paid 1 anna or 2 annas a day, according as he was working in his own village or outside it. As each *amin* requires about five coolies, it is evident that cooly hire is a very expensive item in Orissa, more especially so when the field surveyor is an Uriyah. The Uriyah *amin's* out-turn being 6 acres a day, and 5 or 6 annas being paid for his coolies, the cooly bill alone adds one anna per acre. In order to reduce the expenditure on detail survey, this branch of the work was gradually, to a great extent, handed over to up-country *amins*, the Uriyahs being employed on the *khanapuri*. The complete indifference displayed by the inhabitants to the survey was another and very serious cause of delay and consequent expense.

322. The difficulties experienced in preparing the record of rights have been very great during this season for the following reasons:—

Firstly.—The slow rate of work of the Uriyah.

Secondly.—The number of changes in procedure during the field season. No less than four different forms of *bhowriah* (*khasra*) and three different forms of *warijah* (*khatian*) were successively brought into use during the field season.

Thirdly.—Although the Settlement Department at the commencement of the season were supervising the *khanapuri*, no distinct instructions were received as to the filling up of the records until the Director of Land Records visited Orissa, when on the 26th March 1892 a *hidayatnama* was published; but it was not till the 1st June 1892 that Uriyah translations of these instructions, although repeatedly called for, were received from the Settlement Department.

Fourthly.—Almost throughout the entire area of *khanapuri* no draft *khewats* had been prepared by the Settlement Department; they had therefore to be prepared by the Survey Department and compared with the A, B, and C registers of the collectorate. In some *parganas* draft *khewats* had been prepared *mahalwar*; but these were practically useless, as they had to be converted into *mauzawar*. In addition to this, there was great delay in the supply of the *khewat* forms: some parts (I and III) were not received till the 8th and 12th August 1892.

Fifthly.—With some exceptions, the *khanapuri* officers supplied by the settlement to aid in the supervision of *khanapuri* and settlement of disputes were quite inexperienced, and had to be taught their duties. Until they had learnt their work they did not help greatly.

Lastly.—The establishment of *khanapuri amins* necessary for the large area required could not be obtained.

323. Messrs. Smart and Ewing speak very highly of the help rendered them by Mr. James Taylor and Babu Chakoo Lal Sircar, Assistant Settlement Officers, attached to their camps.

324. The health of the party was on the whole very good, notwithstanding the lateness of the field season. Cholera broke out among the *khalásis* obtained from Hazaribagh on their arrival in Cuttack, and there were several deaths. Cholera was present throughout the district the entire field season, and at times assumed severe proportions, more especially so in the Jajpur sub-division, in which there were 2,330 deaths from this cause; and in the Jagatsingpur *thana* there was also at one time a rather severe epidemic of small-pox. About thirty menials of the temporary establishment died from the above causes. These epidemics interfered not a little with the progress of the work, as it was with the greatest difficulty that the *amins* and *khalásis* were prevailed upon to remain in the district, and the camp officers had to be continually arranging for the transfer of squads from villages where work was in progress, but where cholera had broken out, to other villages which had not so far been attacked. The uncompleted villages were completed after the cholera had abated.

325. In addition to the areas already reported as cadastrally surveyed, certain arrears of the previous season have been completed: 6 square miles, representing portions of 52 villages not completed last season, were surveyed in detail, and the *khanapuri* of 52 square miles, containing 93 villages which remained to be done, was also carried out.

The records of 541 villages of last season's work have been completed and handed over to the Settlement Department, and the records of 32 villages which still remain will be handed over during October 1892. The whole of the records of Killa Kanika have been completed and despatched to the Settlement Officer.

326. The survey of Cuttack city on the 64 inches=1 mile scale has been commenced; it is hoped that this will be completed by the end of next field season.

327. The average cost-rate of the season's work for the complete operations done in the Orissa division, comprising stone embedding, traverse and cadastral survey, *khanapuri* and completion of records, is ₹157-0 per square mile against a rate of ₹179 in the previous season, thus showing a saving of ₹22 per square mile. The real savings on the new work effected during the season is however greater than this, as the rate of ₹157 includes the expenditure incurred

in completing the arrears of the previous season. It is anticipated that the mileage-rate will be still further reduced during the ensuing season.

328. Lieutenant R. T. Crichton has conducted the extensive and difficult survey operations in Orissa with considerable ability.

329. The programme for the ensuing season comprises the traverse survey of the area remaining in the Balasore district, estimated at 1,100 square miles; the cadastral survey and *khanapuri* of 455 square miles in Cuttack completing that district, and of 1,045 square miles in Balasore.

There will then remain an area of 645 square miles for cadastral survey in the Balasore district for the season of 1893-94 to complete the operations in the Orissa division.*

PROME DISTRICT, LOWER BURMA; MINBU AND MAGWE DISTRICTS, UPPER BURMA.

NO. 12 PARTY.

330. This party, which was previously employed on traverse survey operations in Lower Burma, was transferred to Upper Burma to take up cadastral work in district Minbu. Mr. F. Grant held charge of the party till the 18th November 1891, when he was relieved by Mr. W. H. Patterson, who has continued in charge for the remainder of the year. The party left Rangoon on the 15th November and arrived in the Minbu district on the 19th idem, where survey operations were commenced with the establishment noted in the margin. For convenience of survey three detachments were formed, each being so constituted as to admit of traverse work being started at three centres to expedite the plotting of sheets for detail survey, as no traverse work had been prepared in advance.

Personnel.

Mr. W. H. Patterson, Deputy Superintendent, 1st grade, in charge from 19th November 1891.
„ F. Grant, Officiating Deputy Superintendent, 2nd grade, in charge up to 18th November 1891.
„ A. E. Spring, Officiating Assistant Superintendent, 1st grade.
„ W. S. Buttress, Extra Assistant Superintendent, 1st grade.
„ E. G. Little, Extra Assistant Superintendent, 2nd grade.
„ J. S. Swiney, Extra Assistant Superintendent, 4th grade.
„ W. E. Johnson, Sub-Assistant Superintendent, 2nd grade.
„ T. W. Babonau, Sub-Assistant Superintendent, 2nd grade, up to 29th June 1892.
„ F. S. Bell, Sub-Assistant Superintendent, 2nd grade.
24 sub-surveyors and others.

Temporary Establishment.

70 inspectors, draftsmen, computers, etc.
114 field surveyors (Indian).
32 Ditto (Burman).

331. The programme for the field season consisted of—

(*a*) the revision of 112 square miles of traverse survey in district Prome;
(*b*) the traverse and cadastral survey in district Minbu; and
(*c*) advance traverse survey in district Magwe.

332. Field work was closed between the 16th and 20th of July, and the recess office opened at Mandalay on the 25th idem. A few sub-surveyors were kept out during the rainy season in order to push on the traversing in Magwe, so as to ensure having a sufficient number of plots for the field surveyors to commence work on in November 1892; fortunately the rainfall was not heavy and, the ground being on a high level, they were enabled to carry on their work without any very great difficulty.

Traverse Survey of Prome District.

333. It was found that of the traverse area surveyed in 1890-91, 43 *kwins*, embracing an area of 112 square miles, required revision. This was entirely

* Messrs. R. C. Ewing, S. O. Madras and A. W. Smart, in charge of cadastral sections, and Messrs. G. Vander Beek and C. S. Kraal, in charge of traverse sections, deserve credit for the manner in which they managed their sections and for the large arrears accomplished in the face of considerable difficulties.

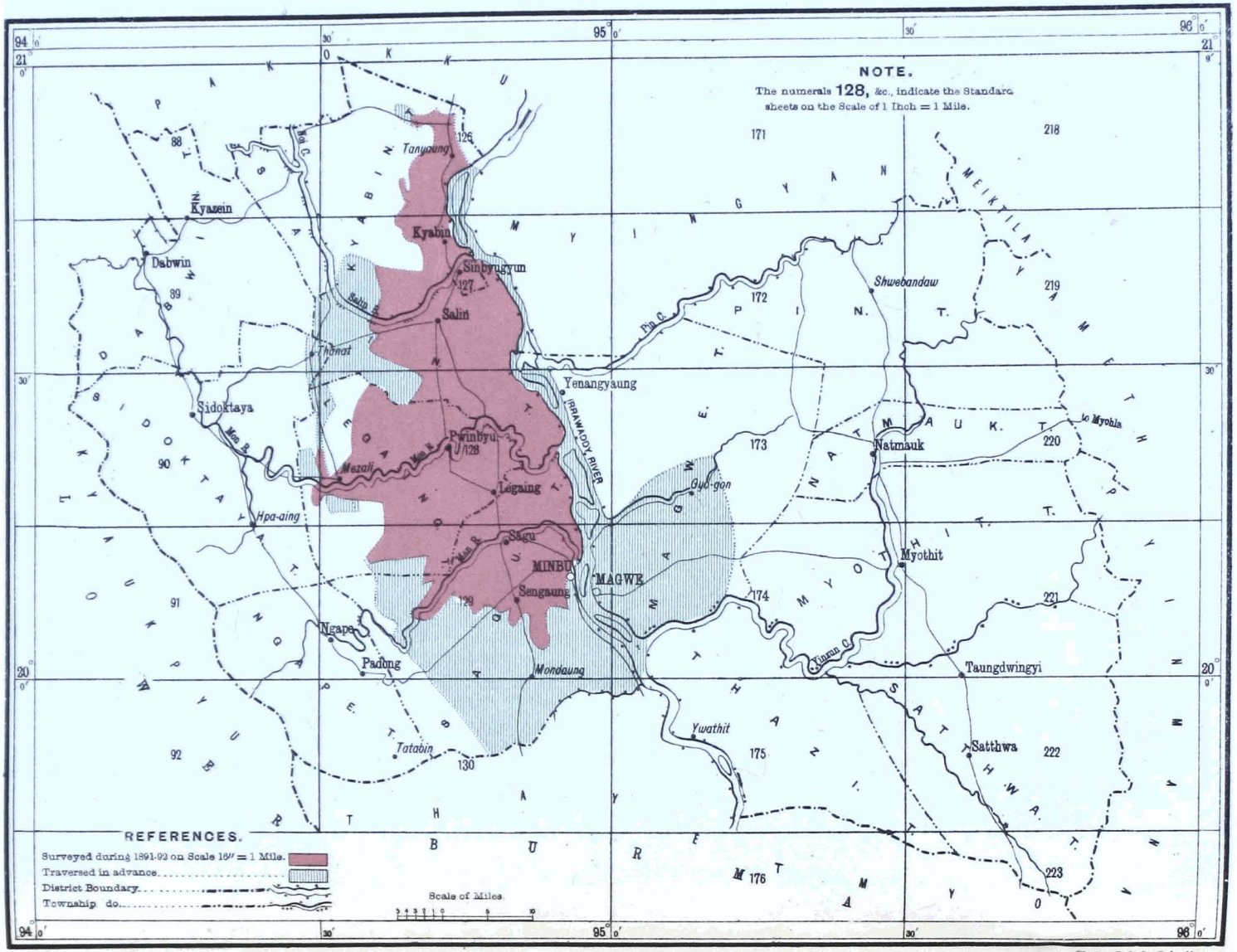
Lieutenant Crichton expresses himself particularly indebted to Messrs. R. C. Ewing and A. W. Smart, whose long experience in cadastral operations he has found most valuable. Messrs. E. F. Berkeley, J. P. Barker and C. S. Gasper, and Babu Nilmoni Chatterji are all reported to have worked hard and well, and to have given valuable assistance to the officer in charge of their sections.

He also reports very favourably on the way Mr. Pyster, Supervisor on the temporary list, has worked. The following members of the native establishment are worthy of mention: Raghubir Saran, Lalji Sahai, Sheo Narain, Manohar Lall, Bindbasni, Imam Ali, Ishri Pershad, Kalka Pershad, Joghobundu Kanungo, Fariduddin and Jawala Pershad.

BURMA SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTS. MINBU & MAGWE.

No. 12 PARTY.



Reg. No. 464, S. I. D.—Mar. 93.—500.

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

owing to the difficult and unsuitable ground over which the traverse survey had to be taken in order to follow closely the boundaries of *kwins*. The completion of the work took longer than was anticipated, owing chiefly to the difficult nature of the ground, to sickness, and to delays in finding the survey stations. The clay cylinders which had been used to mark the stations were in some cases found to have been uprooted, and this necessitated the fixing of new stations. Altogether it took longer to revise this work than it would have done to make an entirely new survey.

334. The following is a statement of the revision work done:—

District.	Traverse Survey.		
	Number of *kwins*.	Number of skeleton plots.	Area in square miles.
Prome	43	111	112

The survey stations were marked with burnt clay cylinders, and notices containing skeleton plots of the village polygons, showing the positions of the theodolite stations, were prepared on the 4-inch scale, and one copy furnished to the *kyedangyis* and one to the Deputy Commissioner.

335. Skeleton plots, on the scale of 16 inches to the mile, of 43 *kwins* on 111 sheets and copies of area tables were furnished to the Superintendent of the local field-to-field survey during the field season, and in the recess months 2-inch plots of the north-east and south-east sections of standard sheet No. 225 were also furnished to that officer for the purpose of inserting thereon the topographical details obtained from the local cadastral survey. The Superintendent was further supplied with certain data of traverse work done in previous years by this party for incorporation with the work to be undertaken by the supplementary survey in the area left unsurveyed by the traverse professional party, and which is referred to in paragraph 336 of the General Report of 1890-91.

336. The records in connection with the traverse work of the present and past seasons' surveys have been completed; the volumes have been bound, indexed and paged, and after final examination will be despatched to the Head-Quarters Office, Calcutta.

Cadastral Survey of Minbu District and Traverse Survey in Magwe District.

337. In consequence of heavy rain in the latter part of November, field work did not fairly commence until the 1st December. The demarcation of the circle boundaries was found ready by the time the survey party arrived, and guide maps of townships, showing roughly the boundaries of circles, were furnished by the Deputy Commissioner, who was the boundary officer; under him a *myook* was appointed as demarcation officer, and he carried on the demarcation of the circle boundaries. The demarcation of the lands forming village areas was unfortunately not done, and this omission was brought to the notice of the Deputy Commissioner in December, when orders were issued for the demarcation of the *kwins* or village boundaries in each circle. The want of the *kwin* boundaries delayed traverse operations somewhat during the early part of the season, as, after the circle boundaries were surveyed, the sub-surveyors had to go over the ground a second time for the traverse surveys of the *kwin* boundaries. Wooden posts were placed by the demarcation officer along the boundaries at salient points Afterwards, in consultation with the Deputy Commissioner, cairns of stones were placed at the base of each post, and where stones were not available bricks were heaped up, and thus some attempt was made to ensure the boundaries being permanently marked. The average size of the circle is 5,606 acres, that of the *kwin* is 1,747 acres. All boundary disputes brought to the notice of the Survey Department were referred to the Deputy Commissioner for disposal.

338. The out-turn of work is given in the following table arranged by townships, both as regards traverse and detail survey :—

Districts.	Townships.	Traverse Survey.		Cadastral Survey, 16 inches=1 mile.		
		Number of *kwins*.	Area in square miles.	Number of *kwins*.	Number of fields.	Area in square miles.
Minbu	Kyabin	81	163	64	78,757	111
	Legaing	111	296	102	113,732	249
	Segu	118	483	95	129,177	216
	Salin	153	331	136	233,245	208
	Sedoktaya	9	15	...	...	...
Magwe	Magwe	47	156	...	...	...
	Total	919	1,444	397	554,911	784

339. The cadastral area forms a compact block, extending from the Irrawaddy to the foot of the hills, and all the cultivable waste, as well as the cultivated, lands has been brought under traverse survey. The total area of the district is estimated at 2,800 square miles, of which 1,230 are covered with hills and are not for survey at present, leaving an area of about 1,570 square miles of cultivable or cultivated lands for survey, of which 784 have now been completed. Of the area surveyed, about 548 square miles are cultivated and 236 square miles uncultivated. The average size of the field on the whole area is 0·90 of an acre, but excluding uncultivated tracts it is 0·66 of an acre in irrigated and 1·26 of an acre in unirrigated tracts. In addition to the usual field survey, special plans of the Municipalities of Minbu and Salin were prepared on the 16-inch scale.

340. The number of linear miles traversed was 4,086. Two chains—one of 100 feet and the other of 66 feet—were used to ensure accuracy. Baked clay cylinders were not used for marking the traverse stations this year. As an experiment, zinc or corrugated iron sheets were introduced with the concurrence of the Director of Land Records. The zinc sheets were cut into strips of 18 inches in length and 10 inches in width, and bent round into a tube; the lower end of it was slit up for an inch in three or four places and turned up at right angles. This was to prevent the tubes from being easily pulled up after being embedded in the ground. The tubes were tarred to prevent them from rusting. The advantages in using the zinc tubes are—

(*a*) that they are light and portable;

(*b*) that they cost less than baked clay cylinders;

(*c*) that the transport charges are considerably reduced owing to one man being able to carry more zinc tubes than clay cylinders; and

(*d*) that there is no breakage, as is the case with clay cylinders.

The advantages mentioned above have been realized, but it is to be seen if the tubes will be as durable as clay cylinders. During the ensuing season some tubes will be taken up to examine their condition and to see how they have stood the rainy season. All the theodolite stations, numbering 26,879 in this season's work, have thus been marked with zinc tubes; the average number of theodolite stations, permanently marked in a square mile, is 19, and the cost of marking them per square mile is ₹3-13-11. Under the Upper Burma Boundaries

Act, notices signed by the Deputy Commissioner have been served on the *thugyis* for the preservation of the theodolite stations permanently marked. A separate notice for each *kwin* was issued, and on each notice a 2-inch skeleton plot was prepared, showing the survey lines and the theodolite stations. One copy was retained by the *thugyi* and the duplicate copy was made over to the Deputy Commissioner. During survey operations none of the survey stations were found to have been disturbed by the villagers.

341. Of the detail area surveyed, 673 square miles were completed by field surveyors from India and 111 square miles by Burmans. The work done by the latter proved on the whole to be good, and only in a few instances was it found necessary to reject portions of field sheets. One Burman inspector and a squad of ten field surveyors, who had worked in No. 7 Party in Lower Burma in the previous year, were transferred to this party, and their out-turn compared favourably with that of field surveyors from India. The average monthly earnings of the Burman surveyors was R25-2-4, and that of the Indian surveyors was R33-0-11, whilst the highest amount earned by a Burman in one month was R38-1-2, as against R47-9-8 earned by an Indian surveyor. In cultivated tracts a trained Burman surveyor will turn out a very good area, not much behind that of a surveyor from India; but it is in surveying fields scattered in jungle that the Indian excels and gets over a larger area: this is due to the Burman not being able to endure the fatigues and exposure to which the Indian from experience and training is accustomed.

342. The field work was tested by check survey lines run by inspectors as the survey progressed, followed by test lines run by the European assistants as the sheets were completed. Three hundred and seventy-three linear miles of test survey were run by Europeans, 1,101 linear miles by inspectors, and 287 linear miles by independent native *partallers*, giving an average of 2·25 linear miles to a square mile of detail survey on the whole area surveyed. The work proved to be, on the whole, very good; the only exceptions were occasionally in uncultivated parts, where the field surveyors were somewhat careless in putting in the cart tracks and streams.

343. The season's detail area is mapped on 951 sheets of the 16-inch scale survey. The drawing of the sheets is well advanced, and will be completed during December. Tracings of the same for the Settlement Department are under preparation and near completion. The field area statements to be furnished with the tracings for the Settlement Department are also well advanced. There is now ample work completed and ready to be made over to the Settlement Department as soon as an officer is appointed.

344. A few of the Burmans (from Lower Burma) who were employed as field surveyors have aided in the preparation of the original sheets, and the work done by them, *viz.*, inking in details and inserting field numbers, is satisfactory. Most of the tracings for the Settlement Department have been prepared by Burmans, and they have also taken a share in calculating the field areas. A few trained local men, who worked as field surveyors under Mr. R. A Gibson, Extra Assistant Commissioner in charge of the local surveys at Mandalay, were made over by that officer for employment in preparing tracings and taking out areas. These men have done good work and will be employed as field surveyors during the ensuing season.

345. The total expenditure for the survey year has been R2,16,426. After deducting the cost of the recess establishment for October and part of November 1891, and the cost of the revision surveys in Prome, the sum of R2,05,796 remains; of this, R1,97,302 represents the cost of the traverse and detail surveys in Minbu, and R8,434 that of traversing in Magwe. The cost-rates per square mile deduced from this are R57-12 for traverse and R156-13 for the detail survey. These rates include the cost of the transfer of the party from Lower to Upper Burma. They may be considered very satisfactory, more especially when it is considered that there was a certain amount of extra expense due to the partial famine in the district.

346. In order to reduce the great expense of importing all the *khalásis* from India, the Commissioner and Deputy Commissioner were consulted as to the feasibility of obtaining a certain amount of local labour to assist the field surveyors in chaining and in carrying instruments. It was decided that each

Hindustani *amin* should be allowed to bring two men with him from India, and that the other two men he required should be supplied locally, the local men to be paid 4 annas a day. The *thugyis* provided the men, and advances were made to them so as to allow of the wages being paid daily. The accounts were finally settled by the camp officer when the survey of the villages forming a *thugyi's* circle was completed. Only in a few villages was there any difficulty in obtaining local labour. The *amins* did not approve of this system, as the men were very apt to be late in coming to work, and the constant change of men interfered with the steady progress of the work: this was of course a disadvantage to men who were working on the contract system. The Burman field surveyors worked entirely with local *khalâsis*. Enquries were made by the Deputy Commissioners and by the inspecting officers when travelling as to whether the *thugyis* were regular in their payments for local labour, and it was found that with very few exceptions they were so. The total sum spent in wages to local *khalásis* amounted to R11,265, which was no doubt of some assistance to the people, who were more or less pinched for food in consequence of the high prices. The villagers willingly rendered help to the surveyors, and notwithstanding a little difficulty in consequence of the strange language, great harmony prevailed between the Indians and the Burmans.

347. The health of the establishment has been good throughout the season. There was a certain amount of sickness at the beginning and at the end of the season, but nothing of a serious nature.

348. The area remaining for survey in Minbu is about 506 square miles. Besides this, there is an approximate area of 280 square miles, consisting of narrow strips of cultivation running along the valleys of the Mon, Man and Salin rivers, which the Chief Commissioner has decided should be omitted at present, it being more to the interests of Government to utilise the survey party on the large compact areas in Minbu and Magwe than in these smaller and scattered areas. There will therefore during next field season be one cadastral camp employed in these 506 square miles in Minbu, whilst there will be a second which will complete a similar area in Magwe. In this district it is proposed to complete the Taungdwingyi sub-division in the first place, extending the work northwards into the irrigated lands of the tracts drained by the Yeu river and its tributaries. The total area of the Magwe district is said to be 3,250 square miles, of which only 2,300 square miles are for cadastral survey.

349. Messrs. Hartnoll and Eales, the Deputy Commissioners of Minbu and Magwe, both rendered much assistance to the party. Mr. Hartnoll took a personal interest in the work, and much of the success of the party, in turning out so large an area during its first season, is due to the ready help afforded by him and by the Sub-divisional Officers of Salin and Pwinbyu.

350. On the 23rd June, the Financial Commissioner, acccompanied by the Deputy Commissioner, inspected the party. The Chief Commissioner also visited the camp at Minbu on the 13th July, and again inspected the recess office at Mandalay on the 22nd August, when he was accompanied by the Deputy Surveyor-General. The season's work and the office itself was thoroughly inspected by the Deputy Surveyor-General on the 24th and 26th August. The office books and records were found in good order; the main circuit traverse observations were neatly recorded, as were most of the village traverses; directions were given that more conspicuous objects, such as pagodas, etc., should be connected with the traverse lines. Several independent *partal* lines were examined with the field sheets and were found to be quite satisfactory. The Deputy Surveyor-General considers that Mr. Patterson deserves credit for the amount of work his party has completed during this its first year of cadastral work in Upper Burma.

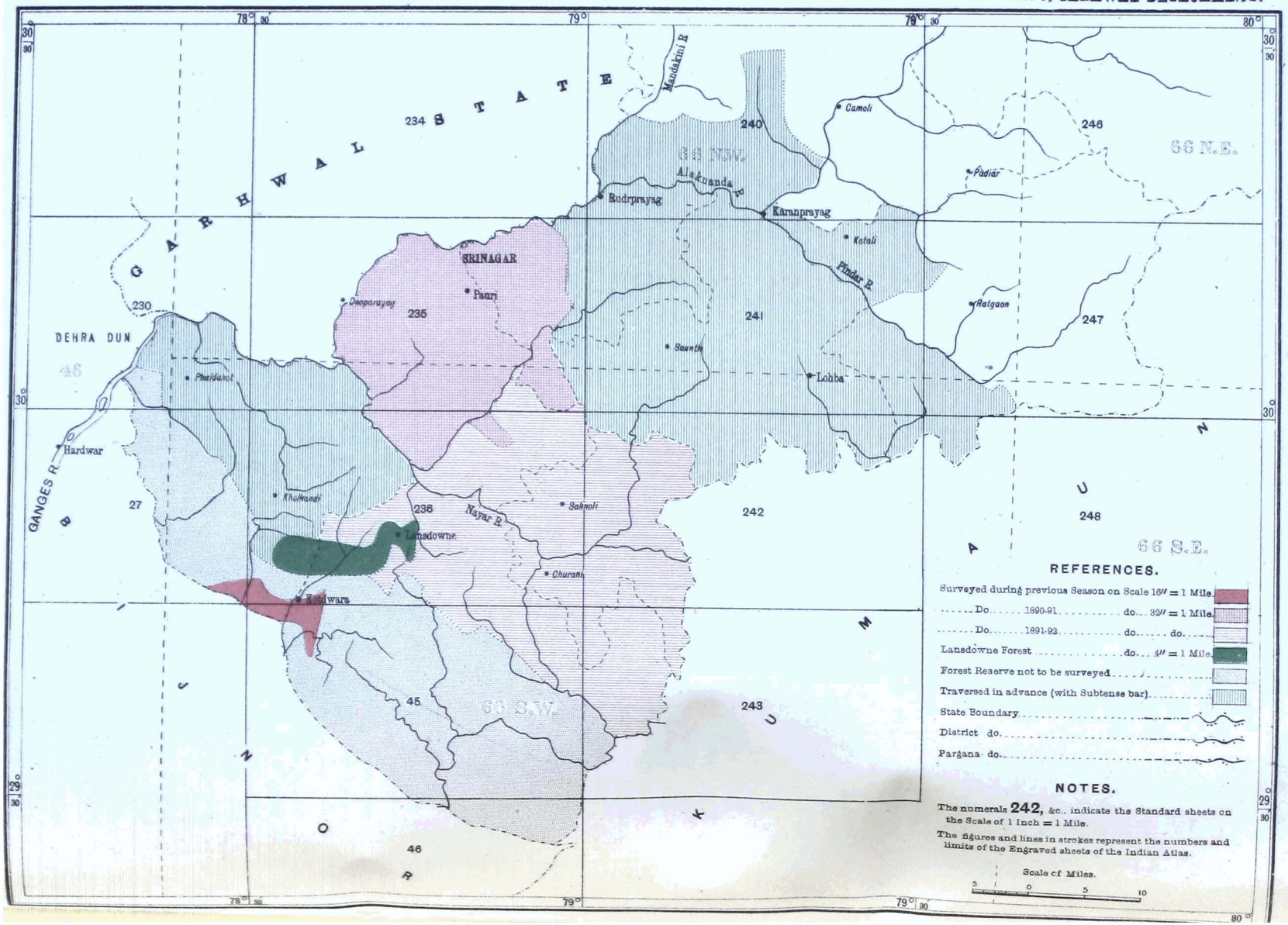
351. Mr. A. E. Spring, Assistant Superintendent, conducted both cadastral and traverse operations, and held charge of a camp office in the field and in recess. He is reported to have performed his duties in a very satisfactory manner.*

* Mr. Patterson thus reports of his assistants: Messrs. Buttress and Little, who were in charge of camps, are experienced and hard-working officers. Mr. Swiney is especially mentioned for his large and satisfactory out-turn of field work. Messrs. Babonau, Johnson, and Bell have all worked well. Of the native establishment he mentions the following as deserving of praise: Rajendra Chatterjee, Abdul Rahman, Rhedoy Chunder Dass, Jogendra Chunder Ghose, Moti Lall, Laximan Kadekar, Abdool Wahid, Tufail Ahmed and Makbool Hossein.

N. W. PROVINCES SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. GARHWAL.

No. 5, GARHWAL DETACHMENT.



REFERENCES.

Surveyed during previous Season on Scale 16″ = 1 Mile.
Do. 1890-91 do. 32″ = 1 Mile.
Do. 1891-92 do. do.
Lansdowne Forest do. 4″ = 1 Mile.
Forest Reserve not to be surveyed
Traversed in advance (with Subtense bar)
State Boundary
District do.
Pargana do.

NOTES.

The numerals **242**, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

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

Scale of Miles.

5 0 5 10

GARHWAL DISTRICT, NORTH-WESTERN PROVINCES.

DETACHMENT OF NO. 5 PARTY.

Personnel.

Mr. T. F. Freeman, Extra Assistant Superintendent, 1st grade, in charge.
„ N. Bedford, Sub-Assistant Superintendent, 1st grade.
„ W. Skilling, Sub-Assistant Superintendent, 2nd grade.
„ T. H. Murphy, Sub-Assistant Superintendent, 2nd grade.
12 sub-surveyors and others.

Temporary Establishment.

18 inspectors.
12 field surveyors (Hindustanis).
198 field surveyors (local).
210 estimators, draftsmen and *muharrirs*.

352. Operations were resumed by this party in the Garhwal district on the 21st October 1891 and were continued until the 11th June 1892, when the drawing, estimating, and traverse sections proceeded to recess quarters at Naini Tal, whilst the vernacular records, under Mr. N. Bedford, were taken to Pauri. Recess work was not commenced at the latter place till the 24th June, as sufficient coolies could not be procured to convey the records, etc., thither until the Deputy Commissioner threatened to suspend the *patwári* responsible for providing the necessary transport.

353. The strength of the establishment is shown in the margin. The number of imported *amins* employed was considerably less than during the previous season, as owing to the dislike they took to the district in consequence of the inconveniences they had to put up with from the physical difficulties, inclemency of the climate, and the fatigue they had to undergo while surveying, not half the old staff returned. This having been anticipated, arrangements had been made to train a number of hill *amins* at Pauri during the recess season of 1890-91, so that the deficiency in the strength of the establishment was made good by the employment of a greater number of local men.

354. The system of traverse by the bar-subtense method described in paragraph 228 of the General Report for 1889-90 was continued. The azimuths and rectangular co-ordinates of the trigonometrical stations which formed the starting and closing points of the traverses furnished the data for these traverses. Theodolite stations were fixed all over the cultivated area at distances of 15 to 25 chains apart. The traverse stations have all been marked by triangular cuttings on rocks *in situ*, or by rough uncut stones embedded in the ground and covered with mounds of loose stones. Receipts have been taken from the village *padhans* for the same.

355. The traverse survey includes the remaining *pattis* of *parganas* Ganga Salan, Dewalgarh and Chandpur, and portions of *parganas* Nagpur and Badhan. As the Government of India have decided not to extend survey operations into the northern or less accessible *parganas* of the district, three of the *pattis* already traversed will not be surveyed cadastrally.

356. The following statement gives the out-turn of the season's traverse work:—

Parganas.	Traverse Survey.			
	Number of main traverses.	Number of sub-traverses.	Number of stations.	Area in square miles.
Ganga Salan				
Dewalgarh				
Chandpur	90	646	12,069	578
Nagpur				
Badhan				

The traverses emanated from and closed on 172 trigonometrical stations. The angle subtended by the bar from which the distances between stations are obtained was generally observed 20 times to ensure accuracy in the deduced measurements. The heavy fog during the winter months and dense haze in the latter half of the field season constantly prevented the observations being made to the more distant trigonometrical stations, thus preventing final connections being effected and causing considerable delay.

357. The cost of the season's out-turn in traversing amounts to R17,480, giving a rate of R30-4 per square mile.

358. The cadastral survey, which is being carried out on the 32-inch scale owing to the small size of the fields, included the remaining *pattis* of *parganas* Chaund Kot and the whole of *parganas* Malla and Talla Salan, with the exception of 11 villages which were left incomplete owing to an outbreak of cholera in them. The details of the season's out-turn is shown in the following table :—

Parganas.	Cadastral Survey, Scale 32 inches = 1 mile.			
	Number of *pattis*.	Number of villages.	Number of fields.	Area in square miles.
Chaund Kot Malla Salan Talla Salan	26	1,500	962,441	231·5

The area surveyed includes small patches of intervening waste, and it is estimated that at least 157 square miles will be classified as assessable land, whilst at the time of last settlement only 65·5 square miles were assessed in these three *parganas*. The average size of the field, calculated on the total area surveyed, is 0·154 of an acre and 0·104 on the assessable area. The total area includes the scattered patches of village lands within the Lansdowne forest reserve. These isolated plots are demarcated by masonry pillars, and the boundaries are supposed to run in straight lines between the pillars. From the nature of the ground it is impossible to say exactly where these lines run, and now that the cultivated lands of these villages have been mapped, it has been found in many cases that portions of fields in the possession of villagers lie outside these lines. The question as to what is to be done in these cases has been referred to the Commissioner of the division for orders.

359. The cost of the detail survey and *khanapuri* of the area surveyed this season amounts to R42,302, giving rates of R182-11 per square mile, Ro-4-7 per acre, and Ro-o-8 per field, which are very considerably less than those of last year. The reduction in rates is chiefly due to the increased rate of progress made by the *amins* and to the reduced pay granted to local *mirdhas* and *khalásis*. The details of the cost are given in the statement at page 86.

360. There were 268 boundary disputes, which were referred to the Settlement Department for decision. Unfortunately no Deputy Collector was available for the settlement of these disputes till March. He had scarcely begun deciding them when he was called away to district work in connection with famine relief and the outbreak of cholera in the *parganas* under his control. Of the 268 boundary disputes, only 13 have been decided up to date, thus rendering it impossible to finally complete the maps and records of 510 villages. Disputes are generally decided according to present possession, as the old settlement maps are mere sketches, not even drawn to any scale, and afford very little assistance in adjusting the claims of the parties concerned. It is very difficult at times to arrive at the truth as to who is in actual possession, as both sides persistently maintain that they are and produce witnesses to prove it.

361. Partitions in fields are usually marked by small slabs of stone 6 to 9 inches long and 4 to 6 inches wide. They are called *odas* and are easily and frequently removed, thus creating numerous disputes at the time of *khanapuri*. At the time of survey these divisions were pointed out quite differently to what they were at the time of writing the *khanapuri*, thus necessitating frequent erasures in the original maps, which is objectionable. The unit of measurement is the field, as defined by the Board of Revenue in its "Directions to Settlement Officers." All terraces within fields have been approximately shown in their respective positions by faint dotted lines; and the number of terraces in each field has been recorded in the column of remarks of the *khasra* to enable the estimator to calculate and allow for the area of the terrace walls at a certain fixed rate per length of terrace. The extraction of field areas in this district is consequently a much more laborious task than usual, as, owing to the very small size of the fields, areas have to be extracted to the third place of decimals of an

acre, and in addition to this the deduction has to be made for all interior terrace walls; the deduced area, both in acres and in the local denominations (*nalis* and *annas*), has then to be recorded opposite each number in the settlement records.

362. The procedure in preparing the record of rights adopted in the previous season was adhered to with slight modifications. The ownership of trees, which at first it was considered unnecessary to record, has been entered during the present season in accordance with orders from the Board of Revenue. *Khatauni* slips or *parchas* (separate lists of all fields held by each cultivator) were prepared on the ground at the time of *khanapuri* and made over to the cultivators, in whose possession they remained for a month or more, in order that they might thoroughly understand at the time of attestation what rights had been recorded in their names. This, it was thought, would considerably lighten the work of the attesting officer. One disadvantge in making over the *parchas* to cultivators was that when they were returned to the Survey Office for entry of areas and final completion: the majority were in such a filthy state that at least 75 per cent. had to be re-copied. Hill *amins* were chiefly employed in writing up the *khanapuri;* but they are very unreliable and require careful watching.

363. Soils have been classified under the same heads as last season, *viz.*, irrigated. first class dry, second class dry, and *katil* (unterraced slope). As irrigated land is assessed at a higher rate than others, the villagers attempted to conceal it, as far as possible, by destroying irrigation channels (*guls*), and persistently denied that the land was irrigated. Several instances of this were discovered by the European assistants after the *khanapuri* had been finished, when the villagers commenced repairing the irrigation channels, thereby disclosing the deception.

364. Inspections have been constantly made by the European officers. The independent *partals* and check lines run by them aggregate 525 linear miles, and those by inspectors to 1,049 linear miles. This gives an average of 6·8 linear miles of check lines in every square miles surveyed. In 13 cases the survey proved bad and had to be re-done; otherwise the work was found to be good. Of the *khasra* entries, 8,837 were tested by European assistants and 277,374 by inspectors, giving an average of 30 fields checked per cent.

365. The season's out-turn is mapped on 2,896 sheets on the 32-inch scale. In some cases where the fields are exceptionally small, enlarged drawings of them have been made in the margin of the sheets in order to admit of the field numbers being clearly inserted. An index map on the 4-inch scale showing cultivation, principal roads, streams and village boundaries, has been prepared for each *patti*, and duplicate tracings of the same have been supplied to the Settlement Officer.

366. The following are the records prepared for the Settlement Department: (1) *khasra*, (2) dispute list, (3) *phant* or *khewat*, (4) *jamabandi*, (5) *muntakhib*, (6) *khatauni* slips or *parchas*, (7) *milan khasra*, (8) crop statement, (9) statistical statements in English, (10) tracing in duplicate of the village map (on one the different classes of soils are coloured). Up to the 1st October 1891 the records of only 223 villages out of 1,050 of that season's out-turn had been completed, thus leaving 827 for completion during the present season. These 827 (with the exception of one village, the *khasra* of which was called for by the High Court and has not been returned yet) and the records of 498 villages of the current season's work were completed this year.

367. The failure of the winter crops, resulting in general scarcity throughout the district, necessitated the importation of supplies from the plains. These not only arrived very irregularly, owing to the difficulty experienced in obtaining carriage, but, when delivered, cost considerably more than the supplies which had previously been obtained in the district. This naturally caused discontent, and many of the office hands absconded. Then again the outbreak of cholera in April in the *parganas* under survey created a great scare amongst the field establishment, particularly amongst the hill *amins*, many of whom left their work and decamped to their homes directly it was discovered that any one in the village was ill. Doubts were at first entertained of the possibility of completing the *khanapuri* of several villages which had been surveyed. In the end, however, all but 11 villages, in which cholera prevailed up to the close of the field season were completed. Moreover, the physical difficulties of surveying in such a mountainous country are so great that men from the plains can only be induced to

come after a great deal of persuasion, and the excessive cold experienced during half of the field season does not admit of the men working for more than five hours a day, thus interfering with their daily out-turn and monthly earnings. All these put together rendered last season's work most arduous, and Mr. Freeman deserves great credit for showing so large an out-turn under such adverse circumstances.

368. The officer in charge acknowledges the effectual aid rendered by Pandit Manik Lal Joshi, Deputy Collector, who was deputed by the District Officer to attend to the requirements of the Survey Department. Unfortunately his own district work would not admit of his constantly remaining near the central camp, and consequently communication with him was frequently delayed. At times, therefore, his assistance in enforcing the attendance of *zamindars* could not be as readily obtained as desired.

369. The recess office of the party was inspected by the Deputy Surveyor-General on the 8th and 10th of October 1892, who closely examined the field and office books and maps, testing several of the latter with the independent *partal* lines. He has expressed his satisfaction with all that he saw and with Mr. Freeman's energy in overcoming the numerous difficulties he has had to contend with in prosecuting an unusually intricate and troublesome survey.*

BURDWAN ESTATES, BENGAL.

DETACHMENT.

370. The survey of the estates of the Maharajah of Burdwan was once more resumed in accordance with a decision come to at a conference held in June 1891 between the Deputy Surveyor-General, the Director of Land Records, and the Manager of the estates. It was then decided that if the latter could prove that in consequence of the survey operations he had been able to resume possession of any missing villages, then these operations should be continued under Mr. Shaw. The Manager, Lala Bun Behari Kapur, afterwards reported that the work done was valuable to the Raj, and that he had in consequence of the survey been able to resume possession of some of the missing villages. He added that he had been opposed to the undertaking at first, but he now asked for the extension of the survey to *tauzis* 1, 2, and 3 of the Bankura district. This application was made in October 1891. The *Gazette* of 23rd December 1891 notified the continuation of the survey.

Personnel.

Mr. T. Shaw, Extra Assistant Superintendent, 4th grade, in charge up to 25th June 1892.

Mr. A. B. Smart, Sub-Assistant Superintendent, 2nd grade, from 20th February 1892, and in charge from 26th June 1892.

Babu Sarat Chunder Sen, Sub-Assistant Superintendent, 3rd grade, from 1st November 1891 up to 1st February 1892.

2 computers.

21 sub-surveyors.

371. The programme comprised—

(1) the cadastral survey of 40,000 acres in Bankura and Burdwan;
(2) the traverse survey of *tauzis* 1, 2, and 3 in Bankura district, the area being about 650 square miles.

372. The recess office of the party closed at Burdwan on 12th December, and the camp office opened at Bishenpur, district Bankura, on 17th December 1891. Field work was begun on 1st January 1892. The work from the commencement of the survey has been of a scattered nature. In 1888-89, the Raj had 177 villages traversed as *khas*: in 1889-90, 434 more villages were surveyed. With the exception of a compact block of villages in the north-west corner of *pargana* Bishenpur and some single villages here and there, the whole of the *pargana* may be said to belong to the Raj.

373. In order to survey *tauzis* 1, 2 and 3, it became necessary to connect the villages comprised in these with the old scattered work done in former

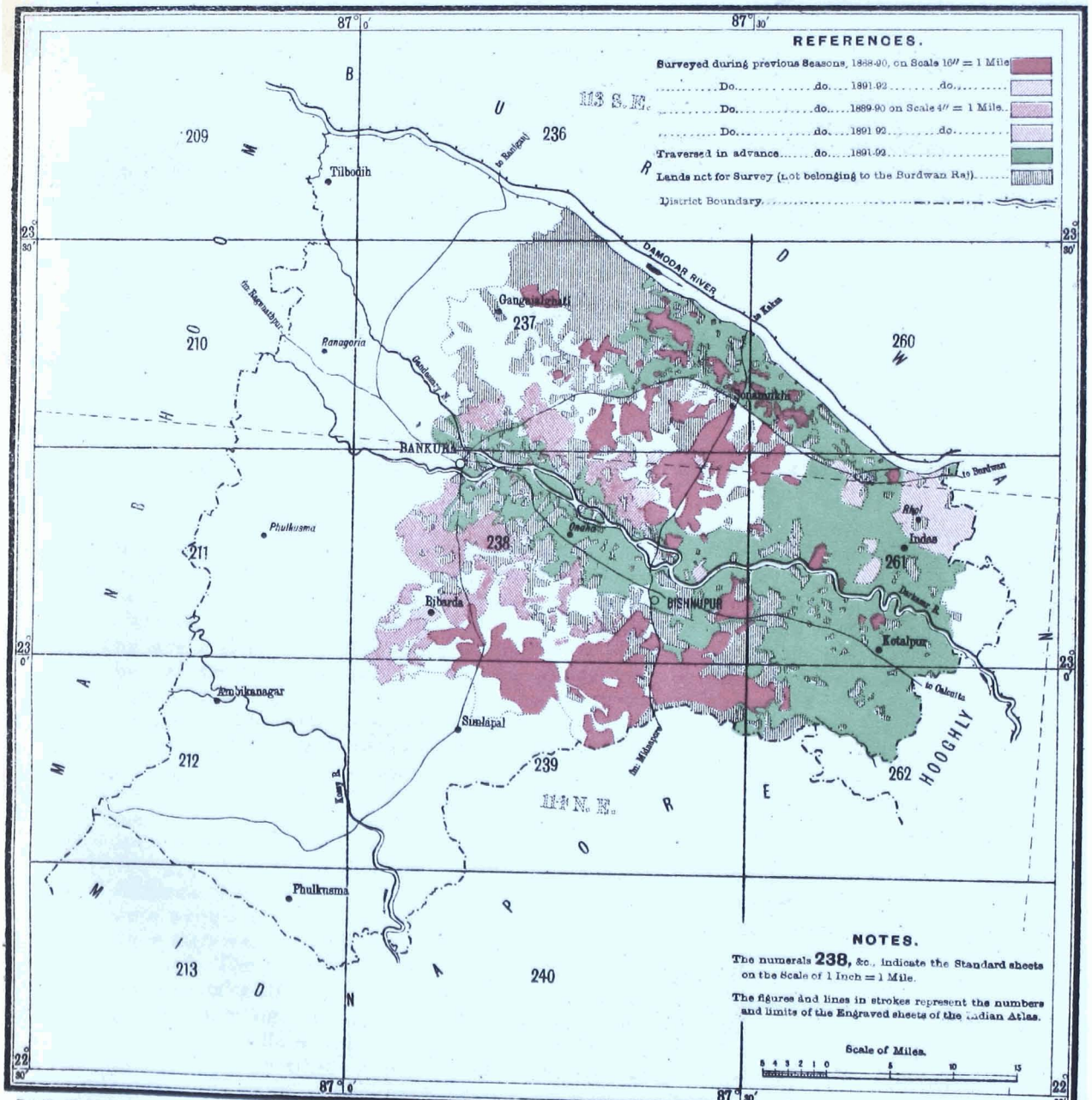
* Mr. Freeman reports well of Messrs. Bedford, Skilling and Murphy, especially of the first, who, he says, is particularly energetic and zealous, and can be relied on to do any work entrusted to him in a satisfactory manner.

Amongst the natives he mentions Budri Parshad, Waris Ali, Hari Singh, Bishambar Sahai, Gunga Parshad and Salamat Ali.

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY OF THE BURDWAN ESTATE IN DIST. BANKURA.

BURDWAN DETACHMENT.



Reg. No 661, Bengal & S. I. D.—Mar. 93.—2,952.

Photo. S. I. O., Calcutta.

seasons, and to incorporate the whole in regular main and sub-traverses, in order to satisfy mathematical requirements, and to render the work fit for future reference.

Tracings of the old revenue survey maps of 1854-55 had to be prepared, and on these tracings had to be coloured all *mauzas* in which the Burdwan Raj had no interest of any sort. The theodolite traverse stations of previous surveys made in 1888—90 had also to be shown on these tracings for the use of the sub-surveyors. This latter operation was very troublesome, inasmuch as the *mauza* boundaries, pointed out during the cadastral survey of 1888—90, did not agree with those shown on the old revenue survey maps.

374. There being no demarcation whatever of the *patni* (permanent tenure) villages, the sub-surveyors were supplied with tracings of the old revenue survey maps, on scale 4 inches=1 mile, with sufficient detail to enable the men to know the boundaries were being followed approximately by the villagers pointing out the lands. Lists of the *patnidars* with their addresses were supplied by the Raj office, but no information was forthcoming showing the particular villages in possession of each *patnidar*. Notices under section 5, Act V of 1875, were served through the post (registered) on the *patnidars* mentioned in the Raj lists, but it was soon found that the names of *patnidars* supplied by the Raj were not correct in many instances. These notices required the *patnidars* to supply the following information :—

(1) *Tauzi* number.
(2) Name of lot.
(3) Name of village.
(4) *Thakbust* number.
(5) Boundaries of villages.
(6) Name and residence of agent properly authorised to point out boundaries and sign maps.

These details, if properly given, would have rendered it possible to discover the *patnidars* in possession of particular lands, and to ensure their attendance to point out boundaries. In very few instances were the *patnidars* either able or willing to give the *thakbust* numbers of the *mauzas* in which their lands are situated. The village names have to be looked out on the revenue survey maps by means of the boundaries supplied by the *patnidars*, and the *thakbust* numbers arrived at in this way. There are altogether 334 *patni* tenures in *tauzi* Nos. 1, 2, and 3. Notices were issued to 313 *patnidars* whose addresses could be ascertained. Of these 313 notices issued, only 132 were returned with the necessary forms filled up, 129 were retained by *patnidars*, but no forms have yet been received, 47 notices were returned twice, and 5 were returned three times. The difficulty of ascertaining the parties responsible for the correct pointing out of the boundaries precluded steps being taken to enforce attendance under the Bengal Survey Act.

375. About the 15th of March, the Manager appointed certain men as *nishandars* to assist the sub-surveyors in procuring attendance of villagers who were acquainted with the *mauza* boundaries, but the assistance rendered by these men was nominal.

376. The *patnidars* were active in their opposition to the survey, traverse station marks and tri-junction stones being removed by them as soon as placed by the surveyors. In several cases the positions of the traverse marks were changed more than once, and it has been difficult when re-surveys have been received to know what discrepancies were due to wrong observations and what to removal of marks. The Magistrate of Bankura was addressed on the subject. Arrangements were in consequence made to have the village *chaukidars* made responsible for the marks, and to grant receipts for them. The police interested themselves for a short while on being stimulated by the Magistrate, and reports from sub-surveyors about removal of marks became less frequent. The full extent to which marks have been removed will only be known when the *amins* go round the boundaries of each village to survey the Raj interests. Owing principally to the uprooting of stations during operations, and of doubtful closings on old work, the re-observations of the angular measurements have been many, 1,500 angles having had to be re-observed out of 18,000.

377. In March 1892, it became apparent that without an increase in the number of sub-surveyors, the traverse work would not be completed by the end of the field season. Six sub-surveyors were transferred from Jalpaiguri to strengthen the detachment.

378. The out-turn of the whole establishment has been very deficient, the average of each man being $22\frac{1}{4}$ linear miles monthly. The cause of this inadequate out-turn was due not only to the peculiarly difficult nature of the work, but to the fact that new men had to be engaged and taught, no experienced traversers being available.

379. The field office was closed at Bishenpur on the 18th August and re-opened at Motihari on the 24th August 1892. The move to Motihari had been ordered by the Director of Bengal Surveys before he proceeded on leave on the supposition that the survey of the Burdwan Raj would be finished by October 1892. But Mr. Shaw's illness and departure on leave frustrated some ends he had in view with regard to the future of the detachment.

380. The out-turn of traverse work for the season under report is—

District.	Number of villages.	Number of stations of observation.	Linear miles of chaining.	Area in square miles.
Bankura . . .	1,656	17,931	2,706	614
Burdwan . . .	7	175	34	7
Total .	1,663	18,106	2,740	621

The boundaries of the villages and of all the Raj interests within them, almost entirely, remain over for survey.

381. To check the angular work, observations for azimuth were made at 63 stations. Three stations of the Great Trigonometrical Survey were connected with the main traverses; but the comparison between direct distances as obtained from traverse chain measurement and from trigonometrical data has not yet been made, owing to the traverse computations being incomplete.

382. The cost-rate of traversing, including computations, has been R52-8 per square mile.

383. At the end of the recess season only 560 villages out of 1,656 which were traversed had been proved in distances. The great number of re-observations found necessary hindered the progress of office work very much: sub-surveyors were employed on revisions throughout the recess. But the backward state of the work is not due to this cause alone; it is in some measure attributable to Mr. Shaw's departure on leave owing to ill-health.

384. The area to be surveyed cadastrally during the year was estimated by the Manager at 40,000 acres, but this area proved greatly in excess of what the Raj officials were able to point out.

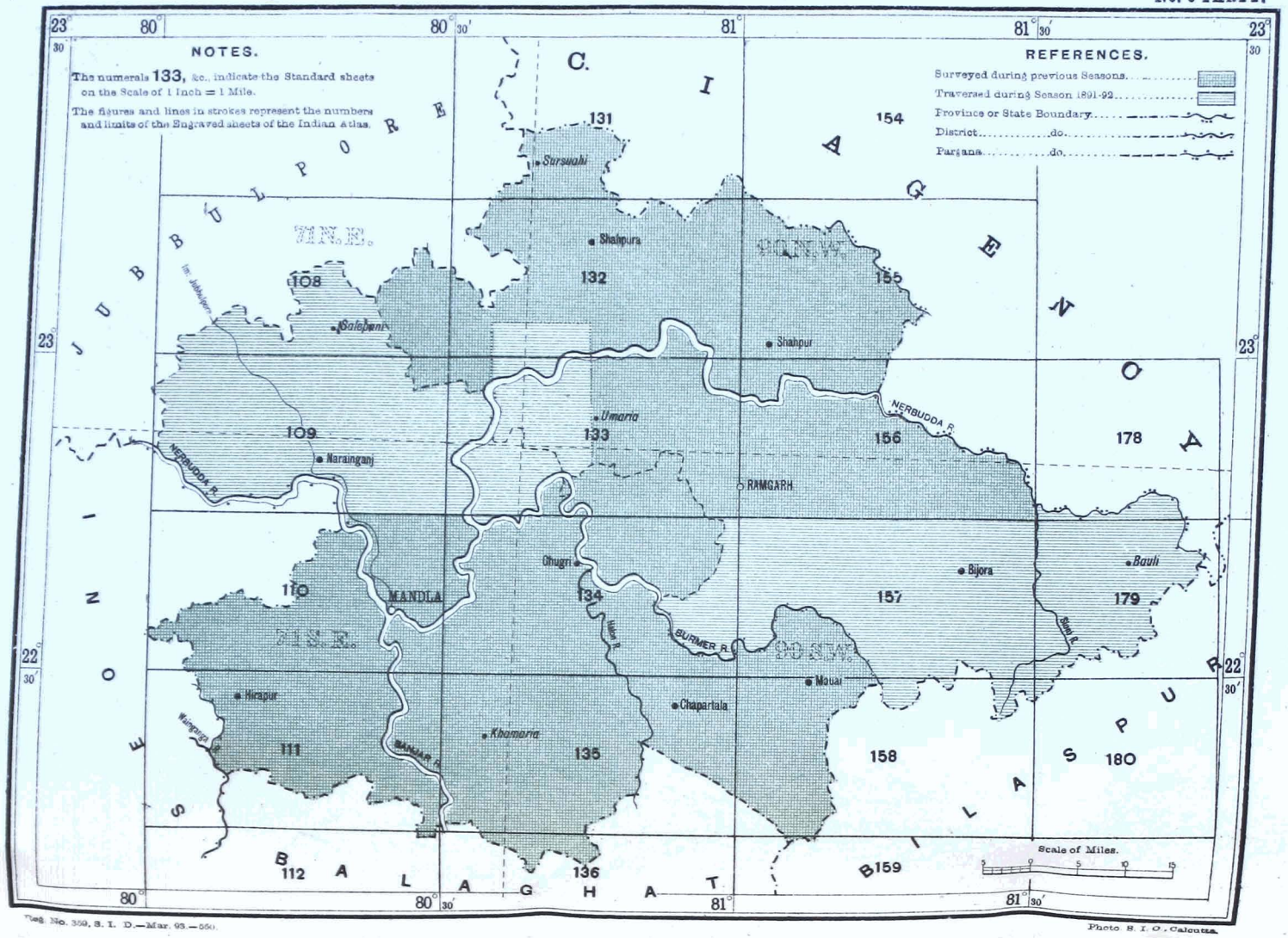
385. Lot Chaitanganj of *tauzi* No. 1, district Bankura, was first taken in hand. The list as supplied from the manager's office gave only the names of the villages. The positions of the villages were discovered from the old maps, and *amins* were sent to survey on the best information they could procure locally. The work dragged on slowly owing to the Raj not being in possession of the lands, and consequently unable to point out their claims. By the 31st of March only 24 small wooden pegs had been placed on the boundaries of a 100-*bigha* plot in the town of Bishenpur. This represented the whole of the demarcation effected by Raj officials, and the officer in charge of the detachment was dependent on this portion of lot Chaitanganj being demarcated by the management, as there were no maps by which surveyors could be guided in distinguishing the Raj lands in the town of Bishenpur.

386. Of the situation of the lands to be surveyed cadastrally in district Burdwan, no information could be obtained from the Manager's office till very late in the season, when a general statement as to the whereabouts of the lots was furnished to the Survey Office. A sub-surveyor was in consequence sent to

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT MANDLA.

No. 9 PARTY.



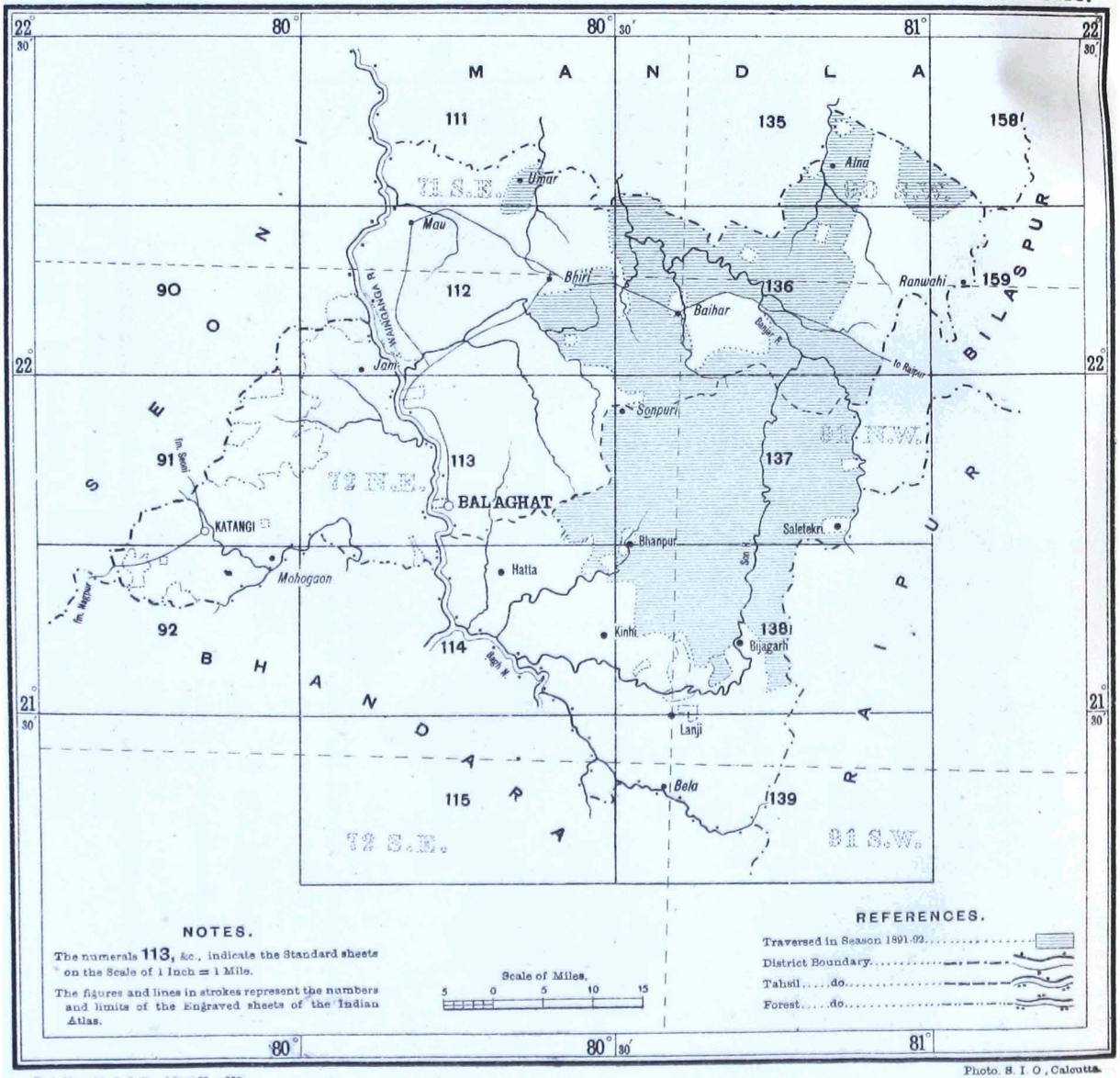
Tes. No. 359, S. I. D.—Mar. 93.—550.

Photo S. I. O., Calcutta.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT BALAGHAT.

No. 9 PARTY.



NOTES.

The numerals **113**, &c., indicate the Standard sheets on the Scale of 1 Inch = 1 Mile.

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

Scale of Miles.

5 0 5 10 15

REFERENCES.

Traversed in Season 1891-92.....

District Boundary.....

Tahsil.....do.....

Forest.....do.....

Reg. No. 425, S. I. D.—Mar. 93.—550.

Photo. S. I. O., Calcutta.

the Manager's office with a request that the lands to be measured should be pointed out to him in detail.

387. Of the seven villages traversed in Burdwan, only three were measured field by field. The out-turn of cadastral work is as follows:—

District.	Number of villages.	Number of fields.	Area in square miles.	Average size of fields.
Bankura	44	40,347	11·29	0·18
Burdwan	3	5,656	2·00	0·22
Total .	47	46,003	13·29	...

388. In order to ascertain the Raj interest in the different *mauzas*, it was necessary to obtain copies of all the *thakbust* maps and statements of *mauzas* in which the estate had any interest. The maps and statements of 1,970 *mauzas* were copied, and efforts will be made during the coming season to discover all missing villages.

389. The total cost of operations for the year was ₹45,954. The cost-rate of cadastral survey and records was ₹281-12-10 per square mile.

390. The area remaining for survey comprises 150 square miles of traversing and 650 square miles of skeleton boundary survey on the 4-inch scale in district Bankura, which will be taken up in the ensuing season.

TRAVERSE SURVEYS.

MANDLA, BALAGHAT AND BHANDARA DISTRICTS,

CENTRAL PROVINCES.

No. 9 Party.

391. This party resumed its traverse operations in the Central Provinces. It was divided into three sections, one for each of the three districts Mandla, Balaghát and Bhandára: the Mandla section continued the traverse work which had been commenced last year, whilst the other two took up the traverse surveys of the *zamindári* and *rayatwári* villages which had been omitted from survey when the Balaghát and Bhandára districts were traversed in previous years. The detachments left recess quarters at Jubbulpore on the 15th November 1891 and closed the field work on the 15th May 1892, when the party proceeded to Kamptee for recess.

Personnel.

Mr. G. H. Cooke, Officiating Superintendent, 2nd grade, in charge up to 15th May 1892.
„ H. Dowman, Extra Assistant Superintendent, 2nd grade, in charge from 16th May 1892.
„ A. George, Sub-Assistant Superintendent, 1st grade.
„ C. H. G. Johnson, Sub-Assistant Superintendent, 2nd grade.
„ G. Rae, Sub-Assistant Superintendent, 3rd grade.
40 surveyors, sub-surveyors and others.

392. Mr. Cooke held charge of the party throughout the whole of the field season, and when he proceeded on furlough on the 22nd May 1892, Mr. H. Dowman was put temporarily in charge, there being no officer of the senior division available at the time.

393. As in previous seasons, the object of the traverse surveys has been to furnish the Settlement Department with a large number of correctly fixed points on which to base the surveys of the fields which are made by *patwáris*. The village traverses closely follow the village boundaries, whilst the sub-traverses, which are about 30 chains apart, divide up the village areas into convenient sized blocks, so that the *patwáris* never have to measure any great distance without finding a fixed point to check their work on.

394. The traverse survey of districts Mandla and Bhandára has been completed, but an area of about 500 square miles remains for survey in district

Balaghát. The following tabular statement shows in detail the out-turn of the season, which is considerably in excess of that of the previous year:—

Districts.	Number of villages.	Number of sub-traverses.	Number of traverse stations.	Area in square miles.
Mandla	876	1,535	29,465	2,174
Bhandára	418	782	14,015	922
Balaghát	399	602	17,140	1,215
TOTAL .	1,693	2,919	60,620	4,311

395. Of the total number of traverse stations fixed, 51,442 have been marked by dressed stones about 2 feet in length, at a cost of 3 annas 1 pie each, or ₹2-5-2 per square mile. As no district or other complete maps showing boundaries existed, skeleton maps of all the villages on the 2-inch scale have been plotted, and the permanently marked stations conspicuously noted. Tracings of these will be supplied to the village headmen (*malguzárs*) as guides to the relative position of marks, for the preservation of which they are responsible.

396. The demarcation in districts Mandla and Bhandára was good, and was kept well in advance of the survey. In Balaghát, however, it had not been commenced when the party took the field, and the surveyors had no alternative but to survey in advance of the demarcation. The result of this was that many of the boundaries of the *rayatwári* villages, as taken up by the surveyors, were not approved of by the Settlement Department when the authoritative demarcation was made, as it was found that a proportion of forest land, which by the conditions of tenure should have been conceded to the cultivator, had not been included in the areas traversed by the surveyors. This necessitated re-surveys of the boundaries and great alterations in the computations, and threw a great deal of extra work on the party.

397. The country traversed this season was for the most part hilly and densely wooded, the cultivation being scattered and difficult of approach on account of the intervening stretches of hills and forests. Traverse surveying in such a country can only be carried on with difficulty, and, notwithstanding every precaution, it was found necessary to revise a large number of the village circuits. An attempt will be made next year to utilise the bar-subtense method for the lines running up and down the hills. The climate is malarious from October to the end of February, and the party suffered considerably. The principal sickness was influenza, which prevailed throughout all the districts under survey. No less than twenty seven men belonging to the party died of it, one being a sub-surveyor.

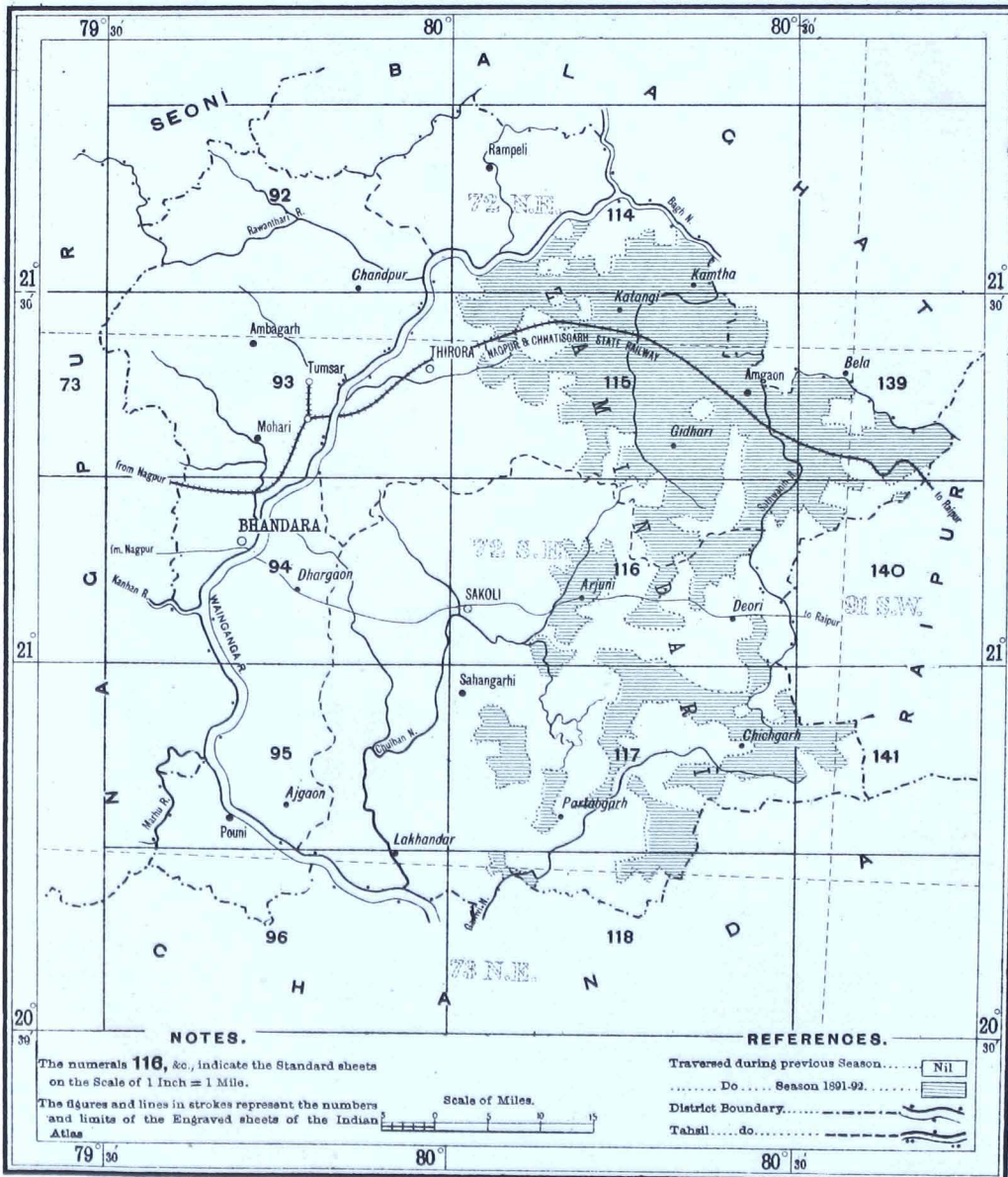
398. Skeleton plots on the 16-inch scale, together with area statements, of 1,171 villages, have been prepared on 2,224 sheets and transmitted to the Settlement Department. The remainder, with traverse data, will follow by the end of November. A skeleton index map of the Mandla district, on the $\frac{1}{2}$-inch scale, is also being prepared for the Settlement Department: this will be the first map showing boundaries that has been prepared.

399. The retention of the party for another year in the Central Provinces having been sanctioned by the Government of India for the survey of the *zamindari* estates situated in districts Raipur, Bilaspur and Sambalpur, covering an area of 1,600, 1,400, and 1,000 square miles respectively, the party will continue to work in the Central Provinces during season 1892-93, and will be again divided into three sections; one section will resume work in Balaghát, as well as commence that in district Bilaspur, whilst to the other two sections will be allotted Raipur and Sambalpur districts. The completion of the whole area, *viz.*, about 4,500 square miles, cannot be guaranteed, as the country presents great physical difficulties, besides being divided into 2,065 villages, which are said to be much scattered, necessitating many extra sub-circuits to connect the work.

CENTRAL PROVINCES SURVEY.

INDEX TO THE TRAVERSE SURVEY IN DISTRICT BHANDARA.

No. 9 PARTY.



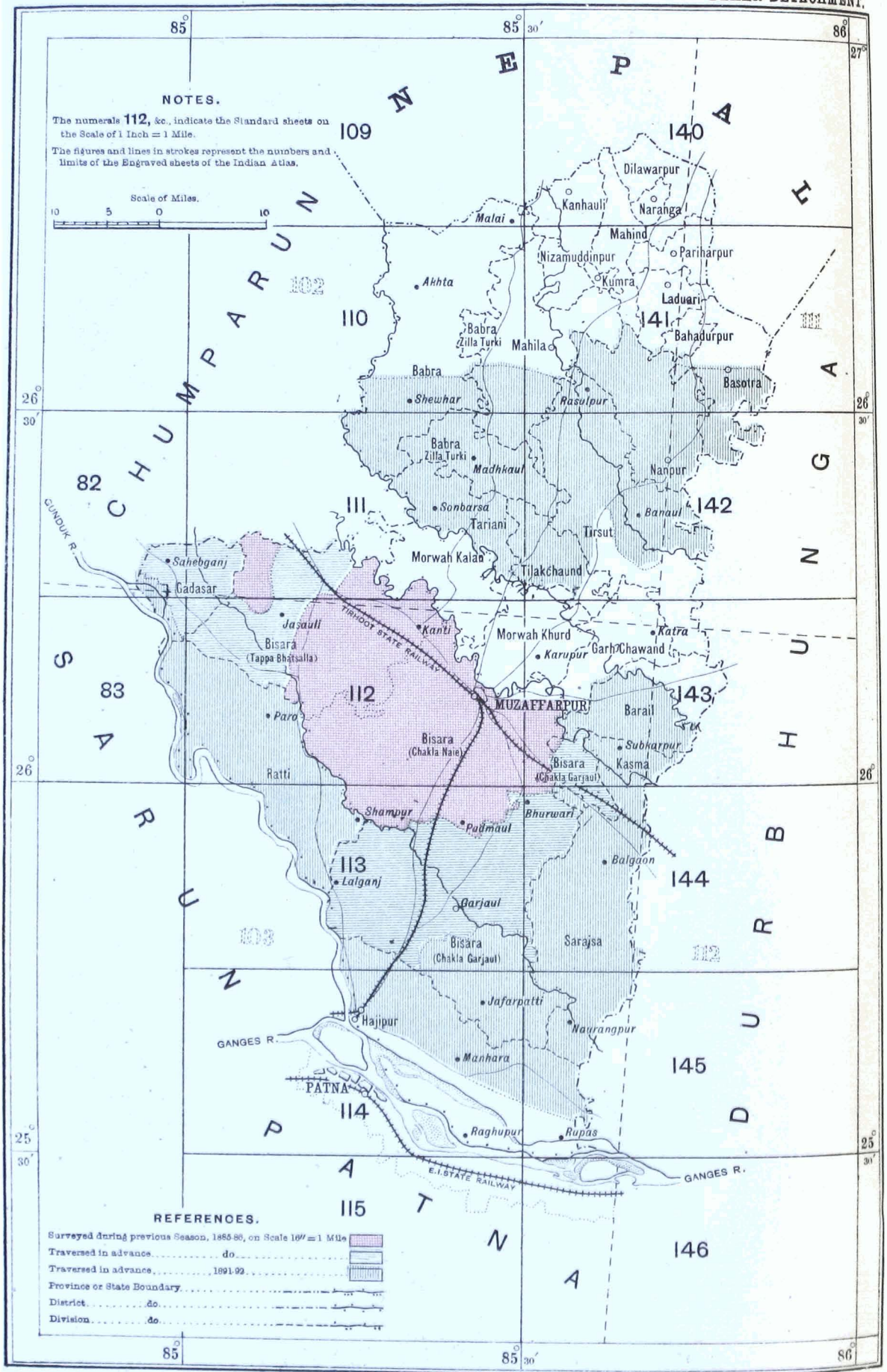
Reg No. 429, S. I. D.—Mar. 93.—550.

Photo. S. I. O., Calcutta.

BEHAR SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DISTRICT MUZAFFARPUR.

BEHAR DETACHMENT.



Reg No 247 Bengal & S. I. D.—Jan. 93—2,252.

Photo S. I. O., Calcutta.

400. The Deputy Surveyor-General inspected the recess office of the party at Kamptee on the 29th and 30th June 1892, and expressed himself well satisfied with the state in which he found the records of the party. *

MUZAFFARPUR AND CHAMPARAN DISTRICTS, BIHAR.

DETACHMENT.

401. The Government of India, subject to the Secretary of State's approval, sanctioned the survey and the preparation of a record of rights in North Bihar in their letter No. 2135—112, dated 18th September 1891. The notification in the *Gazette* ordering the survey under section 3 of the Bengal Survey Act, V (B.C.) of 1875, of the districts of Muzaffarpur, Darbhanga, Saran, and Champaran is dated 17th November 1891.

Personnel.

Mr. J. S. Pemberton, Officiating Assistant Superintendent, 1st grade, in charge.
" W. H. D. Ewing, Sub-Assistant Superintendent, 1st grade, from 25th December 1891.
" H. B. Hanby, Sub-Assistant Superintendent, 3rd grade, from 1st December 1891.
20 sub-surveyors and others.

Temporary Establishment.

13 sub-surveyors and others.
5 *muharrirs.*

402. At the close of season 1890-91, the party known as the Indus Riverain Detachment, having completed its work in the Punjab, was transferred to Bihar and formed the nucleus of the new party, the original strength of which was gradually augmented, by transfers from other parties and fresh appointments, to the strength shown in the margin. The operations were to be restricted during the year under report to the preliminary traverses, the commencement of the cadastral survey being deferred till October 1892.

403. The field of operations was the district of Muzaffarpur, where traverse and cadastral surveys had been commenced experimentally by the late Colonel Barron, Deputy Superintendent, in co-operation with Mr. Collin, Settlement Officer, in 1885-86, but which were discontinued after one season. Before the close of the season the current operations were subsequently extended to Champaran.

404. The detachment assembled first at Patna on the 10th November, pending final orders, which were issued on the 17th idem, the date of the Government of Bengal notification authorising the survey, when all hands moved to Muzaffarpur, where they arrived on the 20th November 1891. A further unavoidable delay was occasioned here, for the notices on landholders and others, required by the Survey Act, V (B.C.) of 1875, had to be printed and issued. Thus it was not till about the 19th of December that actual field work was started, and then only by a small section of the detachment, the entire strength of which was not fully employed till about the 10th January 1892. From this date field work was carried on without any serious interruption until the 17th June, when the field season was practically brought to a close and the party retired to recess quarters at Muzaffarpur, having accomplished during the $5\frac{1}{2}$ months 1,610 square miles, only 90 square miles short of the estimated programme—a result which may be considered satisfactory in view of the late start and other drawbacks, which will presently be noticed.

405. Referring to Colonel Barron's survey of 1885-86, the total area traversed by him aggregates 803 square miles, of which 414 square miles were cadastrally surveyed, leaving a balance of 389 square miles of traverse work, which, added to what has now been done, gives an area of all but 2,000 square miles of traverse survey in advance for next season. In the area previously traversed, the village tri-junction points in 301 square miles were found marked by stones, and this portion was first taken in hand during the season, comprising the whole of *pargana* Ratti, a portion of *pargana* Gadehsar, and a portion of Chakla Gurjaul, *pargana* Bisara.

* Mr. Dowman, who has superintended the party during the recess, has performed his duties well and satisfactorily. He reports very favourably of Messrs. A. George, C. H. G. Johnson and G. Rae, and highly commends Lall Mohun Gungopadhya and Tara Prosunno Roy; he also speaks well of Narsoo, Dinkar, Upendra Nath Mookerjee, Manohar Daji, Kesho Vaijnath, Gopal Sitaram, Keshave Luxmon, Rajaram, Atmaram, Karim Buksh, Wali Mahomed, Gunpat Rai, Murli Manohar, Mayadhari, Murad Ali, Atta Ulla, Issur Singh and Hamid Hossein.

406. The details of the season's out-turn of traverse work are given in the following table:—

District.	Number of villages.	Number of traverse stations.	Linear miles of traverses.	Area in square miles.
Muzaffarpur	2,144	24,537	5,215	1,247
Champaran	238	5,302		363
TOTAL	2,382	29,839	5,215	1,610

407. In *pargana* Hajipur of the Muzaffarpur district, the portion of country bordering the Ganges and Gandak rivers, known as the *diara*, which is subject to fluvial action and embraces an area of about 100 square miles, has been omitted from the present season's operations, and will have to be traversed in the same season that the cadastral survey is undertaken, the reason for the omission being the great probability of the stations being washed away during the floods if put down this season. Likewise the *diara* lands along the Gandak, area about 137 square miles, have also been omitted in the Champaran district.

408. The temporary demarcation of village boundaries was carried out by the *zamindars* simultaneously with the traversing, because no tract of country had been previously prepared for survey. The demarcation pillars are merely earthen mounds from 2 to 3 feet high, well rammed down round a bamboo peg firmly fixed in the ground and plastered over. The demarcation not having been done in advance has been a source of delay throughout the season.

409. Every surveyor was furnished with tracings of the village boundaries from the old 4-inch revenue survey of 1843—47 to enable him to make a rough comparison with the boundary pointed out. Except in a few instances, where new *mauzas* had been formed or boundaries had been altered for other reasons since the old survey, the general run of the boundaries was found to agree well.

410. The angular measurements have been checked by observations for azimuth at 153 stations, and the average error thereof amounts to 1 minute in every 21 angles. The linear measurements were checked by connections with stations of the Great Trigonometrical Survey, and the average error of the chaining was found to be 3 feet per mile.

411. The area remaining for traverse survey in the Muzaffarpur district amounts to—

	Square miles.
Muzaffarpur sub division	430
Sitamarhi ditto	484
TOTAL	914

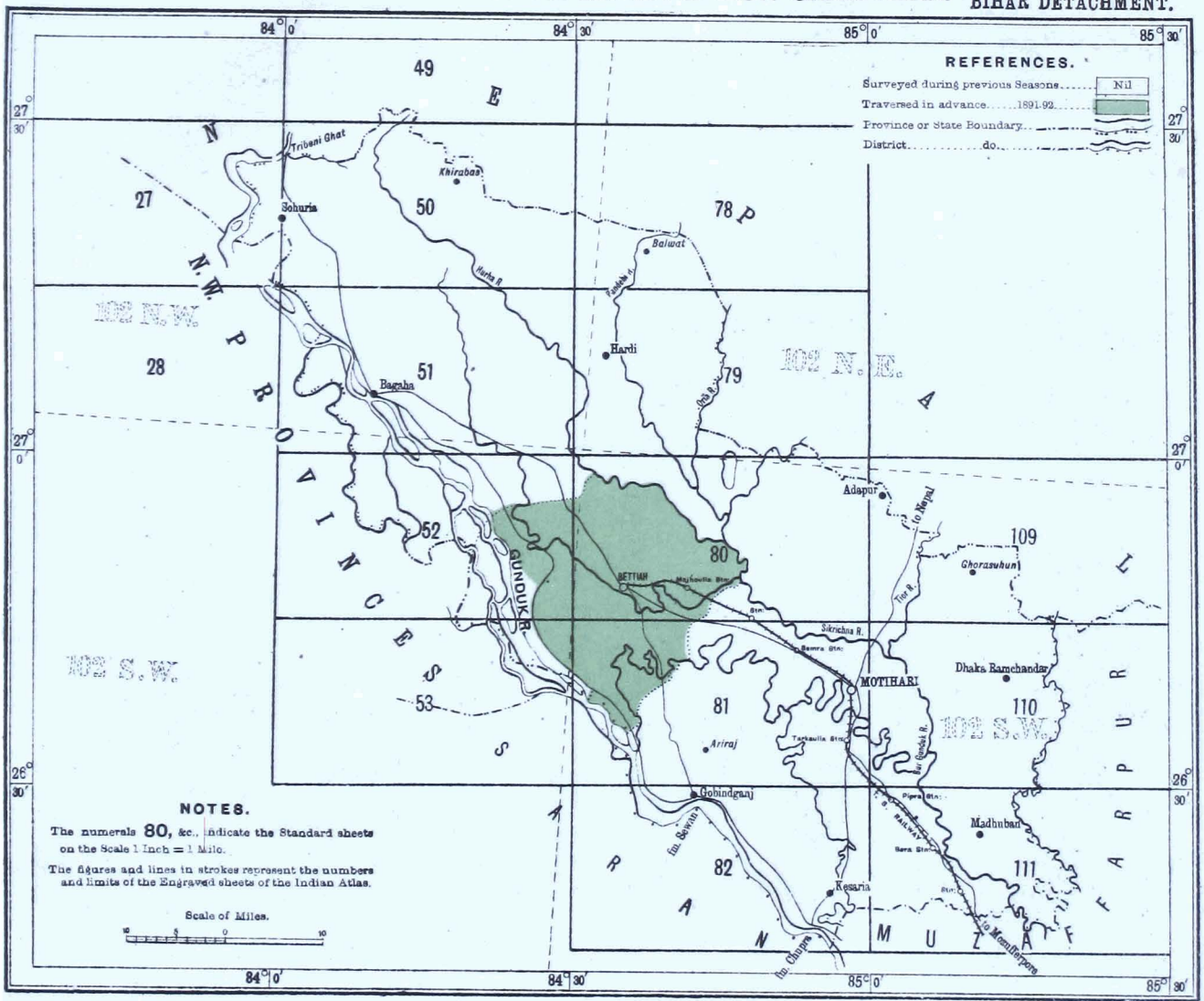
412. The attitude of the inhabitants in Muzaffarpur was one of passive obstruction throughout, principally shown in dilatoriness in attending when called on to point out their boundaries and in disputing for hours over boundaries that had never been questioned before, thus causing serious loss of time: these were not exceptional cases, but said to be the experience of almost every surveyor in the field. These statements are not absolutely reliable.

In the Bettiah estate there was no such obstruction, indeed no checks or hindrances of any kind whatever, due to the influence and good management of Mr. T. M. Gibbon, C.I.E., the Manager of the estate, to whom the officer in charge of the detachment expresses himself as much indebted.

413. One difficulty experienced in the survey was to get landholders generally to understand the distinction between a traverse station and a boundary mark. Nothing would convince them that they were not necessarily one and the same. Hence if any peculiarity in the nature of the country compelled the surveyor to put down a mark anywhere but actually on the boundary, a cry of injustice was immediately raised and petitions were submitted to have the marks removed, notwithstanding repeated assurances that the position of traverse stations in no way affected actual possession or prejudiced the rights of any

BENGAL SURVEY.

INDEX TO THE CADASTRAL SURVEY IN DIST. CHAMPARAN. BIHAR DETACHMENT.



Reg. No. 23, Bengal & S. I. D.—Mar. 93.—2,052.

Photo. S. I. O., Calcutta.

one. If their wishes were not acceded to, they not infrequently refused to allow the survey to proceed. It was not till several fines were inflicted that this difficulty was, to some extent at least, removed. The fines inflicted on *zamindars* were 14 in number, and were for cases of non-attendance and for uprooting and otherwise destroying survey marks, actionable under sections 51, 52, and 53 of Survey Act, V of 1875.

414. The stones used for marking village tri-junctions and certain other intermediate traverse stations were all of one pattern, *viz.*, blocks of sandstone, 2 feet long, rough hewn to $4\frac{1}{2}$ inches from the end, which was cut into a triangular prism of 5-inch sides. In accordance with arrangements made with the Bengal Stone Company, Mirzapur, 22,000 of these stones have been supplied at the rate of 8 annas per stone landed at Muzaffarpur. Of this number, 10,758 have been used in the present season's work, both in the Muzaffarpur and the Champaran districts, giving an average of six stones per square mile of country. The balance, 11,241, have been stored in the office compound at Muzaffarpur. In April, the Director arranged with Messrs. Burn & Co. at Raniganj to supply 11,000 marks of pottery, 10,000 of which are glazed pipes 2 feet long of 2-inch diameter for ordinary traverse stations, costing 2 annas each, and 1,000 for tri-junction points, being cylindrical cones, measuring $2\frac{1}{2}$ feet long of 8-inch diameter, at 12 annas each: these arrived too late to be made use of, and have been stored in the circuit-house compound at Motihari. It is expected that these special marks when filled with clay will answer the same purpose as stones, and being lighter there will be considerable savings in the charges for carriage.

415. The health of the establishment throughout the season was on the whole good. During the months of May and June cholera in an epidemic form prevailed throughout the country, most virulently to the east of the Muzaffarpur sub-division and south of the Sitamarhi sub-division, where work had for a time to be suspended. In the low-lying lands bordering "Tal Barela," the largest *jhil* in the Muzaffarpur district and situated in *pargana* Saraisa, malarial fever is more or less always prevalent, but especially during April and May, the time unfortunately when the men were employed in the neighbourhood, and consequently they suffered a good deal. Only three deaths in the establishment occurred during the season, two from cholera and one from snake-bite.

416. The cost-rates, deduced from the total expenditure incurred from the time the party was transferred from the Punjab, including the extraordinary expenses of transit therefrom, are as follows:—

	Per square mile. ₹ a. p.
Stone embedding	10 6 5
Traversing	24 4 9
Total for traverse survey .	34 11 2

417. During the recess, the traverse computations and skeleton plots, on the 16-inch scale, have been completed of the entire season's work. Also rough skeleton plots have been prepared on the 4 inch scale, comprising congregated villages limited by sub-circuits to serve as indices to the cadastral records for survey and settlement, and to permit of a comparison being made on the same scale with the old revenue survey maps. This is necessary to satisfy the requirements of the Tenancy Act, which limits the hereditary rights of tenants to the "village of the revenue survey."

418. During the recess season training schools were organised at Muzaffarpur and Motihari, and *zamindars* and planters were invited to send in *patwaris* or their relations for instruction. At first, men came forward reluctantly in Muzaffarpur, but matters improved towards the end of June. At the Muzaffarpur school, 279 men were put through a course of instruction and 80 more were under training at the beginning of October. At Motihari, 180 men were trained for work in the Champaran district.

419. Mr. Pemberton deserves credit for his efficient conduct of the operations.

420. This detachment has now been merged into No. 4 Party, which, on completion of its work in the Western Duars, has been transferred to Bihar to carry out the cadastral survey, and the combined establishments will carry out

the following programme in the ensuing season, *viz.*, the traverse survey of 914 square miles in district Muzaffarpur and 2,000 square miles in districts Champaran and Saran, and the cadastral survey on the 16-inch scale, with the record of rights, of 1,000 square miles in districts Muzaffarpur and Champaran.*

GEODETIC.

LONGITUDE OPERATIONS.

NOS. 22 AND 23 PARTIES.

421. The services of two officers being available for astronomical work during the season under review, the operations for the electro-telegraphic determination of arcs of longitude were resumed. Those selected for measurement form part of the general scheme for extending a net-work of longitudinal arcs over the whole of India, and comprised the following arcs:—

Personnel.

No. 22 PARTY.

Captain S. G. Burrard, R. E., Deputy Superintendent, 2nd grade, in charge.
Aulad Hussein, Sub-Assistant Superintendent, 3rd grade.
Gobind Balwant Joshi, computer.

No. 23 PARTY.

Lieutenant G. P. Lenox-Conyngham, R. E., Assistant Superintendent, 1st grade, in charge.
Lal Singh and Hanuman Persad, computers.

1. Calcutta-Waltair.
2. Waltair-Jubbulpore.
3. Waltair-Bolarum.
4. Waltair-Madras.
5. Bolarum-Bombay.
6. Fyzabad-Dehra.

422. The programme was carried out in its entirety, and there is no special novelty to be noticed in the observations that were made. The apparatus has been now in use for so many years that the best methods of using it had become quite familiar to the observers, and no departure from the fixed procedure was deemed advisable. Constant vigilance to guard against the intrusion of minute errors is imperative, and due caution in this respect has been exercised. On the Waltair-Jubbulpore arc, owing to the faulty insulation along the coast and the great length of the telegraph line, which ran *viâ* Ranigunge and was nearly 1,100 miles long, no signals could be passed *directly*, and a translating station had consequently to be introduced at Cuttack. Translating stations have always been carefully avoided hitherto, for fear that they might affect the retardation of the current, and this is the first occasion in the history of Indian longitudes that direct communication has been unattainable. The introduction of a translating station on the Waltair-Jubbulpore arc has been found to almost double the time of retardation of the current, but there is no reason to suppose that the accuracy of the results is in any way vitiated thereby.

423. Great difficulty was experienced in former years in obtaining distinct reflection of the spider lines in the mercury trough at Calcutta owing to the extremely unstable nature of the soil ; a tremor sufficient to obliterate the reflected image of the wires would be set up on the surface of the mercury by the wheels of a passing carriage long before even the sound of the carriage could be heard, and a cough or sneeze would often render the image invisible for five or six seconds. This season the difficulty was overcome by the following expedient : a circular trough of copper, formed like a very shallow saucer, was prepared and its surface was amalgamed with mercury by means of sulphuric acid rubbed over it ; the effect of the *amalgam* was that the surface of the copper became "wetted," and vibrations of the ground were not communicated to the mercury. It was used with complete success, as distinct reflections were obtained when vehicles were passing within 100 yards, and when no reflection whatever was visible in the ordinary mercurial trough.

424. In several previous reports the existence of errors larger than seemed consistent with the great care expended on the work has been noticed.

* Mr. Pemberton reports as follows :—

"Mr. W. H. D. Ewing, Sub-Assistant Superintendent, has laboured zealously. Mr. H. B. Hanby, Sub-Assistant Superintendent, only joined the Department on the 25th November 1891. He has given close application and attention to his duties.

Of the native establishment the most deserving of commendation are Elahi Bux, English writer, Awaz Ali, Abdul Aziz I, Ramjas, Mauladad Khan, Gorumph Singh and Ram Lachun Lal."

In season 1889-90 it was unexpectedly discovered that the value of the collimation constant varied with the angle at which the collimators were inclined to the horizon during the process of determination. This discovery led to the introduction of a new method of deducing the collimation constant. During the recess, the re-computation of all former arcs has been carried out on this new method, and all the abnormally large circuit errors, which had attracted so much attention in the past, have been found to disappear. A detailed account of some experiments connected with this subject will be found in Captain Burrard's narrative report in the appendix. The result of these experiments was that the two collimators of each equipment were found to possess more or less imperfect object glasses; the object glass of telescope No. 2 was also proved to be by no means perfectly true, but no faultiness was discovered in that of telescope No. 1.

425. It fortunately happens that the two transit instruments were admirably designed and made, and that throughout their long career of seventeen years (with the exception of two seasons) they have exhibited no signs of weakness or unsteadiness. If they had been of inferior make, and if *real* variations in the collimation constant had been of frequent occurrence, as was at one time suspected, no remedy now would be forthcoming to correct the effects of the faultiness of the object glasses. If the telescope is shaky and the collimation constant unsteady, the old method of determination is necessary, though it has been shown to be incorrect if the object glasses are faulty. The new method of determining the collimation constant eradicates the evil effects arising from faulty object glasses, but is not applicable to a shaky telescope.

426. In speaking of the faultiness of object glasses, it must not be supposed that any want of care is to be attributed to the makers. The manufacture of object glasses is one of the most difficult known; very few turn out to be perfect in form and refractive properties, and a certain amount of chance is involved in the process. It is possible, though not very likely, that these object glasses may have deteriorated with age.

427. Extracts from the narrative reports of Captain Burrard and Lieutenant Lenox-Conyngham on the season's operations will be found in the appendix.

428. The scheme of longitude work in India proper having been now completed as far as at present contemplated, the simultaneous reduction of the whole network has been taken in hand, and computed during the current year, with very satisfactory results, which rank in point of accuracy with the best continental and American work.

429. Captain Burrard and Lieutenant Lenox-Conyngham both acknowledge the courtesy of Messrs. Chambers and Michie Smith, the astronomers in charge of the Bombay and Madras Observatories, and of the various Telegraph officials with whom their duties brought them in contact.

430. The parties during recess worked in the office of the Deputy Surveyor-General, Trigonometrical Branch, who reports very favourably on their efficiency during the year.*

TIDAL AND LEVELLING OPERATIONS.

No. 25 Party.

431. The charge of these operations has remained in the hands of Lieutenant-Colonel J. Hill, R.E., throughout the year. His staff has been strengthened by the addition to it of an Assistant Superintendent. Lieutenant C. C. D. Morice, R.E., joined the party in that capacity

Personnel.

Lieutenant-Colonel J. Hill, R.E., Superintendent, 2nd grade, in charge.
Lieutenant C. C. D. Morice, R.E., Assistant Superintendent, 2nd grade, from 11th November 1891.
Mr. G. Belcham, Extra Assistant Superintendent, 2nd grade.
" E. J. Connor " " " 3rd "
" J. Bond " " " 3rd "

Surveyors, etc.

Narsing Das, Dhondu Venayak, Venayak Narayan, 2 native mechanics, and 17 recorders and computers.

*Captain Burrard and Lieutenant Lenox-Conyngham report favourably of the work performed by their assistants. In No. 23 Party, Babu Hanuman Persad is stated to have proved himself an exper recorder.

on the 11th November, and Colonel Hill in his reports mentions him in very high terms.

TIDAL OPERATIONS.

432. The automatic recording of the tidal curves, their reduction, and the publication of the predicted times and heights of high and low water, have been continued, and tidal observations, by means of self-registering gauges, have been carried on during the year at fourteen stations, *viz.*, *Aden*, *Kurrachee*, Bhávnagar, *Apollo Bandar* (*Bombay*), Prince's Dock (Bombay), Cochin, Minicoy, Tuticorin, Trincomalee, *Kidderpore*, Akyab, *Rangoon*, Mergui and *Port Blair*. The eight 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 period of observations lasts for nineteen years, and where observations should be continued until the whole scheme of tidal operations has been completed. In addition to the automatic observations taken at the stations enumerated above, personal tidal observations to graduated staves were taken daily with the object of comparing the actual heights and times of high and low water with those predicted in the Tide Tables. This was done at the following tidal stations, at all of which the tidal observatories are closed, *viz.*, Cochin, Cocanada, Chittagong, Akyab, and Moulmein.

433. During the season under report no tidal observatory has been newly established, and two have been closed. The Cochin tidal observatory, after having been at work for six years, was closed on the 20th March, an extra year's observations being taken at this station in consequence of the interruption to the registrations mentioned at page XXXII of the appendix to the General Report for 1886-87. The Akyab tidal observatory was closed on the 23rd May on the completion of five years' observations.

434. Thus, since the resumption of systematic tidal operations in 1877, observations have been taken at 31 tidal observatories, of which 19 (including Madras) have been closed on the completion of their registrations and 12 are now in operation.

435. The Port Blair tidal observatory was destroyed during the cyclone of the 1st November, and details of the disaster are given by Colonel Hill in the appendix. The observatory was re-established and the self-registering tidal observations were resumed on the 30th January, and it is due to the prompt and energetic help given by Colonel Cadell, V.C., the Chief Commissioner of the Andamans, and his staff, that the interruption to the registrations did not extend beyond this period of three months.

436. It was reported last year that the commencement of tidal observations at the four following new minor stations had been sanctioned: Diamond Island (Burma), Muscat (Arabia), Bushire (Persia), and the island of Sálbet (Káthiáwár). Since then Port Albert Victor in Bhávnagar has been substituted for Sálbet as being better suited for the purpose; the site chosen is two miles north of the island of Sálbet. Work connected with the erection of the observatories is in progress at Diamond Island, Bushire, and Port Albert Victor. The work at Diamond Island has proved more difficult, tedious, and expensive than was anticipated. At Bushire, the masonry has been finished, under many difficulties, by Mr. R. H. New, to whom our thanks are due for his kind assistance. At Port Albert Victor, Mr. Proctor Sims, the Bhávnagar State Engineer, has been carrying out the masonry and other work of the tidal observatory, which, according to his plans, will be combined with a light-house. At Muscat, where no preliminary masonry construction is contemplated, the preparations are complete. It is expected that tidal observations will be commenced at all four stations during the ensuing field season. Mention must not be omitted of the great assistance received from Mr. W. W. Squire, the Engineer to the Bombay Port Trust, who had the necessary timber observatory houses, float cylinders, and other accessories for Muscat and Bushire made under his personal supervision and forwarded to their destinations, and who, in many other ways, has helped on the tidal work from time to time. It is to be hoped that tidal observations at Madras will be resumed eventually, but no decision on that point has as yet been arrived at by the Madras Government.

437. All the tidal observatories, without exception, have been inspected, and a detailed account of the working of each will be found in the appendix, where also certain circumstances requiring special notice are reported at Kurrachee, Bhávnagar, Prince's Dock, Bombay, Minicoy, Tuticorin, Cocanada, Moulmein, and Port Blair. If the loss of three months' observations at Port Blair, which is a matter of great regret, be excepted, the tidal operations of the year may be pronounced very successful—a result due to a great extent to the assistance received from local officials, whose kind co-operation has been acknowledged by Colonel Hill.

438. The reduction of the tidal observations has been carried on steadily during the year. Observations for one year at fourteen stations have been reduced, and 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 1893, and sent to Mr. Roberts, of the Nautical Almanac Office, ready for use; he was also furnished with tabulated comparisons for the year 1891 between the predicted times and heights of high and low water at 51 stations, published in the Tide Tables for that year, and their values obtained by actual measurement, thus giving him in a convenient form information adapted to assist him in improving subsequent predictions, especially at the principal riverain ports, Kidderpore, Rangoon, and Moulmein.

439. The Tide Tables for 1893 will contain predictions for 33 tidal stations, the new stations of Minicoy and Trincomalee having been added since the last issue.

440. The usual tables showing the results of the predictions are given, for the year 1891, in the appendix, and may be summarised as follows :—

Percentage of Time predictions within 15 minutes of actuals.

	High water, per cent.	Low water, per cent.
11 Open coast stations	76	75
4 Riverain stations	68	62

Percentage of Height predictions within 8 inches of actuals.

	High water, per cent.	Low water, per cent.
11 Open coast stations	94	87
4 Riverain stations	66	64

Percentage of Height predictions agreeing with actuals within one-tenth of mean range at springs.

	High water, per cent.	Low water, per cent.
11 Open coast stations	97	96
4 Riverain stations	92	88

These figures are very satisfactory, and show a high standard of accuracy in the predictions taken as a whole.

Spirit-levelling Operations.

441. The levelling operations of the last field season consisted of a continuous line of double levelling carried along the Great Indian Peninsula and Bengal-Nagpur Railways, comprising the following sections :—

Section from Malkhed (Great Indian Peninsula Railway) to Nagpur.
Section from Nagpur to Bilaspur.
Section from Bilaspur to Sakti.

The total out-turn-amounted to 452 miles of double-levelling, in the course of which the heights of 529 permanent bench-marks and 12 stations of the Great Trigonometrical Survey have been determined. This is a good and creditable out-turn, which would have afforded unmixed satisfaction had it not been accompanied by the loss of an old and valued member of the Department, Sub-Surveyor Narsing Das, who died in the field on the 5th April, and whose promotion to the junior division was under consideration at the time of his death. Every assistance was given to the levelling detachment by the Railway officials, for which Colonel Hill has expressed his obligations.

442. It is intended to postpone the extension of the levelling beyond Sakti on the Bengal-Nagpur Railway, and to employ the levelling detachment in Burma during next season on a double line of levelling from Rangoon to Mandalay, with branch lines to connect certain stations of the Eastern Frontier and Mandalay series of the Great Trigonometrical Survey.

This line, besides checking the trigonometrical heights, will furnish bench-marks for reference in irrigation and other projects of the Public Works Department, and test bench-marks for the Rangoon and Elephant Point tidal observatories ; the programme also includes a line of double-levelling between Rangoon and Elephant Point.

443. In addition to the regular departmental work of the tidal and levelling party, a considerable amount of extra work had to be undertaken in order to furnish other departments and Local Governments with information applied for by them, the particulars of which are given in the appendix.

444. The office of this party at Poona was inspected by the Officiating Surveyor-General in August 1892, who reports his satisfaction at the efficient state of the party and the out-turn of its work.*

GEOGRAPHICAL SURVEYS.

OPERATIONS IN UPPER BURMA.

NO. 11 PARTY.

445. At the commencement of the year under review, the charge of this party was held by Captain Renny-Tailyour, R.E., but on the return of Captain Jackson, R.E., from furlough on the 4th November 1891, that officer resumed charge and conducted the operations throughout the field season. On return to recess quarters in June 1892, he was invalided by a medical board and granted a year's sick leave, when Captain Renny-Tailyour resumed charge of the party. Colonel Woodthorpe, R.E., on his re-appointment to the Survey Department in July, was posted to the charge of the party, and held it during the remainder of the year. The strength of the party is shown in the margin.

Personnel.

Captain H. M. Jackson, R.E., Deputy Superintendent, 1st grade, in charge from 4th November 1891 up to 11th July 1892.
Captain T. F. B. Renny-Tailyour, R.E., in charge up to the 4th November 1891 and from the 4th June 1892 up to the 11th July 1892.
Colonel R. G. Woodthorpe, C.B., R.E., Officiating Superintendent, 2nd grade, in charge from 11th July 1892.
Mr. F. Kitchen, Extra Assistant Superintendent, 3rd grade.
„ J. Doran, Extra Assistant Superintendent, 4th grade.
„ R. F. Warwick, Sub-Assistant Superintendent, from 1st November 1891 up to 28th May 1892.

Surveyors and Sub-Surveyors.

Malimud Hosein, Mr. J. Sebastian, Ramsabad, Kudratullah, Abdul Rahim, Mowni Ram, Sita Ram and Nuruddin.

446. The party arrived on the 6th November 1891 at Pyinmana, which was made the headquarters for the field season. The operations were closed in May 1892, and the various members of the party reached Bangalore between the 19th May and 6th June, when the office opened for recess work.

447. The operations were similar in character to those carried on during the previous season, the methods employed being a mixture of plane-tabling, traversing and route-surveying, as circumstances permitted. The work lay in the districts of Pyinmana and Toungoo, the Bret country, Karenni, the Southern Shan States, and the independent State of Baw.

448. Captain Jackson generally supervised the field work of the party, carrying on the triangulation and doing a small portion of the topography. Mr. Kitchen with two surveyors worked in the Shan States east of the Kyaukse district ; Mr. Doran with two surveyors was employed in the Maingkaing State ; and Mr. Warwick and the other surveyors in the other tracts.

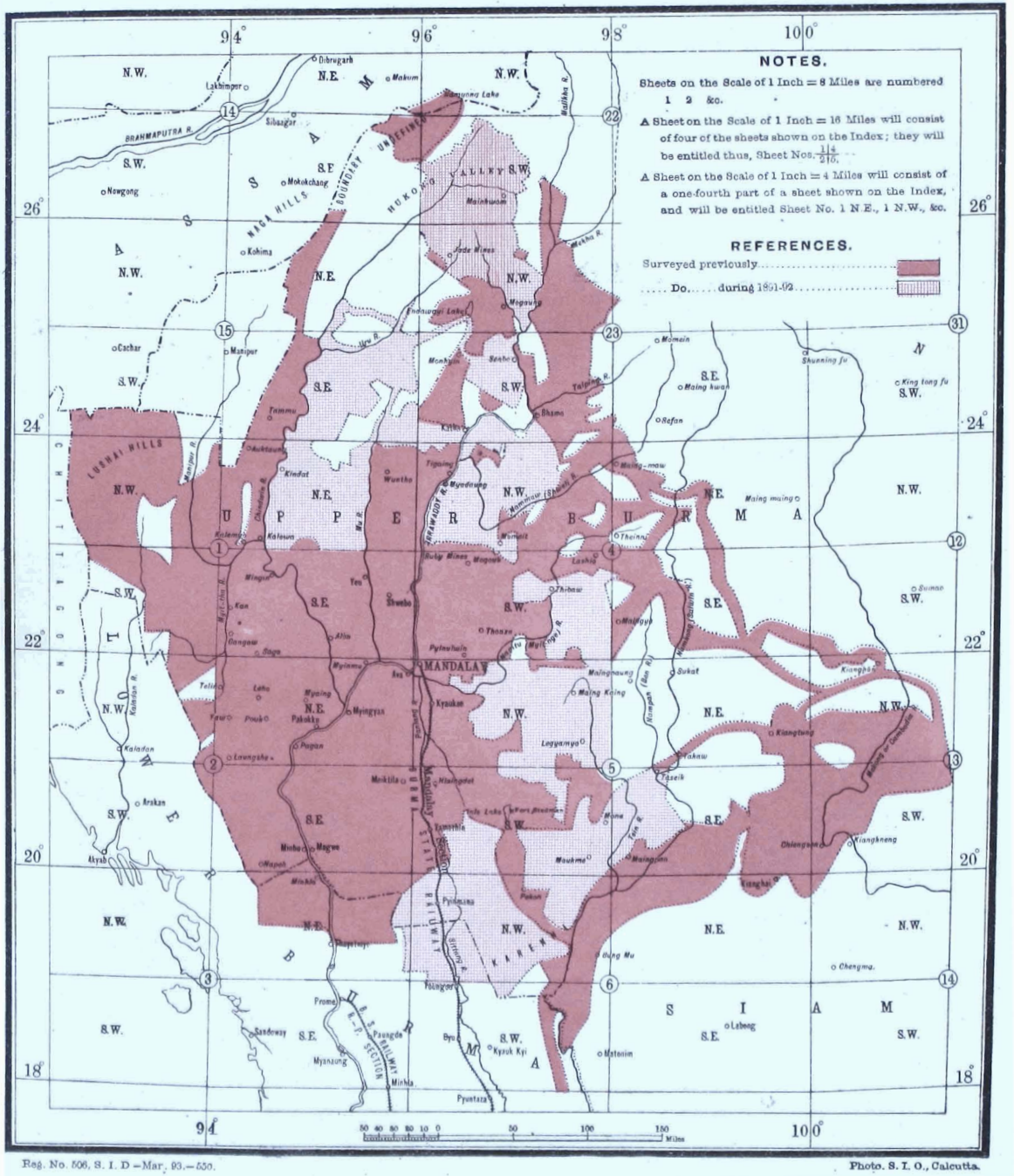
Messrs. Kitchen and Doran did some triangulation in addition to the plane-tabling ; and the work of the rest was confined to topography. A small portion of Karenni is left unfinished owing to the mutiny of the escort with the surveyor there. It is hoped that this gap will be filled in this season.

* Colonel Hill reports most favourably of Messrs. Belcham and Connor and Surveyor Dhondu Venayak 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 favourably noticed ; and the staff of native mechanics, surveyors, sub-surveyors, and computers are reported to have worked well and given satisfaction.

NORTH EASTERN & SOUTH EASTERN FRONTIER SURVEY.

INDEX TO THE GEOGRAPHICAL SURVEY IN UPPER BURMA.

Nos. 11 & 21 PARTIES.



Reg. No. 506, S. I. D.—Mar. 93.—550.

Photo. S. I. O., Calcutta.

449. The result of the season's operations is as follows :—

Triangulation	6,400 square miles.
Topography on ½-inch scale . . .	18,002 ,, ,,

450. The country surveyed is generally of a difficult nature. The forest-clad hills are wild and rugged or low and undulating, and the valleys covered, in many cases, with almost impenetrable grass. In parts, as in the Laihka State, which was once flourishing, fire, sword, and famine have desolated the country, which is quite deserted, and though the people are beginning to return, it will be long before the old order is restored. This desolation renders a surveyor's work very arduous, as the whole of the ground once under cultivation, when neglected, soon becomes covered with high elephant grass.

451. The health of the party was good on the whole, though Mr. Doran's men suffered somewhat on the road to his work. Messrs. Warwick and Sebastian suffered a good deal at times from fever ; and Captain Jackson returned, under Captain Renny-Tailyour's care, so ill that he had to be invalided home as soon as he was able to bear the journey.

452. During January, Captain Jackson visited a portion of the " Bret " country, which lies south-west of Karenni in the valley of the Tuchaung. He has submitted a short report on the country traversed and its inhabitants, which will be found in the appendix.

453. The programme for the next field season includes the deputation of surveyors to accompany the Burma-Siam Boundary Demarcation Commission and continuation of work in the Southern Shan States, as far as the means available will permit.

454. The recess office of the party at Bangalore remained, as heretofore, under the same roof as the office of No. 21 Party, an arrangement productive of much convenience to both, as their work is intimately connected and constant references are necessary. Both parties were inspected by the Officiating Surveyor-General in August 1892, who found them in a highly efficient state, and controlled in a manner that reflects credit on the executive officers who have held charge of them.*

NO. 21 PARTY.

455. The party, under the charge of Captain Longe, R.E., left recess quarters for the field on the 24th October 1891 and arrived at Mandalay on the 6th November. Captain Longe retained charge till 21st February 1892, when he was deputed to England to attend a course at the School of Military Engineering, Chatham, and made over charge to Captain Renny-Tailyour, R.E. This officer held it until the 19th July 1892, and was then relieved by Colonel Woodthorpe, who had been recently re-appointed to the Department, and who retained charge during the remainder of the recess season.

Personnel.

Captain F. B. Longe, R.E., Officiating Superintendent, 2nd grade, in charge up to 21st February 1892.
Captain T. F. B. Renny-Tailyour, R.E., Deputy Superintendent, 2nd grade, in charge from 22nd February up to 19th July 1892.
Colonel R. G. Woodthorpe, C.B., R.E., Officiating Superintendent, 1st grade, in charge from 19th July 1892.
Captain P. J. Gordon, S.C., Officiating Deputy Superintendent, 2nd grade.
Mr. W. C. G. Barckley, Sub-Assistant Superintendent, 1st grade.
„ J. M. Kennedy „ „ „
„ C. George „ „ „
„ W. F. E. Adams „ „ 3rd grade.

Surveyors and Sub-Surveyors.

Sher Shah, Ikbaluddin, Faida Ali, Ali Nawaz Khan, Mahomed Latif, Mahomed Alum, Mahomed Sayed, and Mahomed Nawaz Khan.

456. The operations were of the same character as in former years, *viz.*, geographical surveys and reconnaissances, on the scale of 1-inch = 4 miles, north of the parallel of 22° N. latitude.

457. The distribution of work for the season was arranged as follows :—

Captains Renny-Tailyour and Gordon to conduct triangulation from Wuntho to Kamaing *viâ* Katha and Mogaung.

Mr. Barckley to carry on triangulation in the Upper Chindwin district northwards from Kendat, and to supervise the work of Mr. Adams and three surveyors in that district.

* Captain Jackson, who held charge of the party during the field season, reports well of the work done by Messrs. Kitchen and Doran. Of the surveyors and sub-surveyors, he specially mentions Mahmud Hosein, Kudratullah, Abdul Rahim and Nuruddin.

Mr. Kennedy and one surveyor to accompany the column under Major Dalzell, which was to start from Bhamo on the 30th November 1891 to explore the Hukong valley.

,, George and three surveyors to work in the Katha district.

One surveyor was deputed to complete the survey of Yeu district, another to make a survey of the Thibaw State, and two others to be attached to Police columns in the Môngmit State and the Kyaukkwe valley.

458. The programme laid down was on the whole satisfactorily carried out, although the work was retarded to a certain extent by the ill-health of some members of the party, and by the unfavourable conditions of the weather during the latter months of the field season.

459. The total area surveyed amounts to 24,075 square miles on the $\frac{1}{4}$ inch scale, made up as follows:—

	Square miles.
Upper Chindwin district	5,000
Yeu district	1,900
Katha district	6,425
Bhamo district	4,350
Ruby Mines district	500
Northern Shan States	2,150
Hukong valley	3,750
TOTAL	24,075

460. The triangulation executed covered an area of 7,100 square miles, of which 2,500 square miles was in the Upper Chindwin district and 4,600 square miles in the Katha and Bhamo districts, and it was carried out under considerable difficulties owing to the forest-clad nature of the country. In the Katha and Bhamo districts the series was taken mainly along the proposed line of railway from Wuntho to Mogaung and thence to Kamaing.

461. Captain Renny-Tailyour was engaged on the latter triangulation during the first half of the field season, and was accompanied by Captain Gordon, who executed a plane-table reconnaissance of the route taken. On the completion of this work, Captain Renny-Tailyour returned to Mandalay to take charge of the party, and was subsequently engaged in arranging for the requirements of the several detachments and in inspecting the work of the members as far as circumstances permitted, while Captain Gordon was deputed to the Katha district to supervise the work which was being carried on between Katha and the Chindwin river. He visited and checked the work of Messrs. George and Adams and of three sub-surveyors, and rendered invaluable assistance in securing combined work.

462. After receiving orders to join the Maingkwan column, Mr. Kennedy with one sub-surveyor proceeded *viâ* Bhamo to Sinbo, taking observations on various points *en route*. He proceeded on the 15th December with a detachment to Mogaung and met the main body of the column on the 19th. From Mogaung the expedition took a north-westerly direction, reaching Laban on the Namkong river on the 30th December, where a halt was made, and opportunity was taken to make surveys of the neighbouring country. Here he was obliged to send back the sub-surveyor whose health had broken down. Laban was left on the 6th January, and the expedition proceeded across the watershed *viâ* Sadusot into the Hukong valley, and on to Maingkwan, which was reached on the 9th. Here Mr. Kennedy measured a base line and took observations for latitude, and also made various short excursions into the surrounding country and surveyed it as far as the Tanaika river. On the 14th January the column was joined by another under Mr. Needham, which had come from Assam: a traverse of the route taken by this column had been kept, and was incorporated by Mr. Kennedy with his work.

Expeditions were thence made to Lalaung, 'Ntup'nsa, Ningbyen and Saraw, the most important villages in the valley, and the column left Maingkwan on the 13th February in two detachments. Mr. Kennedy accompanied the one which proceeded along the Chindwin into the Taro valley and *viâ* the Jade mines back to Mogaung.

During the expedition Mr. Kennedy succeeded in reconnoitring 3,750 square miles of new country, having triangulated 600 square miles on his way up from Bhamo to Mogaung. After returning from the expedition he surveyed a further area of 1,000 square miles between Mogaung and the Irrawaddy. Extracts from Mr. Kennedy's report on the country traversed by the Maingkwan column will be found in the appendix.

463. The party left Mandalay for the recess on the 20th May 1892, and arrived at Bangalore on the 27th May. It was engaged during the recess season in the computations appertaining to the triangulation executed during the field season and in drawing fair maps. Seven new editions were completed, *viz.*, sheets Nos. 22 S.W., 23 N.W., 23 S.W. of the North-Eastern Frontier Series, and 4 N.W., 4 S.W., 15 S.E., and 1 N.E. of the South-Eastern Frontier Series.

A practical course of instruction for the apprentices and younger surveyors was carried out under Mr. Barckley.

464. The health of the party was not so good as usual, fever being very prevalent among its members. Two sub-surveyors had to be invalided—one in the middle of the field season and the other on return to recess quarters—while two others had to go to Mandalay for medical treatment during the field season. Three *khalásis* died of sickness, and one from accident during the season.

465. As already mentioned in paragraph 454, the recess office of the party was inspected by the officiating Surveyor-General, together with that of No. 11 Party, in the month of August, and was found to be in a high state of efficiency.

466. The ensuing field season will, in all probability, see the close of the first survey of Upper Burma, which has been carried out by these two parties, as there are now but few gaps left in the topography. A little also remains to be done for the triangulation, and that little is so laid out as to throw light upon some of the discrepancies incidental to a first and hurried survey of a country, and will render it possible to sift out to a great extent what is really reliable and worthy of permanent record from what is ephemeral, and only designed to meet the wants of a geographical survey.*

OPERATIONS WITH THE ISAZAI FIELD FORCE.

467. A small survey detachment accompanied the column under Sir William Lockhart, K.C.B., which operated against the Isazai tribes in the Indus Valley during the month of October 1892.

Personnel.

Captain R. A. Wahab, R.E., Deputy Superintendent, 1st grade, in charge.
Asghar Ali, sub-surveyor.
Duffadar Lall Singh, soldier-surveyor.

468. The survey party joined at Derband on the 28th September 1892. One surveyor, Duffadar Lall Singh, 19th Bengal Lancers, remained at Derband to revise the survey of the ground between Derband camp and that surveyed on the 2-inch scale during the last expedition, and Captain Wahab with the remainder of the party accompanied the force throughout its advance.

469. Owing to the short time the troops remained across the border, there was little opportunity for extending the survey; some valuable information was, however, gained during the few hours available at Baio, where it was found possible to sketch in, approximately, on the $\frac{1}{2}$-inch scale a considerable extent of country in the Chamla and Buner valleys covering an area of 250 square miles; and at the same time to survey on the 2-inch scale the ground in the neighbourhood of Baio and to fix the position of several of the Hasanzai and Chagarzai villages on the western side of the Baio-Duma range.

* Captain Renny-Tailyour reports on his assistants as follows:—

"Captain Gordon proved himself most capable and zealous in his work, and is now quite fitted for the charge of a party.

"It is creditable to Mr. Barckley that, in spite of much sickness among his men, his section brought in such a large out-turn of work, *viz.*, 5,300 square miles of detail survey and 2,500 square miles of triangulation.

"Mr. Kennedy as usual proved himself a first-rate reconnoitrer, and maintained his reputation for zeal and energy. His talents as a draftsman are well known.

"Mr. George is a neat worker, and his out-turn was on the whole satisfactory.

"Mr. Adams appeared to be diligent and painstaking, but the difficulties of the country, added to his want of experience, rendered his work of little value. The native surveyors are generally well reported on, the work of Sher Shah, Ikbaluddin, and Mahomed Latif being specially commended."

470. This survey shows that the Hasanzai territory south-west of the Baio hill extends further than was supposed; the whole spur on which Punar and Nask lie, down to Wano on the left bank of the Barandu river, being Hasanzai. The *nala* running due west from Baio past the village of Maliar appears to be the boundary between Hasanzai and Chagarzai lands, the latter extending up to the high spur from Duma which bounds the view to the north-west; beyond that, Buner territory commences, but as far as could be ascertained no Buner village lies within two miles in a direct line from Baio.

471. The general character of the country between Baio and Buner is similar to that of the hills along the Indus valley. High spurs from the Duma range descend steeply to the Barandu, the hill sides are generally bare and stony but with villages and terraced fields on the gentler slopes and occasional patches of pine forest. The Buner and Chamla valleys, as far as could be seen, are open, fertile plains with numerous large villages and orchards. Their elevation rises from about 2,000 feet above sea level at the junction of the two valleys near Chirorai, to some 3,000 at the head of the Chamla valley, and 4,000 or 5000 feet at the head of Buner. The former valley is about 18 miles in length, the latter about 30. The hills enclosing both valleys are well wooded.*

* Captain Wahab reports that both the native surveyors worked hard and well. Asghar Ali is a quick and accurate topographer. Duffadar Lall Singh is a hard-working and efficient surveyor and an excellent non-commissioned officer.

Summary of the out-turn of work of the Field Parties during the year 1891-92.

Scale of Survey.	Number of Party.	Locale of Field Operations.		TRIANGULATION. Instrument used.	Area triangulated in square miles.	Number of stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Secondary—in which each angle is usually observed on two zeros. Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	Tertiary—in which two angles of each triangle are observed. Number of intersected points fixed.	Number of triangles.	Error per mile in feet.	Number of heights.	SPIRIT-LEVELLING OPERATIONS. 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 benchmarks.	TRAVERSING. Number of stations at which theodolite was set up.	Linear miles.	Average angular error per *station* in seconds.	Average linear error per *mile*.	Square miles of village survey.	DETAIL 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.	Remarks.
32 inches=1 mile	Detacht. of 5	Garhwal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12,069	2,541	7	0·4	578	232	...	1,584	1,500	9,62,441	1·10 (*a*)	(*a*) Calculated on the cultivated portion only.
16 inches=1 mile	2	Chittagong	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13,603	1,360	6	0·4	297	675 (*b*)	...	1,179	434	22,91,185	0·14	(*b*) Includes 187 square miles of skeleton boundary work.
		Tippera	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5,225	860	14	...	150	...	...	...	851	...	...	
	3	Sagaing	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15,342	3,582	6	0·4	1,219	1,818	...	3,752	1,150	10,01,010	0·64 (*a*)	(*c*) 7,513 additional heights determined by clinometer.
		Shwebo	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	11,995	2,866	...	...	800	...	...	...	...	...	...	
	4	Jalpaiguri	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	666	72	1	3·6	5	23	...	47	92	5,797	2·31	
		Darrang	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	589	137	3	0·3	81	310	...	885	326	83,440	2·37	
		Lakhimpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,276	964	5	0·6	269	269	...	748	319	96,704	1·78	
	6	Kamrup	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	27	...	108	31	7,737	2·23	
		Sibsagar	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10	2,587	466	1	...	150	150	...	336	140	25,123	3·82	
		Sylhet	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8,259	1,267	5	0·7	347	72	...	70	77	14,816	3·11	
		Amherst	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7,427	1,553	6	0·5	423	550	...	1,135	382	4,80,099	0·38	
	7	Mergui	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7,369	976	4	0·5	187	150	...	813	157	65,427	0·49 (*a*)	
		Tavoy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10,575	1,715	3	0·3	408	310	...		342	2,84,573	0·42 (*a*)	
		Balasore	15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	13,938	2,903	2	0·3	588	...	...	...	...	...	...	
	8	Cuttack	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	33,519	5,901	2	0·2	1,252	1,095	...	5,337	2,233	19,22,884	0·36	
		Puri	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,905	756	0·5	0·2	167	307	...		612	4,51,111	0·43	
		Balaghat	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17,140	2,574	5		1,215	...	...	...	399	...	...	
	9	Bhandara	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14,005	2,648	5	0·2	922	...	...	...	418	...	...	
		Mandla	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20	29,465	4,597	5		2,174	...	...	...	876	...	...	
		Minbu	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	27,647	4,086	6	0·4	1,288	784	...	1,761	392	5,54,911	0·63 (*a*)	
	12	Magwe	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,138	568	4	0·4	156	...	...	...	...	...	...	
	17	Bombay (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	40	149	40	...	...	...	
	Detacht.	Burdwan	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	175	34	...	...	7	2	...	22	3	5,656	0·22	
		Bankura	25	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25	...	...	...	...	...	11	...		44	40,347	0·18	
	Do.	Muzaffarpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	24,537	3,988	3	0·4	1,247	...	...	...	2,144	...	...	
		Champaran	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5,302	1,227	5	0·1	363	...	...	...	238	...	...	
8 inches=1 mile	4	Jalpaiguri	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17	86	...	...	...	...	
	10	Kolhapur City	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	...	...	...	...	...	
	17	Bombay (Forest)	30	7″	458	227	2	2	256	600	14	0·5	256	469	911	0·5	469	...	...	...	30	...	...	11	0·9	...	202	197	170	...	...	...	
6 inches=1 mile	15	Baluchistan	...	6″	18	4	0·7	0·8	4	9	22	1·7	4	22	38	1·4	80	...	...	...	...	...	...	...	...	...	15	31	10	...	...	...	
4 inches=1 mile	4	Jalpaiguri (Forest)	...	...	684	93	0·9	0·9	85	146	20	0·6	86	584	969	0·7	584 (*c*)	...	...	...	...	...	...	...	...	...	327	81	...	...	...	...	
		Bhutan Boundary	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76	...	...	...	25	...	...	...	...	...	
	14	Hoshangabad (Forest)	...	6″	150	29	3·7	3·7	29	64	13	0·8	29	5	5	...	4	...	...	...	...	3,856	574	9	2·5	...	483	92	219	...	...	...	
	17	Bombay (Forest)	35	7″	540	118	0·2	0·2	114	309	13	0·3	114	511	782	0·5	193	35	...	...	...	2,556	258	5	0·7	...	195	108	75	...	...	...	
	18	Himalayas	...	7″	1,196	152	2·6	...	140	242	18	0·5	140	344	473	0·9	339	...	...	...	...	...	...	...	...	...	290	55	37	...	...	...	
	19	Madras (Forest)	...	5″ & 6″	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,605	253	17	2·0	...	659	33	(*d*)	...	...	...	
	20	Lower Burma (Forest)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10,521	477	3	6·8	...	226	141	78	...	...	...	
	Detacht.	Bankura	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17,931	2,706	...	...	614	...	...	...	...	...	...	
2 inches=1 mile	2	Chittagong	40	...	...	...	...	...	...	...	...	...	...	...	...	...	...	40	...	...	...	...	...	...	...	...	194	...	...	...	...	...	
	4	Jalpaiguri	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	229	21	2	0·2	22	337	34	...	...	...	...	
	6	Brahmaputra islands, etc.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	23	...	...	...	...	...	
	7	Amherst	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	106	...	...	...	...	...	
		Gujarat	...	10″	300	26	...	...	26	56	5	0·4	21	131	222	1	48	...	...	...	...	...	...	...	...	...	841	20	149	...	...	...	
	10	South Maratha country	45	8″	1,810	82	...	...	82	150	8	0·4	82	218	480	0·5	218	45	...	...	...	2,047	672	7	...	...	1,680	9	136	...	...	...	
	15	Baluchistan	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	26	5	...	...	...	...	
	18	Himalayas	...	7″	617	83	0·1	0·1	73	339	11	0·5	35	611	1,027	0·5	341	...	...	...	...	...	...	...	...	...	239	30	10	...	...	...	
	20	Lower Burma	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,507	159	5	6·8	...	68	57	12	...	...	...	
1 inch=1 mile	3	Upper Chindwin	...	7″	106	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	106	3	...	...	...	...	
	Detacht.	Mergui	50	6″	320	21	...	...	9	13	20	1·5	9	2	4	3	8	50	...	...	...	318	31	...	...	...	765	7	...	...	...	...	
½ inch=1 mile	15	Baluchistan	...	6″	4,900	29	95	178	27		20	0·8	24	73	103	1·8	60	...	...	...	...	...	...	...	...	...	603	2	(*d*)	...	...	...	
	Detacht.	Aden	...	6″	7,000	19	67	60	17	41	17	0·3	17	87	164	0·7	60	...	...	...	...	...	...	...	...	...	,426	0·25	...	...	...	...	
	Do.	Hazara border	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	250	...	...	...	...	...	
¼ inch=1 mile	11	Upper Burma	...	6″	6,400	33	...	...	15	40	36	2	4	56	101	3	24	...	...	...	...	...	...	...	...	...	18,002	...	85	...	...	...	
	15	Baluchistan	55	6″	7,500	10	170	178	14	24	4	0·02	14	30	45	0·04	20	55	...	...	...	...	...	...	...	...	19,084	0·16	(*d*)	...	...	...	
	21	Upper Burma	...	6″	6,500	33	45	50	...	...	...	...	...	113	227	0·7	151	...	...	...	...	...	...	...	...	...	24,076	...	...	...	...	...	
	24	Upper Burma	...	12″ (new)	4,300	14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Trigonometrical operations only.
	25	Bombay and Central Provinces	58	...	...	...	...	...	...	...	...	...	...	...	...	...	...	58	452	48	12	481	...	...	...	...	...	...	...	...	...	...	...	
		Total	...	...	42,799	972	...	...	891	2,087	...	...	835	3,256	5,571	...	2,499		452	48	12	481	3,18,139	53,106	...	...	14,929	80,101	...	18,776	12,661	82,93,281	...	

Statement showing the cost-rates of work executed by the several Field Parties during the year 1891-92.

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 and preparation of maps on scales of								Scale 16″ = 1 mile.		Stone embedding.	Records (*Khanapuri.*)		Compilation of vernacular records, assessment statistics, etc.			
				½″	1″	2″	4″	6″	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	...	...	...	...	23·1	...	...	...	92·5(*a*)	...	...	...	...	...	...	...	...	21,768	(*a*) Skeleton boundary survey.
3	Upper Chindwin	...	...	...	56·4	...	...	...	...	...	...	...	...	...	...	...	...	...	5,982	(*b*) Includes ₹4,349 expended on 2-inch mapping of cadastral survey.
4	Jalpaiguri	...	...	...	...	67·9	...	...	139·8	...	...	...	...	...	...	...	...	...	29,615(*b*)	
6	Brahmaputra islands, etc.	...	...	...	...	13·7	...	...	...	...	...	...	...	...	...	...	...	...	323	(*c*) Includes ₹11,734 expended on Gujarat survey general degree reports and ₹4,824 on instruction of apprentices.
7	Amherst	...	...	...	...	45·3	...	...	...	...	...	...	...	...	...	...	...	...	4,804	
10	Belgaum	4·7	9·3	...	...	15·0	...	...	100·3	...	...	...	...	...	...	...	...	...	79,791(*c*)	(*d*) Includes ₹65,897 expended on the ½-inch geographical survey of 19,084 square miles.
	Gujarat	14·2	...	...	...	23·8	...	...	...	...	...	...	...	...	...	...	...	...	108,935(*d*)	
15	Baluchistan	2·8	...	40·1	...	100·0	...	151·0	...	...	...	...	...	...	...	...	...	...	72,430(*e*)	(*e*) Includes ₹201 expended on trans-frontier surveys, ₹1,678 on instruction of soldier-surveyors, ₹2,220 on survey schools, ₹2,078 on revisionary survey, and ₹19,867 on arrears of mapping.
18	Himalayas	7·3	...	...	...	...	99·1	...	...	...	...	...	...	...	...	...	...	...	54,868(*f*)	(*f*) Includes cost of surveying 81 tin mines on 8-inch scale.
		13·5	...	...	...	50·8	...	...	...	...	...	...	...	...	...	...	...	...		
Det.	Mergui	...	...	...	71·7	...	...	...	...	...	...	...	...	...	...	...	...	...	34,577	(*g*) Includes ₹4,831 expended on classification of forests and soils of 483 square miles.
Det.	Aden	1·5	...	5·2	...	...	...	...	...	...	...	...	...	...	...	...	...	...		(*h*) Includes ₹1,391 expended on work of Dakhin Shahbazpur and Serail Survey.
	Forest Surveys.																			(*i*) Includes ₹4,120 expended on demarcation and ₹1,560 on instruction in surveying.
4	Jalpaiguri	...	...	...	...	...	129·1	...	...	...	...	...	...	...	...	...	...	...	42,284	(*j*) Includes cost of demarcation.
14	Hoshangabad	21·1	22·5	...	...	...	118·8	...	...	...	...	...	...	...	...	...	...	...	87,152(*g*)	(*k*) Includes cost of completing a portion of records of 1890-91.
17	Bombay — Northern Circle	5·8	26·5	...	...	...	...	...	145·3	...	...	...	...	...	...	...	...	...	69,326	(*l*) The cost-rate, ₹313·8, under the head detail survey, includes both cost of cadastral survey and *khanapuri*.
	Bombay — Southern Circle	22·1	18·7	...	...	...	85·4	...	...	187·4	...	...	...	...	...	...	...	...		
19	Madras	20·1		...	...	...	77·3	...	...	..	...	...	...	...	...	...	...	...	72,706	(*m*) Includes ₹4,287 expended on Rampur survey and ₹607 on 2-inch mapping of districts Jhansi and Tarai.
20	Lower Burma	35·2	150·6	...	...	66·2	175·3	...	...	...	...	...	...	...	...	...	...	...	111,124	(*n*) Includes ₹583 expended on demarcation, ₹2,140 on instruction of *mandals* ₹1,209 on revision surveys, and ₹2,921 on 2-inch mapping.
	Cadastral Surveys.																			(*o*) Includes ₹575 expended on demarcation, and ₹447 on 2-inch mapping.
2	Chittagong	...	84·8	...	...	..	...	..	..	170·8	...	6 9	0 11	12·9(*j*)	...	...	...	...	114,177(*h*)	(*p*) Includes ₹6,052 expended on demarcation, ₹1,550 on revision work, and ₹3,167 on 2-inch mapping.
	Tippera	...	59·3	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	14,575(*i*)	
3	Sagaing	...	30·8	...	...	...	...	..	...	100·2	...	3 3	3 9	3·7(*j*)	...	...	2·9	0 1	256,898	(*q*) Includes ₹23,635 expended on revision of irrigation survey of 1878-79, ₹26,821 on revision work of 1890-91, ₹1,992 on 2-inch mapping, ₹5,219 on Rampur and Jhansi mapping, and ₹1,068 on Cuttack city survey on 64-inch scale.
	Shwebo	...	30·5	...	...	...	...	...	...	...	...	...	...	3·5(*j*)	...	...	...	...		
Det. of 5	Garhwal	...	30·2	...	...	...	...	...	...	...	313·8	8 7(*k*)	1 3(*k*)	...	(*l*)	...	...	...	95,104(*m*)	(*r*) Includes ₹2,002 expended on revision survey in district Prome and ₹8,627 on completing the traverse records of previous season of Lower Burma.
6	Kamrup, Sibsagar, Darrang, and Lakhimpur	...	31·0	...	...	...	...	...	...	53·1	...	2 1	4 10	...	...	...	24·5	1 4	81,402(*n*)	
	Sylhet	...	32·4	...	...	...	...	...	...	39·9	...	1 10	5 7	...	...	...	25·5	2 9	16,973(*o*)	(*s*) Includes ₹970 expended on cadastral maps of previous season and ₹1,745 on copying *thak* maps.
7	Amherst	...	42·5	...	...	...	...	...	...	118·6	...	4 0	1 6	...	...	...	...	...		
	Mergui	...	119·6	...	...	...	...	...	...	137·2	...	6 5	3 2	...	...	...	...	...	212,809(*p*)	
	Tavoy	...	81·7	...	...	...	...	...	...		...	5 6	2 4	...	...	...	...	...		
8	Balasore	...	17·7	...	...	...	...	...	...	...	...	...	...	6·5	...	...	...	...		
	Cuttack	...	32·3	...	...	...	...	...	...	88·8	...	3 1	1 1	5·9	35·8	0 4	0·9	...	303,208(*q*)	
	Puri	...	51·4	..	...	...	...	...	...	109·8	...	4 0	1 9	7·0	30·0	0 4	0·7	...		
12	Magwe	...	49·9	...	...	...	...	...	...	...	...	...	...	4·2	...	...	...	...		
	Minbu	...	53·9	...	...	...	...	...	...	152·4	...	5 2	3 3	3·9	...	...	4·4	0 1	216,426(*r*)	
Det.	Burdwan and Bankura	...	52·8	...	...	...	...	...	...	191·0	...	6 0	1 1	10·3(*j*)	97·8	0 5	16·9	0 1	45,954(*s*)	
	Traverse Surveys.																			
9	Mandla, Bhandara, and Balaghat	...	15·7	...	...	...	...	...	...	...	...	...	...	2·2	...	...	...	...	77,133	
Det.	Bihar	...	24·3	...	...	...	...	...	...	...	...	...	...	10·4(*j*)	...	...	...	...	55,891	

Particulars of Cadastral Surveys completed since 1890-91.

Districts.	Scale of survey.	Number of villages.	Area surveyed in square miles.	Number of fields in acres.	Average size of fields.	Cost, exclusive of demarcation and charge for instruments.	Rate per square mile.			By whom and when surveyed.
							Traverse survey.	Cadastral survey.	Cadastral survey with record of rights.	
	Mile.					₹	₹ a. p.	₹ a. p.	₹ a. p.	
Burma.										
Kyaukse	16″=1	484	550	509,857	0·69	178,309	85 2 11	227 6 4	...	Mr. G. B. Scott, during 1889-90.
Mandalay	,,	183	584	424,247	0·88	115,250	56 5 5	143 3 6	...	Mr. G. B. Scott, during 1889-91.
Meiktila	,,	642	563	376,925	0·96	107,895	43 8 2	147 4 5	...	Mr. G. B. Scott, during 1890-91.
Sagaing	,,	1,184	1,818	1,001,010	1·16	256,222	35 8 5	103 2 7	...	Mr. G. B. Scott, during 1890-92.
Bengal.										
Jalpaiguri	,,	1,734	782	730,909	0·68	369,801	65 8 4	...	392 11 2	Lieut.-Colonel S. H. Cowan, Colonel W. H. Wilkins, Captain G. B. Hodgson, and Mr. H. T. Hanby, during 1888-92.

PART III.

THE OPERATIONS AT THE HEAD-QUARTERS OFFICES.

472. 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.

Superintendence.

Colonel H. R. Thuillier, R.E., Surveyor-General of India.
Colonel G. Strahan, R.E., Officiating Surveyor-General of India, from 2nd August 1892.
Lieutenant-Colonel C. Strahan, R.E., Deputy Surveyor-General in charge Revenue Branch.
Lieutenant-Colonel J. E. Sandeman, S.C., Director of Bengal Surveys, from 1st April 1892.
Lieutenant-Colonel M. W. Rogers, R.E., Assistant Surveyor-General, up to 4th May and from 24th June 1892.
Colonel W. H. Wilkins, S.C., Officiating Assistant Surveyor-General, from 5th May up to 23rd June 1892.
Captain W. J. Bythell, R.E., Deputy Superintendent, 2nd grade, Personal Assistant to the Surveyor-General, up to 30th June 1892.
Mr. T. W. Babonau, Registrar.

Correspondence.

Mr. M. Francis, Head Clerk, up to 18th April 1892.
„ J. F. Burbridge, Head Clerk.
„ J. A. Vallis, Clerk.
Babu Kali Podo Banerji, Clerk.
„ Bani Madhub Banerji, „
„ Durga Narain Ghose, „
„ Ram Kisto Chunder, „
„ Chuni Lal Dey, „
„ Gopal Chander Dass, „
Mr. E. Bonnaud, „
Babu Kali Kristo Chunder, „ and 8 others.

Accounts.

Mr. C. O. Gray, Head Accountant.
„ T. E. Ware, Accountant.
Babu Bama Churn Chuckerbutty, Accountant, to 30th August 1892.
„ Raj Krishna Mukerji, Accountant.
Mr. E. D'Cruz, Accountant, from 1st September 1892.
Babu Hem Nath Dutt, Accountant, and 5 others.

473. The general direction of these offices remained in the hands of Colonel H. R. Thuillier, R.E., except during his absence on privilege leave from the 2nd August 1892 till the close of the year, during which period Colonel G. Strahan, R.E., officiated as Surveyor-General in addition to his other duties. The Revenue Branch section continued under the superintendence of Lieutenant-Colonel C. Strahan, R.E., during the year, and the General and Topographical Branch sections under that of Lieutenant-Colonel M. W. Rogers, R.E., and Colonel W. H. Wilkins at different times. Captain W. J. Bythell, R.E., held the office of Personal Assistant to the Surveyor-General.

474. On the 1st April 1892, the appointment of Director of Bengal Surveys was created, and Lieutenant-Colonel J. E. Sandeman, S.C., was appointed thereto. The administration of the several parties working in the Bengal Presidency was transferred from the Deputy Surveyor-General in charge of the Revenue Branch to the Director of Surveys in Bengal. Colonel Sandeman, however, obtained six months' leave from the 18th April 1892, and his duties during the period of his absence were performed by Lieutenant-Colonel C. Strahan in addition to his other duties.*

* The Assistant Surveyor-General reports as follows: —

Mr. T. W. Babonau, the Registrar, has superintended the office in a very satisfactory manner. Messrs. Francis, Gray and Vallis have given satisfaction in the performance of their duties. The clerks have also worked well, and the following are deserving of special mention: — Babus Bani Madhub Banerji, Chuni Lal Dey, Raj Krishna Mukerji, Kanti Chunder Sen, and Mohendro Chunder Aich.

The Deputy Surveyor-General reports that in the Revenue Branch Office, Mr. J. F. Burbridge continued to give satisfaction in the discharge of his duties; that Babus Kalipodo Banerji, Ram Kristo Chunder and Norendra Nath Mukerji are hard working and efficient, while Mr. E. Bonnaud is an intelligent and very steady assistant.

DRAWING OFFICE.

475. The Drawing Office remained in the charge of Colonel W. H. Wilkins, S.C., up to the 4th May 1892, when, on his assuming temporary charge of the Surveyor-General's Office from Lieutenant-Colonel M. W. Rogers, R.E., proceeding on leave, he made over the superintendence of the drawing office to Colonel J. R. Wilmer. On the return of Lieutenant-Colonel Rogers from privilege leave on the 24th June 1892, Colonel Wilkins again assumed charge of the office, which he retained for the rest of the year.

Personnel.

Colonel W. H. Wilkins, S.C., Assistant Surveyor-General, in charge up to 4th May and from 24th June to 30th September 1892.
Colonel J. R. Wilmer, S.C., Superintendent, 2nd grade, from 5th May to 23rd June 1892.
Mr. G. A. McGill, Chief Draftsman, up to 4th January 1892.
Mr. S. M. Smylie, Chief Draftsman, from 5th January 1892, and Head Draftsman up to 4th January 1892.
Mr. A. G. Wyatt, Officiating Head Draftsman, from 5th January to 29th July 1892.
Mr. Lovell Pocock, Head Draftsman, from 30th July 1892.
Mr. G. D. Cusson, Draftsman.
„ W. Green, „
„ A. J. Musgrove, „
„ J. R. Adels, „
„ R. C. Sinclair, „
„ A. S. Bateman, „
„ A. J. Rodrigues, „
„ E. Dowling, „
„ E. Andrews. „

Native Draftsmen.

Babu Harihur Sen,
„ Mohesh Chandra Shaw,
Munshi Muttiullah,
Babu Purna Chandra Sen,
„ Gopal Chandra Roy,
„ Tincowry Sen, and 38 others.

Additional Establishment.

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

Extra Assistant Superintendents and Sub-Assistant Superintendents on duty.

Mr. H. E. T. Keelan, Extra Assistant Superintendent, 1st grade.
Mr. A. J. Wilson, Extra Assistant Superintendent, 1st grade, from 1st December 1891 to 7th May 1892.
Mr. A. G. Wyatt, Extra Assistant Superintendent, 2nd grade, up to 4th January 1892, and from 30th July 1892.
Mr. W. C. Price, Extra Assistant Superintendent, 2nd grade.
Mr. G. Campbell, Extra Assistant Superintendent, 4th grade, to 6th November 1891, and from 24th June to 23rd September 1892.
Mr. P. White, Sub-Assistant Superintendent, 1st grade, to 3rd March 1892.
Mr. E. J. Martin, Sub-Assistant Superintendent, 1st grade.
Mr. C. W. Seyers, Sub-Assistant Superintencent, 1st grade.
Mr. W. H. D. Ewing, Sub-Assistant Superintendent, 1st grade, to 19th November 1891.
Mr. O. C. Ollenbach, Sub-Assistant Superintendent, 3rd grade, from 23rd November 1891.

476. In January, Mr. G. A. McGill, the Chief Draftsman, who had been in indifferent health for many months, died. He had served for 36 years in the department and for the last seven years had held the post of Chief Draftsman. Throughout his service, Mr. McGill has borne a high character and has always carried out the duties entrusted to him with satisfaction to his superiors. Mr. S. M. Smylie was then appointed Chief Draftsman, and Mr. Wyatt to officiate as Head Draftsman until the arrival of Mr. L. Pocock from the Dehra Office on 30th July 1892, when the latter officer was appointed permanently to this post.

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 is given in the appendix.

SECTION I.—GEOGRAPHICAL DRAWING AND COMPILATION.

477. The maps of Burma on various scales have again formed the principal work of this section. Three sheets, on the 8-mile scale, Nos. 2, 4 and 6 of the South-East Frontier series, have been compiled and completed, from the latest edition of the $\frac{1}{4}$-inch scale maps, while sheets No. 1, 4th edition, No. 3, 2nd edition, Nos. 5 and 23 of the North-East Frontier series, are in progress. The preparation of these maps has again thrown a great deal of labour on this section, as the supply of fresh materials, received annually from the officers of the Survey and Quarter Master General's Department, necessitates the compilation of new editions.

478. It was stated in last year's annual report that the 2nd edition of the map of Burma and adjacent countries, on the scale of 1 inch = 32 miles, was completed. The publication was held in abeyance until the divisional and other boundaries could be received from the authorities in Burma with a view to their being inserted on the map. Advantage was taken of this unavoidable delay to bring the map up to date by the insertion of fresh material. Eventually, as there seemed no hope of receiving these boundaries, and as the map was much wanted, a preliminary edition was published.

479. The compilation of the map of Upper Burma, on the scale of 1 inch= 16 miles, commenced in 1891, is very nearly completed. It comprises the country between the parallels of 18° and 28° North latitude and the meridians of 92° and 101° East longitude, and it is expected that the map will be published by June 1893. This map is an entirely new compilation; so many changes having been made in the orthography of village names, and so much new topography having been supplied, it was considered preferable to compile a new map than to attempt to alter the old one, which had already borne the changes of five editions; moreover, the new map will show considerable additional country, as it embraces the country from the Koladyne river on the west to the Mekong (Cambodia) river on the east.

480. It was stated in last year's annual report that the 3rd edition of the 32-mile map of India was expected to be published by June 1892. The drawings have all been completed, but the publication has been delayed in consequence of the want of orders from the Government regarding the frontier boundaries that are to be inserted, and these are still awaited.

481. The skeleton railway map, on the 64-mile scale, which was prepared last year for the Director General of Railways, showing the names of all railway stations throughout India and Burma, has been corrected up to June 1892. After a few additions have been made it will be sent to press. This edition will shortly be published and will prove useful to the general public.

The railway map of India, on the scale of 1 inch = 48 miles, has been brought up to date, to be adopted in lieu of the 32-mile railway map of India, which is held in abeyance until the 3rd edition of the map of India on that scale is completed.

482. The Postal maps of the Province of Bengal and of the Eastern Bengal Circle, on the scale of 1 inch=4 and 8 miles, were prepared for the Post Master General and Deputy Post Master General, respectively.

483. The new compilation of the 16-mile provincial map of Bengal, Behar, Orissa, and Chota Nagpur, which has been in hand for some years, has been brought up to date and completed. This will be a most useful map for the general public.

484. The preparation of the maps for the new editions of Aitchison's Treaties, required by the Foreign Department, has continued during the year. Fourteen maps are completed and three are in progress, which will soon be sent to press.

485. The maps of the reconnaissance surveys in Somali land, on various scales, done by Captain Swayne, R.E., the preparation of which for reproduction was undertaken at the request of the Foreign Department, have been finally completed. There are in all seven maps, and it has taken a considerable time to prepare them.

486. The preparation of maps for other departments during the year has not decreased and still employs a large proportion of the staff. In last year's report it was intimated that the Government of India would be addressed on the subject of sanctioning a larger establishment, to be entertained with a view of meeting these yearly increasing demands. It is a matter of great satisfaction to be able to state that sanction has now been given for an increase of sixteen draftsmen to the existing staff. By a new system of dividing the native draftsmen of the Drawing Office into two divisions,—the senior beginning on a salary of R25 rising to R125, and the junior beginning on a salary of R10 rising to R50, in which recruitments will be separately made,—it is now possible to obtain a better class of men who are likely to become efficient for the higher class of work required, and who could not be attracted by the former low initial salaries. Already four pupils who have been trained in the Calcutta School of Arts have been entertained on probation in the senior section, and it is expected that in the course of two or three years the full establishment will be efficiently trained. The Superintendent of the School of Arts has been kind enough to promise to introduce the style of drawing required for the Survey Department into the curriculum of his school.

SECTION II.—REVENUE.

487. The ordinary work of this section consists in examining and preparing for photo-zincography the fair maps received from the field parties of the

Revenue Branch, in bringing up to date and re-publishing old maps, and in supplying data. This regular work has included the completion up to margin, from the latest survey materials, of several of the 1-inch scale standard maps of district Karnal in the Punjab, and of districts Bijnor, Moradabad, and the late district of Kumaun (now divided into the two districts of Naini Tal and Almora), in the North-Western Provinces. The old maps of district Lakhimpur, in the Province of Assam, have been compiled according to graticule in 1-inch standard sheets; and also two sheets of district Kamrup from the old 1-inch maps of the district for second editions. The map of British Sikkim, by Captain Harman, has been re-typed and the boundaries re-drawn for reduction, and incorporated with the old standard sheets of district Darjeeling for a second edition.

The 6-inch map of the city of Calcutta has been revised and sent to press for a third edition, and a 3 inch map of the same city, which was in progress during last year, has been completed and published.

488. Besides the regular work, a considerable amount of mapping has been done by this section for other departments. A map of Delhi and its environs, as existing before the mutiny, showing the British position during the siege of 1857, a map of Badli Sarai and a sketch map to illustrate the marches of the Delhi field forces in 1857, were prepared for the Military Department of the Government of India.

For the North-Western Provinces Government, the $\frac{1}{2}$-inch district map of Basti has been published, and that of Gorakhpur will shortly be sent to press; the maps of districts Mirzapur and Garhwal on the same scale are in progress.

489. The small computing establishment attached to this section has as usual been engaged on a great amount of miscellaneous work for other departments. Notwithstanding this, the arrears in the examination of the traverse records of the field parties have somewhat lessened; those of the three districts of Hoshangabad, Damoh and Jhansi, each embracing the operations of two field seasons, having been examined, although the assistance expected from the field parties has not been available, as no computers therefrom could be spared. The main reason for these arrears, a large quantity of which still remain to be examined, is due to the large amount of traverse surveys that have been done during the past few years to furnish a basis for settlement surveys. It is, however, confidently expected that help may be obtained from one or other of the field parties during the recess months and the arrears considerably decreased during the next two years.

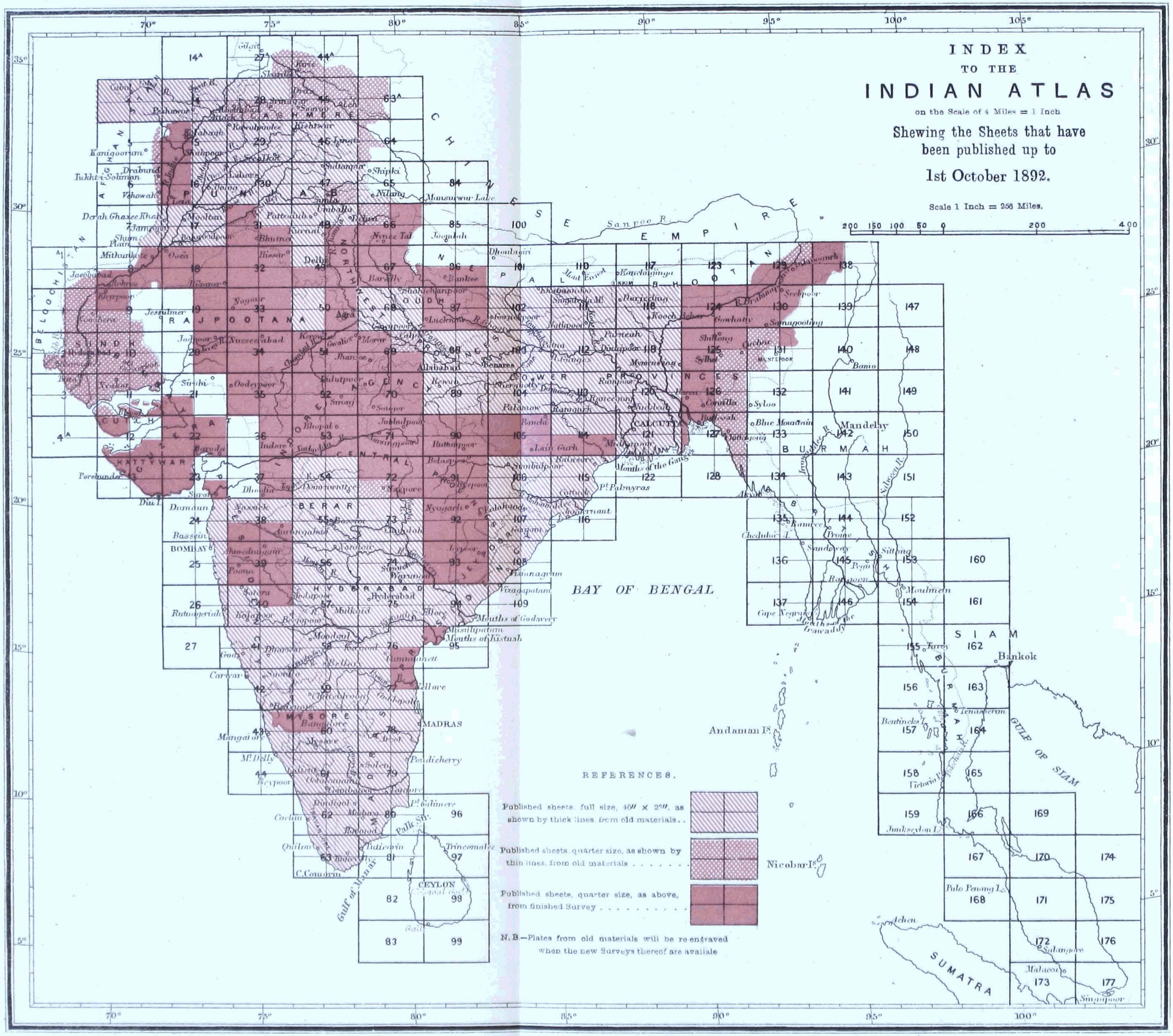
SECTION III.—CADASTRAL.

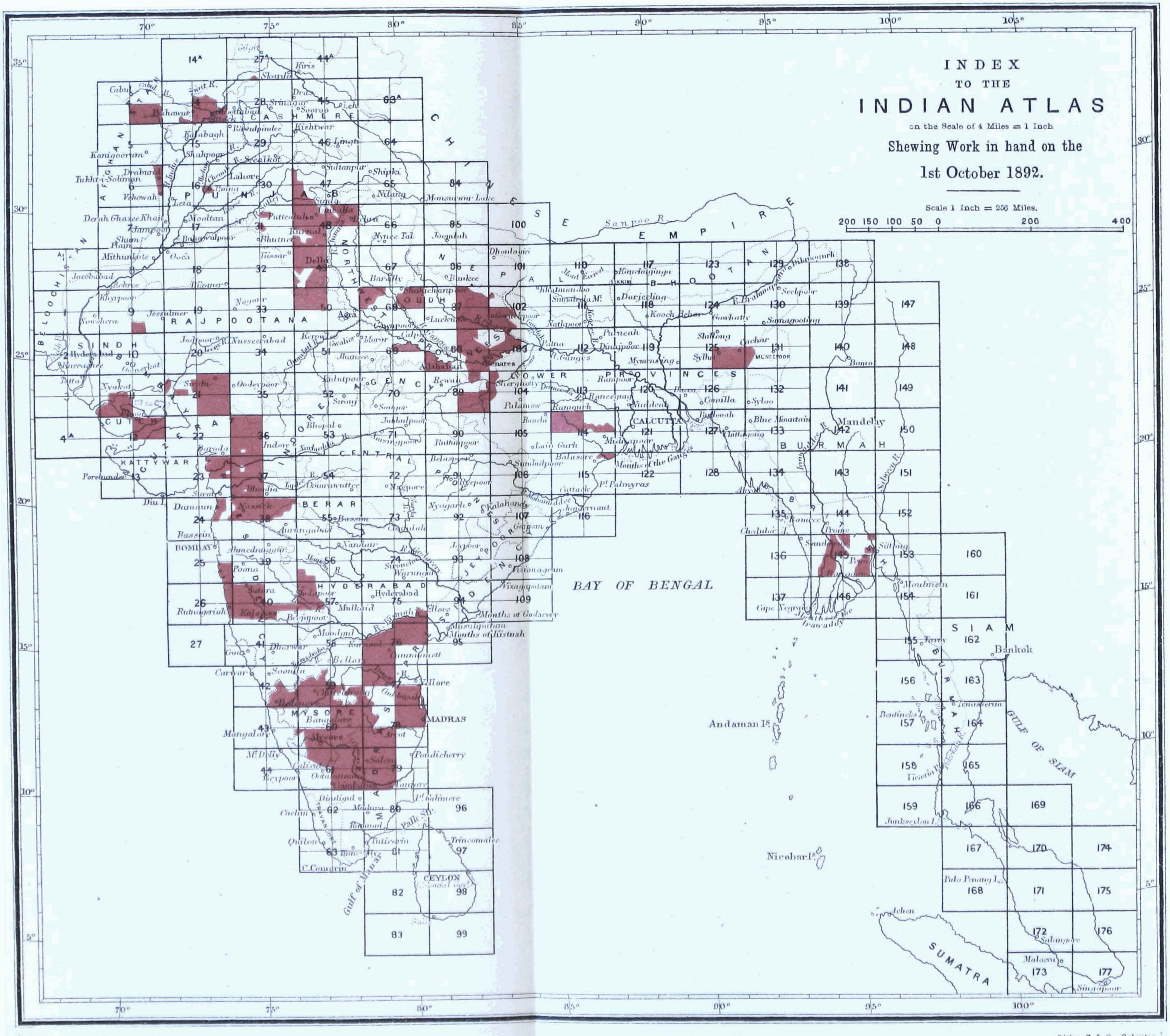
490. This section is employed in preparing the original maps of all the cadastral surveys for zincography and photo-zincography. The method is to examine the numbering of the fields and to observe if all holdings and divisions of land are correctly tabulated in the area statements. The total number of maps passed for publication during the year was 4,992, of which 1,331 were for zincography and 3,566 for photo zincography, being an increase of 448 in the return of the previous year. Of these 4,897 were actually printed, 4,028 being coloured, examined, and sent for record with the Settlement Officers of the districts to which the maps belonged.

The maps completed and printed have been arranged and bound into 77 volumes for record in this office, as well as 44 volumes of maps of districts Cuttack and Bilaspur, which are not intended to be reproduced. Forty-eight volumes of printed cadastral maps of district Thongwa have been arranged in circles and townships, indexed, examined, bound and forwarded to the Chief Commissioner of Burma.

491. In consequence of the urgent demands made for the publication of the cadastral maps of the North-Western Provinces, Assam and Burma, no re-prints of former published maps were undertaken. The maps of the district of Gorakhpur have been completed with the exception of 6, in which some revisions have to be carried out.

492. At the end of the year there were 4,634 sheets in this office for publication, against 4,252 in last year, or an increase of 382. The work of examination and preparation of the maps of the current cadastral surveys is found to be


INDEX
TO THE
INDIAN ATLAS
on the Scale of 4 Miles = 1 Inch
Shewing the Sheets that have been published up to
1st October 1892.
Scale 1 Inch = 256 Miles.
REFERENCES.
Published sheets. full size, 40″ × 27″, as shown by thick lines. from old materials . .
Published sheets quarter size, as shown by thin lines, from old materials . . . .
Published sheets, quarter size, as above, from finished Survey . . . .
N. B.—Plates from old materials will be re-engraved when the new Surveys thereof are available
BAY OF BENGAL
CHINESE EMPIRE
CALCUTTA
BOMBAY
MADRAS
CEYLON
SIAM
SUMATRA
GULF OF SIAM
Andaman Is.
Nicobar Is.



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greater than can be accomplished with the existing establishment, but as it is expected that the demands from the North-Western Provinces Government for printed maps will cease during 1893, and as the maps of the Bengal surveys are not to be printed, it is hoped that the arrears will be gradually worked off with the existing staff. *

ENGRAVING OFFICE.

493. The superintendence of this office was held for different periods by Colonels Wilkins and Wilmer, S.C. The supervision of the engravers has remained in the hands of Mr. J. Fulford, head Engraver, during the whole of the year.

Personnel.

Colonel W. H. Wilkins, S. C., Assistant Surveyor-General, in charge up to 4th May and from 24th June to 30th September 1892.
Colonel J. R. Wilmer, S.C., Superintendent, 2nd grade, in charge from 5th May to 23rd June 1892.
Mr. J. Fulford, Head Engraver.
„ W. Donaldson, Engraver.
„ S. M. Coard, „
„ T. B. Rodger, „
„ A. W. N. James, „
„ A. R. Coard, „
„ E. C. V. 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.

494. The out-turn of work, a summary of which will be found in the appendix, is a little in excess of last year, though the number of plates worked on is smaller.

495. Four quarter sheets of the atlas of India have been completed and published, 58 plates have been corrected with additions, while 43 others are in various stages of progress.

496. The 32-mile map of India, in six plates, referred to in para. 442 of last year's report, has been completed in readiness for electro-typing. The duplicate of No. 6 plate is completed and the other 5 plates are in various stages of progress. All the plates had to be enlarged, both on the east and west, to take in additional areas in Burma and Baluchistan. The duplicate plate of the 96-mile map of India has been completed as well as that of the 96-mile railway map of India for the administration report of the Railway Department. The maps of India on the scales of 128 and 256 miles have been in progress, but are still unfinished, as the 32-mile map, above alluded to, occupied the time of the best engravers for many months.

497. Heavy corrections and additions have been carried out, as in last year, to 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 are completed in outline and lettering. A duplicate of the latter by the electro-typing process is now being made, upon which the hills will be engraved.

498. The map of Darjeeling, on the scale of 1 inch = 4 miles, the out-lining of which was completed last year, is well advanced in lettering. Of the Administration Report maps, nine districts have been commenced and five completed, while additions have been made to 17. Many miscellaneous plates have been begun and are in various stages of progress.

499. The Copper-plate Printing Section pulled 18,567 impressions and the Steel-facing Section dealt with 158 plates. The number of impressions pulled is about 2,000 less than last year, which is due to two of the large presses having broken down and consequently been thrown out of work for some months until the necessary repairs were executed. A new press of very substantial construction for dry printing has been received from England, and with this addition to the office, the number of pulls can be much increased if necessary.†

* The Assistant Surveyor-General reports as follows on his assistants:—
Mr. Smylie, who became Chief Draftsman on the death of Mr. McGill, has performed his duties very satisfactorily.
Mr. James in charge of the cadastral section, and Mr. Price in charge of the examining section, have also rendered efficient service. Messrs. Wyatt, Martin and Cusson have also done well.
Mr. Pocock, who assumed the office of Head Draftsman in July, has given the greatest satisfaction.
Among the European draftsmen all, except Messrs. Adels and Bateman, are well spoken of, and Babus Mohesh Chandra, Harihur Sen, Purna Chandra Sen, Gopal Chandra Roy, are favourably reported on; the native establishment generally have done good work.

† Mr. Fulford supervised the office in the most efficient manner. The European and native engravers are generally very favourably reported on.

CALCUTTA CITY SURVEY OFFICE.

500. This detachment has remained throughout the year under the supervision of the Assistant Surveyor-General, Drawing Office, Calcutta. Mr. D. Atkinson, who had been in immediate charge of the detachment almost from the commencement of the survey, retired on a superannuation pension on the 8th May 1892, and Mr. A. J. Wilson was appointed in his place.

Personnel :
Colonel W. H. Wilkins, S.C., Superintendent, 1st grade, in charge.
Mr. D. Atkinson, Extra Assistant Superintendent, 1st grade, up to 8th May 1892.
Mr. A. J. Wilson, Extra Assistant Superintendent, 1st grade, from 9th May 1892.
Mr. A. B. Smart, Sub-Assistant Superintendent, 2nd grade, up to 18th February 1892.
Babu Sarat Chunder Sen, Sub-Assistant Superintendent, 3rd grade, from 1st April 1892.
15 draftsmen and others.

501. In last year's report it was recorded that the undermentioned work remained to be completed :—

(1) The house-to-house enquiry as to names and addresses of proprietors, and the investigation of the boundaries of about 300 holdings in the Sutanoti *taluk*.
(2) The completion of the 459 original field sheets, 228 of which, comprising the southern division, were nearly finished, and the remaining 231 sheets, comprising the northern division, being well advanced.
(3) The survey and adjustment of about 1,550 holdings, of which the proprietors were not present at the time of survey.
(4) The completion and publication of the 235 fair sheets.
(5) The completion of the register of proprietors.

502. The following progress has been made during the year under report :—

(1) The house-to-house enquiry has been completed.
(2) The colouring of the 228 sheets of the southern division has been finished, and that of the 231 sheets of the northern division only remains incomplete in those places where re-surveys have been made.
(3) In the survey and adjustment of boundaries, 1,386 holdings have been demarcated, of which 120 were situated in the Sutanoti *taluk* and 1,266 in the area under the Collector. Since last year, many other holdings have been found, and instead of about 1,550 left for survey, as was then supposed, there were really about 2,250. The total number of holdings demarcated since the commencement of the survey is as follows :—

Up to 30th September 1891 . .	20,398
During 1891-92	1,386
TOTAL .	21,784

There are probably about 864 holdings still left for final demarcation.

(4) Out of the 236 fair sheets, 12 have been completed and sent to press, and block XII of the southern division has been prepared and sent to the Municipal Office to be placed on view for two months before final publication, in accordance with section 20 of Act I of 1887. It should be explained that, in consequence of the reclamation of land near Prinsep's Ghât, one more has been added to the number of fair sheets, thus making the total 236 instead of 235, as given in last year's report. The reason why block XI has not been prepared, as promised in last year's report, is that there was great delay in demarcating the boundary of Calcutta, which runs through both this and block XII.
(5) The fair register of the names of all proprietors, who were present at the time of survey, has been completed up to date.

503. During the year, the claims of 548 disputed boundaries were filed in the Court of the Assistant Superintendent under the Calcutta Survey Act. Of these, 281 were decided. Rai Bahadur Kally Churn Ghose, Assistant Superintendent of the Calcutta Survey, having retired on the 25th April 1892, Babu Tarini Kumar Ghose was appointed in his place. He began his new duties on the 28th May, and he has settled 148 cases since that time.

504. The preparation of the 16-inch map direct from the original fair sheets by heliogravure, a specimen of which was given in last year's report, was found to entail so much work of a very difficult nature in obliterating the small superfluous details and correcting the negatives that the method was considered to be impracticable. Another experiment was then made; blue prints of the fair sheets reduced to about one-half were supplied to the Drawing Office and were then re-drawn specially for reduction to the 16-inch scale. The results, however, were not satisfactory, and were not suitable for the heliogravure process. It is now arranged to utilise printed proofs of the fair sheets and paint out all unnecessary detail and all names. These proofs will then be pieced together in groups of four, and reduced by photography to the 16-inch scale; they will then be etched on copper by the photo-etching process. The names of streets, etc., will be engraved on these copper-plates by hand. This has not yet been given a trial, as it has been postponed on account of the press of other work connected with the original fair sheets and maps of blocks.

505. During the month of August 1892, the office was inspected by His Honour the Lieutenant-Governor of Bengal, when the difficulties connected with the demarcation of the boundaries of holdings, owing principally to the non-attendance of the proprietors, was explained to him. His Honour desired that section 6 of Act I of 1887 for the survey of the city of Calcutta should be more generally enforced. It was found in practice, however, to be so extremely difficult to make sure that the necessary notices had been duly served upon the rightful proprietor or person having permanent interest in the land that it was thought better to make use of the powers conferred by this section with care, and now that the field survey has been so far completed that some of the fair sheets can be really finished and published, the delay caused by the want of demarcation, which not long ago extended more or less into every sheet, has to a great extent ceased to exist, and it is believed that by about March 1893 the whole of the boundaries will have been demarcated without having to resort to extreme measures. There will then remain the completion and final examination of the fair sheets, which requires a great amount of careful examination on the part of the draftsmen and of the Extra Assistant Superintendent in charge, who is finally responsible for their accuracy. As the sheets are finished they will be sent to press, and will then be made up into block maps and sent to the Municipal Office, where they will be on view as already explained. It is hoped that, so far as this department is concerned, the whole work will be completed during the year 1893.*

* Colonel Wilkins reports that Mr. D. Atkinson has always discharged his duties very satisfactorily, and that it was a matter of regret that he had to retire, as he was so thoroughly acquainted with the details of the work. His successor, Mr. A. J. Wilson, has been attentive to his duties and painstaking. Babu Sarat Chunder Sen has been of great assistance in the demarcation.

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE.

Personnel.

Colonel J. Waterhouse, S.C., Assistant Surveyor-General, in charge from 12th November 1891.
Mr. T. A. Pope, Deputy Superintendent, 4th grade, in charge up to 11th November 1891.

NEGATIVE SECTION.

Normal Establishment.

Mr. H. Haward, Head Assistant.
Munshi Ismail Khan, Assistant Photographer.
Mr. G. W. Mackie, Assistant Photographer, up to 30th August 1892.
Mr. E. Savedra, Apprentice.
One assistant photographer and two negative re-touchers.

Cadastral Establishment.

Mr. L. Lagnier, Photographer.
„ T. Lloyd, Offg. ditto.
„ C. D'Cruze, Asst ditto.
Three native assistant photographers and three negative re-touchers.

PHOTO-TRANSFER PRINTING SECTION.

Normal Establishment.

Mr. J. Harrold, Photographer.
Munshi Habibul 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.
Mr. J. T. Meade, Collotype printer.
One assistant photographer, two engravers and three copper plate printers.

LITHOGRAPHIC DRAWING SECTION.

Mr. H. L. Lepage, Head Assistant.
Babu Umbica Churn Mukerji, 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 4 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, Chromo-Lithographer.
„ U. S. Ravenscroft, Assistant Lithographer.

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 Mukherjee, Clerk, and one other.

Cadastral Establishment.

Babu Nagendra Nath Mukerji, Clerk.
Babu Rajani Kanta Chatterjee, Clerk, and three others.

506. The office was under the charge of Mr. T. A. Pope from the commencement of the year till the 12th November, on which date Colonel Waterhouse returned from furlough and resumed charge. There have been no important changes in the *personnel* of the establishment during the year, and no casualties among the European assistants. Mr. G. W. Mackie was discharged on the 31st August for dishonestly bringing in outside work to be copied in the office.

507. Notwithstanding that the machine and hand presses have all been fully occupied during the year, it has been found exceedingly difficult to deal with the large amount of printing work in hand, and to meet the many urgent demands continually coming in from other departments. The difficulty is principally owing to the large increase in colour work, as each separate colour involves a separate printing, as well as in larger numbers of copies being asked for. It is hoped that the additional power gained by the new lithographic machine, which is now being put up, will enable the office to overcome these difficulties and keep abreast of the increasing work.

508. The general abstract of work turned out, given in the tabular statement below, again shows a large increase over the previous year in almost all items, though not to so large an amount as in last year.

General Abstract of work done during 1891-92.

Classification.	Sheets or subjects.	Negatives and transparencies.	Photo-zincographic and Lithographic Printing.								Type Printing.			Silver and other Printing.		Heliogravure and Electrotyping.				Value.
			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.	Electro	R a. p.
Departmental maps and plans	1,152	1,440	1,049	375	333	82	130,244	14,709	110,036	124,745	8,615	1,318,597	678,968	415	2,357	9	1,517	5	14	69,186 0 0
Cadastral maps	4,956	3,634	3,648	4,906	4,966		149,979	...	139,819	139,819	...	...	...	...	...	...	...	...	...	68,479 14 0
Extra-departmental maps and plans	1,424	1,075	1,032	526	609	497	475,84	114,445	363,248	477,693	...	...	...	2,583	10	41	40,89	52	..	72,677 12 0
TOTAL	7,532	6,153	5,729	5,867	5,908	579	756,068	129,154	613,103	742,257	8,615	1,318,597	678,968	2,998	2,466	50	42,415	57	14	210,356 10 0
TOTALS of 1890-91	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	208,653 13 0
Differences	+ 465	+ 459	+ 150	+ 426	+ 297	+ 6	+ 44,090	+ 18,354	— 36,465	— 18,111	— 483	+ 244,317	+ 97,278	+ 1,893	— 225	— 20	+ 8,400	+ 22	— 12	+ 1,702 13 0

509. The increase in the number of subjects, negatives and zinc plates transferred and printed, is due to the larger number of cadastral maps reproduced, amounting to 580 sheets more than last year. Of the surveys in the North-Western Provinces 2,464 sheets, of Burma 1,715 and of Assam 777 sheets were printed. The increase is chiefly in the Burma sheets. Apart, however, from the increase of the cadastral work, there has been a large increase in the number of pulls from zinc and stone and in the number of coloured copies, though the uncoloured copies show a large falling-off, which does not affect the actual increase of work in the printing sections. In the type-printing section, the number of items set up again shows a decrease, though the number of pulls and copies shows a further very large increase, and in consequence it has been found difficult to get through all the demands ; it will soon be necessary to set up another printing machine to meet the increased demands for forms, etc. The silver printing section shows a large increase in silver printing on account of 2,136 silver prints supplied to the Secretary of State for the illustration of the late Dr. Forchhammer's reports on the antiquities of Arakan and Pagan, though the number of blue prints has fallen off.

510. The completion of the third edition of the 32-mile map of India has again been delayed by further heavy additions and corrections, chiefly in sheets 1 and 4, but the publication is otherwise prevented by want of orders from the Government regarding the frontier boundaries to be shown therein. Among the provincial maps reprinted with corrections and additions may be noted Bengal, Behar, Orissa and Chota Nagpore, with additions and corrections to railways to August 1891, in 2 sheets, scale 1 inch=16 miles; a re-issue of the maps of Bengal (Eastern and Western), on the scale of 1 inch=8 miles; a third edition of the map of the North-Western Provinces on the scale of 1 inch=16 miles, in 4 sheets, corrected to March 1891. Maps of the Gorakhpur and Benares divisions, in 3 sheets, on the scale of 1 inch=4 miles, of the Rajshahye division on the scale of 1 inch=8 miles, and also of the Kumaun, Rohilkhand and Gorakhpur divisions, on the scale of 1 inch=4 miles, were printed. Maps of districts Shahabad, Sylhet and Patna, on the scale of 1 inch=4 miles, have been lithographed by transfer from the engraved copper-plates of the Atlas of India ; while maps of the Sundarbans, in 2 sheets, on the scale of 1 inch=4 miles; Hooghly and Howrah, in 5 sheets, on the scale of 1 inch=1 mile; Benares in 3 sheets and Basti in 4 sheets, both on the scale of 1 inch=2 miles, have been photo-zincographed.

511. Of 430 standard sheets in hand, on various scales, 99 have been published during the year, exclusive of reprints. Of a large number of sheets, blue print proofs have been supplied for examination and correction, after which they will be transferred to zinc. Among the sheets published may be noted 7 sheets of Bengal, including 4 of district Mymensingh, on the scale of 1 inch to 1 mile; 4 sheets of Bombay surveys on the 1-inch scale and 3 sheets on the 2-inch scale; 5 sheets of Lower Burma survey on the 1-inch scale, districts Prome, Tharrawaddy and Henzada, and 4 sheets on the 4-mile scale; 3 sheets of the Central India and Rajputana surveys on the 1-inch scale; 2 sheets of the Central Provinces survey on the 1-inch scale and 11 sheets on the 4-mile scale; 3 sheets of the North-Western Provinces and Oudh survey, and 2 sheets of the Oudh revenue survey, on the 1-inch scale; 28 sheets of the Punjab surveys, on the 1-inch scale, in districts Ferozepur, Jullunder, Lahore, Montgomery, Faridkot, Ludhiana and Sikh States, Hoshiarpur, Umballa, Patiala and Hissar; 7 sheets of the North-Eastern Frontier on the 4-mile scale and 2 sheets on the 8-mile scale; 10 sheets of the South-Eastern Frontier on the 4-mile scale and 1 sheet on the 8-mile scale. The majority of these Eastern Frontier maps are new editions of sheets published before. Thirty sheets of the Madras forest survey maps, on the scale of 4 inches=1 mile, have also been published during the year.

512. Several sheets of the new survey of Calcutta have been reproduced to scale during the year, but as yet none of them have been printed off. The experiments noticed last year as under progress for preparing a reduced map by heliogravure were continued, but it was found that the system of re-drawing upon reduced cyanotype prints would not answer on account of the blue details coming up. This system, which had every promise of success, had therefore to be abandoned, and trials are now being made of a system by which the proofs

of the original sheets will be prepared for reproduction. The question is one which presents a good many difficulties in finding a successful method by which a complete re-drawing of the map may be avoided. A 3-inch map of Calcutta has been brought out, based on the 6-inch map. Other cantonment plans published are Kamptee and Satara, each in two sections, on the scale of 8 inches =1 mile, and Dinapore, in 2 sheets, on the scale of 6 inches=1 mile.

Besides these a large number of index-maps, technical charts and miscellaneous maps and items have been reproduced for departmental purposes.

513. The extra-departmental work again shows a very large increase, not so much in the number of subjects received as in the number of pulls, owing to the very large proportion of colour printing now required, and also to the much larger number of copies now asked for than was formerly the case. Where the demands formerly amounted to hundreds, they now amount to thousands. The amount of work done for the various departments is shown in the table attached to Colonel Waterhouse's report in the appendix, but the following items may be specially noticed. A very large amount of work has been done for the Railway Department, including three maps, on the scale of 1 inch=96 miles, showing railways, also railway systems and gauges, each of the latter being shown in many colours. The new railway map specially engraved for the purpose is now being used for obtaining transfers from the copper to be printed from stone. This saves a great deal of labour in preparing the maps, but nevertheless a large amount of correction is always required. A large number of drawings of girder bridges, and a railway specimen plan, have been lithographed in colour, besides diagrams of engines, carriages, etc., photo-zincographed. The demands of the Meteorological Department have again increased, and for the most part involve printing in two colours. Besides the regular work of printing the forms of the daily weather charts for India and Bengal, five plates monthly are printed for the *Monthly Weather Review*, besides plates for the *Cyclone Memoirs* and the *Annual Review*. In face of the numberless urgent demands from other departments, it has been found exceedingly difficult to meet these large regular demands. Nine maps have been prepared and copies printed off during the year for the new edition of *Aitchison's Treaties*. The printing of the maps and diagrams for the Leprosy Commission Report, of which 2,500 copies were required, 11 of the maps being in colours, has also been a severe tax on the resources of the office. Another heavy colour printing job has been the partial printing of copies of a series of 8 plates of native soldiers to illustrate the Historical Records of the Bengal Native Army: these are in several colours, and as they have had continually to make way for other more urgent work, the printing off has taken a long time and was not completed at the end of the year.

A new geological map on the scale of 1 inch = 96 miles, in 11 colours, has been prepared and proved, but copies have not yet been printed off; this will also be a heavy piece of printing work. A Coal and Iron map has also been prepared on the same scale for the Reporter on Economic Products. The usual maps for the Administration Reports, Bengal and the Punjab, all of which are in at least two colours, were prepared and most of them printed off.

A series of maps of British Guiana, north-western district of British Guiana, Guadeloupe, Jamaica, St. Lucia, Surinam, Martinique and Antigua, were reproduced by lithography and photo-zincography for Dr. Comin's Report on Colonial Emigration, but had not all been printed at the close of the year. The ordinary work of the year has been further increased by the preparation of maps and diagrams to illustrate the Reports on the Census Operations in Rajputana, Assam, and Berar, all the maps being in colours and those of the Rajputana States requiring special care in the preparation and printing of the colour stones.

A set of maps illustrating Professor Forrest's History of the Indian Mutiny of 1857 have been photo-zincographed, and one of them will be printed in colours.

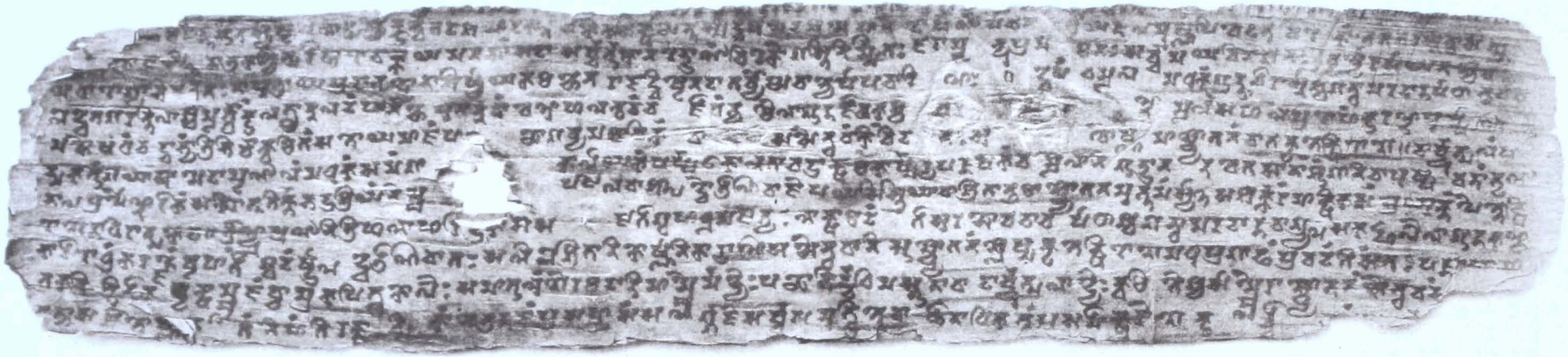
Besides the above, several divisional maps of the North-Western Provinces and Oudh on the scale of 1 inch = 4 miles have been lithographed and printed, also a large number of plans of the grass *rukhs*; and plans of the Yenang Young, Yenang Yat, Twingon and Beme oil-fields were photo-zincographed. The value of all the extra-departmental work done was R72,677-12 against R61,944-3 in last year.

514. The heliogravure section has made steady progress during the year, though there is nothing very special to report beyond the extension of the use

The Bower Manuscript.

Part I. Leaf 4. Plate IV.

Obverse.



Reverse.

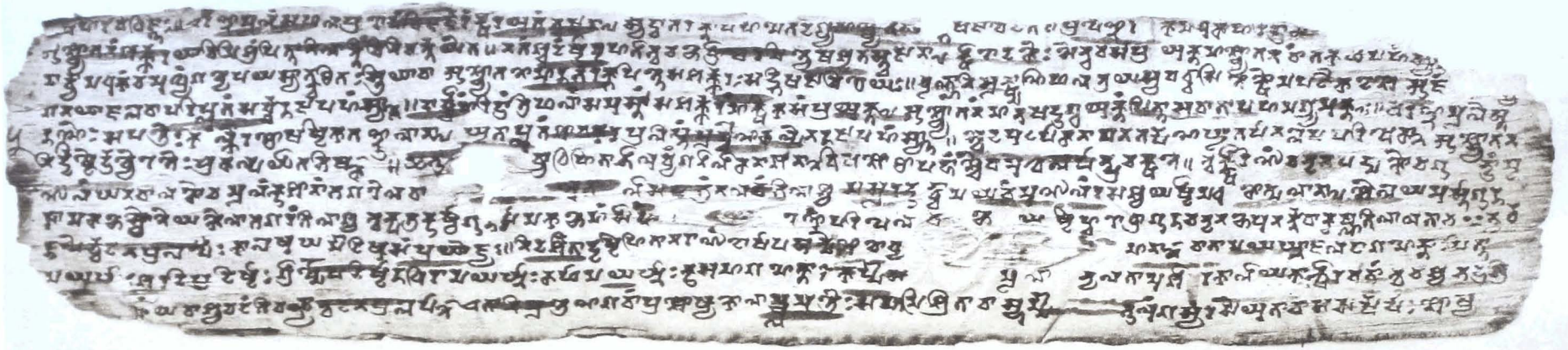


Photo-etching. ORIGINAL SIZE. Survey of India Offices, Calcutta, January 1893.

of photo-blocks. By the photo-etching process, 50 plates have been produced and 42,415 copies printed; 57 photo-blocks have been prepared and 14 plates electrotyped as matrices or duplicates Eight plates of the Technical Art Series have been printed off and distributed. Forty-seven photo-blocks were prepared for the illustration of the Indian Museum Notes on Economic Entomology. The principal work of the year has been the reproduction of the manuscripts discovered by Lieutenant Bower in Western Turkestan, of which 13 plates have been prepared, as described in Colonel Waterhouse's report in the appendix: a specimen plate of this work is appended. A set of 12 plates of Fishes and Crustacea was prepared and printed to illustrate Dr. Alcock's Report on "The Zoology of I. M. S. S. 'Investigator.'" These plates were reproduced from the original Indian ink drawings and will show the value of the process as a substitute for lithography. The view of the tomb of Itmad-ud-Daula, Agra, given as a frontispiece to this Report, shows the result of direct enlarging from a small plate, and the application of heliogravure to architectural illustration. Further details of improvements in working, etc., will be found in the appendix.

515 The preparation of a revised proposal for the reorganisation of the office, and latterly ill-health, have prevented Colonel Waterhouse from completing his investigations on the production of reversed positives by the use of thio-carbamides in the developer, though the subject is not lost sight of. The principal experimental work done has been in connection with the very sensitive collodio-bromide emulsion process, noticed in last year's report, which might be exceedingly useful in the office for ordinary negative work, if a satisfactory means could be found of obtaining clear lines for line-work and also of retaining the sensitiveness of the plates in a dry state. Colonel Waterhouse's work in this direction is detailed in the appendix. Various new developing agents have been tried and experiments made upon the action of electricity in the formation and development of the latent photographic image, but these were interrupted by various causes and are not sufficiently advanced for publication.

516. Fresh proposals for the reorganisation of the office were submitted in June, but had not been sanctioned at the close of the year. It may be pointed out that with the continual increase in the demands upon the office some corresponding increase in the working power of the establishment is absolutely necessary. The additional power given by the new machinery is already insufficient, and it will be impossible to carry on the work any longer in the state of strain it has been during the past year. The new lithographic machine which has been received during the year will relieve the pressure as far as the colour printing goes, but the additional establishment is also most urgently required to work this machine and enable the general work of the office to be efficiently carried on.*

MAP RECORD AND ISSUE OFFICE.

Personnel.

Colonel W. H. Wilkins, S.C., Assistant Surveyor-General, in charge up to 4th May 1892 and from 1st July 1892.
Captain W. J. Bythell, R.E., Officiating Deputy Superintendent, 2nd grade, in charge from 5th May to 30th June 1892.
Mr. A. E. Byrn, Head Assistant.
" H. R. Vallis, Map Curator, and 14 clerks.
" B. M. Wilson, Sub-Assistant Superintendent, 2nd grade, attached.

517. During the year under report the general superintendence of this office has been in the hands of Colonel W. H. Wilkins, S.C., and Captain W. J. Bythell, R.E., respectively.

* Colonel Waterhouse again reports favourably of all his principal assistants, who have zealously met the increased work devolving on them, *viz.*, Mr. H. L. Lepage, Mr. B. Mackenzie, Mr. D. Deas, Mr. E. A. Lefranc, Sergeant Vandyke, and Mr. DePyvah, in the Lithographic, Zincographic and Type Printing sections; Mr. H. Haward, Mr. A. W. Turner, Mr. J. Harrold, Mr. R. George, and Mr. L. Lagnier, in the Photographic sections; also Mr. W. Moore, Store-keeper. Among the junior assistants and apprentices; Messrs. J. Mackenzie, S. U. Ravenscroft, G. A. Le Franc, C. J. Meade, J. T. Meade and P. Michael have worked well and made good progress in their respective duties. In the Lithographic Drawing section, Babu Umbica Churn Mukerji and Munshi Abdul Hamid may be specially noticed among the native draftsmen, but all have worked well. Among the native assistants in the Photographic sections, Mahomed Ismail, Habibul Hossain, Abdul Rahman, Umbica Charan Bhuttacharjee and Preonath Chatterjee, assistant photographers; Azizur Rahman, native engraver, and Aghore Nath Sircar, copperplate printer, have all done their work steadily and well. In the Correspondence and Account sections, Babu Kanai Lal Sen, head clerk and accountant, Babus Gopal Chandra Mukerji, Kedar Nath Ghose, Rajani Kanta Chatterjee and Surjee Kumar Banerjee are all well reported on.

518. The number and value of maps issued during the year are as follows :—

Maps issued.	Number.	Value.
		₹
General maps to Government officials	41,093	41,487
Ditto to India Office, London	7,189	9,018
Ditto to Agents	967	1,448
Ditto to private individuals	8,116	12,999
TOTAL .	57 365	64,952
Cadastral maps to Government officials	133,214	71,127
GRAND TOTAL .	1,90,579	1,36,079

519. There has been a decrease in the number of maps issued, which is principally due to smaller demands from Government officials, but a small increase in their value, as compared with last year's totals which were ₹2,08,484 and ₹1,35,245, respectively.

520. The amount realized from cash sales was ₹22,091, *viz.*, ₹12,999 from private individuals, ₹1,638 from Map Agents, and ₹7,454 from Government officials. Thus the cash receipts exceeded those of the preceding year by ₹9,174 : this is chiefly due to the enforcement of the rule requiring Government officials to pay cash for supplies under the value of ₹50. In the Revenue section, 281 applications were received for extracts from original records of the Revenue Surveys, and 3,487 certified copies of village plans, tracings, and traverses were supplied at a cost of ₹7,291.

521. The details of work done are given in the following statement, and compare favourably with those of the year preceding :—

Details.	Number.
Applications received for maps	5,015
Letters issued in reply	2,881
Cash and credit map sale bills	1,294
Invoices and receipts issued for published map	1,904
Ditto ditto cadastral maps	315
Ditto ditto extracts from original records . . .	281
Packets, parcels, and local despatches	3,173
Ditto received	724
Packages despatched by rail and steamer	431
Ditto received ditto	43
Maps, coloured, for sale and issue	33,176
Ditto for other departments	9,910

A list of the maps and charts published during the year will be found at page 106.*

* Mr. H. R. Vallis has discharged the duties of curator and salesman in a satisfactory manner.

MATHEMATICAL INSTRUMENT OFFICE.

522. For the greater part of 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. Whilst that officer was absent on privilege leave from 5th May to 23rd June 1892, the charge was held by Colonel W. H. Wilkins, S.C., Assistant Surveyor-General.

Personnel.

Lieutenant-Colonel M. W. Rogers, R.E., Assistant Surveyor-General, in charge up to 4th May and from 24th June 1892.
Colonel W. H. Wilkins, S.C., Assistant Surveyor-General, in charge from 5th May to 23rd June 1892.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument Maker.
„ T. R. Theakston, Officiating Assistant Mathematical Instrument Maker, from 29th October 1891.
198 artificers.

Store Branch.

Mr. M. C. Belletty, Instrument Store-keeper, up to 12th April 1892 and from 1st August 1892.
Mr. W. R. Tulloch, Officiating Instrument Store-keeper, from 12th April up to 31st July 1892.
Babu Woomesh Chunder Chowdhury, Material Store-keeper.
1 packing sircar and 2 packers.

Office Establishment.

Mr. W. Campagnac, Head Clerk, up to 11th April 1892.
„ M. C. Belletty, Officiating Head Clerk, from 12th April up to 31st July 1892.
Mr. W. R. Tulloch, 2nd clerk.
8 clerks and 3 temporary clerks.

523. The figures given in this report refer to the financial year 1891-92, *i.e.*, from 1st April 1891 to 31st March 1892. During this period, 93,661 serviceable instruments valued at ₹3,85,697 were received into store, and 83,202 instruments valued at ₹3,16,373 were issued. The number of serviceable instruments in store has thus increased by 10,459 and their value by ₹69,324. Compared with the figures of the preceding year there is a large increase both in issues and receipts, as shown below :—

	1890-91.	1891-92.	Increase.
Number of instruments received . . .	63,196	93,661	30,465
Value of ditto . . ₹	2,59,909	3,85,697	1,25,788
Number of instruments issued . . .	64,203	83,202	18,999
Value of ditto . . ₹	2,88,337	3,16,373	28,036

524. The following tabular statement shows the principal sources from which the serviceable instruments were received :—

Sources of Receipt.	No.	Value.
		₹
From England on indent	19,402	1,88,462
By purchase in local market	39,316	31,563
Manufactured in workshop	19,640	38,811
Returned to store by public officers	1,083	15,304
From other manufacturing offices	5,000	63
„ repairable stock after repair	6,051	1,05,811
„ other sources	3,169	5,653
TOTAL .	93,661	3,85,697

525. The number and value of the instruments received from England is considerably larger than those of any previous year, and it has been found necessary to increase the indents on England in order to meet the much larger demands from all departments; these become greater each year as work on railways, canals, surveys, etc., increase, and in many kinds of smaller instruments, *e.g.*, compasses, measuring tapes, etc., the supplies asked for are in hundreds where they were in tens a few years ago. The number of instruments purchased in the local markets is nearly double that of last year, but their value remains almost the same. The number of instruments manufactured in

the workshops is almost the same, but their value is about ₹12,000 more. As explained in last year's report, the amount of these manufactures depends on the number of men who can be spared from the repairs work; the class and value of the instruments manufactured will be found in Table C in the appendix.

526. The number of instruments taken from the repairable stock and rendered serviceable for issue is considerably greater both in number and value than last year, and it is satisfactory to note that this increased out-turn has been accomplished without any decrease in the amount of current repairs. During the year, the office received 5,912 repairable instruments valued at ₹75,365, compared with 3,668 instruments valued at ₹60,784 in last year. The total issues from the repairable stock were 6,051 valued at ₹68,329; these were repaired in the workshops at a cost of ₹37,512, and transferred at the enhanced value to the serviceable stock. The repairable stock has thus been diminished by 139 instruments and increased in value by ₹7,036. It may therefore be considered that there has been no increasing accumulation of repairable instruments, but the results of the last few years show that the increase made to the establishment some years ago barely suffices to prevent the accumulation of repairable instruments, and is unable to diminish their number.

527. The conversion of old pattern theodolites and levels alluded to in paragraph 475 of last year's report has been continued, and in the financial year under report, 11 theodolites and 36 levels were made into serviceable instruments and issued, at a total value of ₹10,005; these instruments in their previous condition were practically worth nothing.

528. During the year, the number of indents supplied has greatly exceeded those of any previous year; this being in some measure due to the large requirements of the Meteorological Department mentioned in paragraph 476 of last year's report. These requirements have been all supplied, and only the current demand for meteorological instruments has now to be met.

529. Large indents for compasses and scales have been received from the Governments of the Central Provinces and North-Western Provinces, which have been duly supplied. The Madras Revenue Survey has again indented on the office for a very large number of measuring chains, etc.

530. The work of altering the service heliographs to agree with the new sealed pattern has continued during the year, and in addition, the Ordnance Department sent a number of binoculars to be altered so as to render the distance between the eyes adjustable.

531. The payments in cash for charges under ₹50 alluded to in paragraph 478 of the last report continue to increase, and in order to meet the extra work entailed by this procedure, as well as by the general expansion of the work of the office, it has been found necessary to employ extra clerks and pay them from the grant for contingent establishment, whereby the amount available for the workshop has been diminished. Table A (in the appendix) shows the amount 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 into store. The value of the issues and repairs executed on book debit was ₹3,08,269, being ₹24,000 in excess of last year: this amount includes the value of instruments purchased with the extra-departmental grant of ₹40,000. The credits for instruments returned into store amounted to ₹93,145, which is about ₹9,000 in excess of last year. The cash sales were ₹23,137, against ₹14,871 last year, and ₹10,203 in 1889-90. It will thus be seen that the cash sales have been more than doubled within the last two years, which, as already mentioned, has greatly increased the clerical labour of the office.

532. The number of principal instruments repaired in the workshop is 2,284, which is nearly the same as last year: the total number of instruments of all kinds repaired amounts to 3,691 compared with 3,565 in 1890-91.

533. It will thus be seen that there is a steady increase in the demands on the Mathematical Instrument Office and that its work is continually becoming greater. The Survey of India still continues the largest customer, having taken instruments valued at ₹82,000 or a little under one-fourth of the total issues, but several provinces, notably Burma, which has taken instruments valued at ₹50,000, are also large indentors.

534. During the year, a surveyor has been deputed to take stock of the instruments, and this work has been completed and his returns are now being

checked by the Assistant Mathematical Instrument Maker and another surveyor. Stock-taking is an extremely difficult and troublesome business, and is complicated by the necessity of continuing the issues and receipts during the considerable time it takes to complete it. When finished, a detailed report will be submitted, but as far as the results have been checked, the state of the stock is very satisfactory.

535. The profit and loss account of the workshop will be found in the appendix, the result of the operations showing an apparent profit of ₹18,191. Of this quite half is due to the apparent loss shown in the account for last year and explained in paragraph 484 of the last report. The resulting net profit of about ₹9,000 is, however, too large and points to rates being too high. The attention of the Mathematical Instrument Maker has been directed to this point, and it is hoped that in the current year the account will more nearly balance.*

II.—TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

536. 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.

537. 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 the differences of longitude; also with spirit-levelling operations and tidal observations.

Personnel.

Colonel G. Strahan, R.E., Deputy Surveyor-General, in charge Trigonometrical Branch.
Captain S. G. Burrard, R.E., Officiating Deputy Superintendent, 1st grade, in charge Computing Party, from 3rd May to 7th August 1892.
Mr. J. Eccles, M.A., Officiating Deputy Superintendent, 1st grade, in charge Computing Party, up to 3rd May 1892, and from 7th August 1892.

(1) *Correspondence, Accounts, and Records.*

Mr. F. A. D'Rozario, Head Clerk, and four writers.

(2) *Computing.*

Mr. H. W. Peychers, Extra Assistant Superintendent, 2nd grade.
Mr. L. J. Pocock, Extra Assistant Superintendent, 2nd grade, up to 17th July 1892.
Mr. A. Christie, Extra Assistant Superintendent, 2nd grade, from 1st May 1892.
Mr. H. G. Shaw, Sub-Assistant Superintendent, 3rd grade, up to 30th September 1892.
Munshi Rahmutulla, Sub-Assistant Superintendent, 3rd grade up to 30th September 1892.
Babu Kali Mohan Ghose, Senior Computer.
Babu Kali Kumar Chatterji, Computer.
Babu Amba Parshad, Computer, and 31 other permanent and temporary computers, record and account-keepers, librarian and writer.

(3) *Type-printing.*

Mr. B.V. Hughes, Printer, 20 Compositors and temporary hands.

(4) *Drawing and Compiling.*

Mr. C. H. McA'Fee, Extra Assistant-Superintendent, 3rd grade, 5 draftsmen, 1 sub-surveyor, and 11 assistant and apprentice draftsmen.

(5) *Photozincography.*

Mr. S. Manuel, Assistant Zinco grapher, 2 assistant photographers, 2 drafts men, and 1 map-keeper.

(6) *Solar Phot graphy.*

Mr. C. F. Guthrie, Assistant Solar Photographer.

538. The reduction of the tidal observations is made in the field party office; it is only in the compilation and publication of the results to be embodied

* Colonel Rogers reports that Mr. T. Bolton performed the duties of Mathematical Instrument Maker with his usual zeal and ability, and that he has every reason to be satisfied with the energy and intelligence with which he has worked. Mr. Marshall, the Assistant Mathematical Instrument Maker, was absent on furlough during the year, and his place was very satisfactorily filled by Mr. T. R. Theakston, who was sent out by the Secretary of State for the second time to officiate in Mr. Marshall's place. On the termination of his appointment he has obtained a somewhat similar appointment in the Telegraph Department. Mr. Theakston is a promising officer and is well reported on by Mr. Bolton.

The Correspondence and Store Branch under Messrs. Campagnac, Belletty and Tulloch have worked well and satisfactorily, and these officers report favourably of all their subordinates.

in one of the series of professional volumes 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.

539. The drawing and compiling sections and the photo-zincographic 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.

540 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 appear.

541. 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.

542. During the year under report the office has made very considerable progress towards printing Volume XV of the *Account of the Operations, etc.*, which is to contain the results of the electro-telegraphic differences of longitude, in continuation of those published in Volumes IX and X of the same series, as well as the final reduction of all the longitude materials collected up to date: the work is so well advanced that it is expected to be completed in the early part of next year. The volume to contain the Tidal observations has also been in hand, and some progress has been made, chiefly with the compilation of the introductory chapters.

543. During the year the synoptical volumes of the several chains of principal triangles, which are required by local officials and detail surveyors, have made rapid progress. Five of the Southern Trigon and five of the South-West Quadrilateral were occupying special attention. Of these, two have been bound and issued, as well as the three reported last year to be in the hands of the binder; three are nearly finished and expected to be ready for issue in the early part of next year; three others are very considerably advanced, and some progress has also been made with the remaining two. The pamphlet of spirit levelled-heights No. 6, Bombay Presidency, and a reprint of an exploration report, were printed, bound, and issued.

544. In addition to the regular work of the office, assistance was afforded to the field parties, etc., as follows:—Two computers were lent for seven weeks to the Astronomical parties for the completion of the latitude calculations of season 1890-91 and of the electro-telegraphic longitude work of season 1891-92, and two others were engaged for two weeks for the Quarter Master General's Department in reducing astronomical and other observations taken by Captain Bower in his journey through Tibet.

545. The work done by the drawing and compiling section and by the photo-zincographic section will be found detailed in the appendix.

546. Photographs of the sun have been taken throughout the year on all days that the sun was visible, and the negatives have seen 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.

547. 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 set of examination papers for the Junior Division was prepared and looked over, and three officers of the same division have received special instructions 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.

548. The work in the various sections has made very satisfactory progress, and gives evidence of skilful administration, especially with the final reduction and publication of the trigonometrical records of past years. With the increased means placed at the disposal of the computing section a very considerable progress has been made.*

III.—DRAWING OFFICE, SIMLA.

549. The charge of this office was resumed by Colonel Holdich on his return from furlough on the 15th October, 1891. On his proceeding to the field as officer in charge of No. 15 Party on the 17th November, 1891, the charge devolved nominally upon the Deputy Quarter Master General, Intelligence Branch, until the return of Colonel Holdich from the field on the 27th April, 1892. Practically, however, Mr. G. W. E. Atkinson had almost entire control of the work during this period, and conducted the office business with his usual care and skill. During the recess season Colonel Holdich remained personally in charge, except for a short period whilst he was visiting the head-quarters of No. 15 Party at Quetta, when Mr. Atkinson again assumed the superintendence.

Personnel

Colonel T. H. Holdich, R.E., Superintendent, 1st grade, in charge.
Mr. G. W. E. Atkinson, Extra Assistant Superintendent, 1st grade.
„ W. J. Cornelius, Extra Assistant Superintendent, 4th grade.
„ A. Kitchen, Sub-Assistant Superintendent, 1st grade.
„ F. E. Warde, Sub-Assistant Superintendent, 2nd grade.
„ F. Rozario, Surveyor.
„ H. Sindon, Draftsman.
Munshi Jafir Khan, Draftsman.
Mr. W. Manly, Draftsman, and four other draftsmen.

550. The sheets of the South-West Asia series (comprising Western Persia) and of the North-West Trans-Frontier series on the scale of 8 miles =1 inch have furnished the office with the principal work of the season. The South-West Asia series is now completed in its first edition. The only recent geographical information which has not as yet been compiled into these maps, is part of that obtained by Captain Vaughan, whose work affects so many sheets that have only just been published that it is impossible at present to revise all of them. Captain Vaughan's reconnaissance has however been published separately. As regards the North-West Trans-Frontier series on the scale of 8 miles=1 inch, about half of it may be said to be complete. The maps are progressing fairly and are level with military requirements in their rate of publication. In addition to the standard sheets of the survey, a very large amount of miscellaneous drawing has been completed to meet special demands and other maps have been compiled. Under this head, too, are included the new edition of the map of Turkestan (the revision of which well-known map has required a great deal of laborious attention) and the compilation of Captain Bower's route traverse through Tibet, which was practically carried out in the field by Atma Ram, a native employé of the Drawing Office, and is perhaps the chief geographical contribution of the year. The Turkestan sheets are incomplete and still afford room for revision and improvement: every effort will be made to complete this edition at an early date.

551. Colonel Holdich draws attention to the services of Atma Ram, who is considered to have earned special commendation. This sub-surveyor volunteered to accompany Captain Bower on his most adventurous journey through Tibet and has brought back an unbroken traverse of 2,100 miles, besides a large amount of useful information. This is perhaps hardly within the sphere of Drawing Office duties, but this untried and untrained surveyor left this office on exploration duty and returned to it again, and thus his most excellent record can hardly be included elsewhere. A narrative report of his journey will be found in the appendix. He is now attached to the Baluchistan party.†

* Mr. Eccles reports very highly of his assistants, making special mention of Messrs. Peychers, McA'Fee, Hughes, Manuel, and Guthrie, who stand at the head of their respective sections; also of Messrs. Pocock, Christie, and Shaw.
He also bears testimony to the good work of the computers.
The Deputy Surveyor-General records his satisfaction with the work of Mr. D'Rozario, the head clerk, and Babu Hira Singh, the second clerk of his office.

† Colonel Holdich states that, with one exception, his assistants, both European and native, worked most satisfactorily. Of Mr. Atkinson he writes: "I have nothing to add to the excellent report of his services made by Captain Wahab, except my entire concurrence in the views which he expressed in the last year's report as to Mr. Atkinson's ability and efficiency." Messrs. Cornelius and Kitchen are also specially mentioned among the European staff, and the native assistants generally are said to have worked well.

LIST OF MAPS AND CHARTS PUBLISHED DURING THE YEAR 1891-92.

Title.	Scale.	Number of Sheets.	Remarks.
Atlas of India.	In. M.		
Sheets Nos. 40, 42, 59, 74, 94, 114 and 115	1=4	7	With additions to 1891.
Sheet No. 111	1=4	1	With additions to 1890.
Quarter sheets Nos. 22N.E.; 35S.W.; 39N.E. and 114S.W.	1=4	4	
Quarter sheet No. 105S.E.	1=4	1	With additions to 1891.
Quarter sheet No. 130S.E.	1=4	1	With additions to 1890.
General Maps.			
Afghanistan	1=24	2	With additions to railways to March 1892.
India	1=64	4	With additions to railways to January 1891.
India	1=96	1	2nd edition.
India	1=256	1	With additions to railways to 1890.
Provincial Maps.			
Western Bengal	1=8	10	With additions and corrections to boundaries and railways to 1891.
Eastern Bengal, sheets Nos. 11, 12, 13 and 16	1=8	4	With additions and corrections to boundaries and railways to 1891.
Eastern Bengal, sheet No. 14	1=8	1	With additions and corrections to March 1892.
Bengal, Behar, Orissa, and Chota Nagpur	1=16	2	With additions and corrections to railways and boundaries to August 1891.
Central Provinces	1=16	2	With additions to 1891 (engraved).
N.-W. Provinces and Oudh	1=16	4	3rd edition.
Divisional Maps.			
Gorakhpur and Benares (N.-W. P.)	1=4	3	
Gorakhpur (N.-W. P.)	1=4	2	Corrected to 31st December 1891.
Kumaon (N.-W. P.)	1=4	4	Corrected to 31st January 1891.
Rohilkhand (N.-W. P.)	1=4	4	Corrected to January 1891.
Rajshahi (Bengal)	1=8	1	
District Maps.			
Hooghly and Howrah (Bengal), sheets Nos. 1 to 5	1=1	4	With additions and corrections to boundaries and railways to February 1892.
24-Pergunnahs (Bengal), sheet No. 5	1=1	1	With additions to railways to April 1892.
Basti (N.-W. P.), 1883—88	1=2	4	
Benares (N.-W. P.), 1882—84	1=2	3	
Patna (Bengal)	1=4	1	With additions and corrections to July 1891.
Shahabad (Bengal)	1=4	1	With additions and corrections to boundaries, roads and canals to December 1891.

Title.	Scale.	Number of Sheets.	Remarks.
District Maps—*contd.*	In. M.		
Sunderbuns (Bengal)	1=4	2	With additions and corrections to 1891.
Sylhet (Assam)	1=4	1	With additions and corrections to October 1891.
Standard Maps.			
Bengal.			
Sheets Nos. 1, 2, 5, 6, 343, 363 and 374	1=1	7	
Bombay.			
Sheets Nos. 279N.E., 308S.W. and 309N.W.	2=1	3	
Sheets Nos. 185, 186, 255 and 330	1=1	4	
Burma (Lower).			
Sheets Nos. 225 $\frac{\text{S.E.}}{2}$; 272 $\frac{\text{S.W.}}{3}$ and 273 $\frac{\text{N.W.}}{1}$ $\frac{\text{N.W.}}{3}$, $\frac{\text{S.W.}}{1}$; and $\frac{\text{S.W.}}{3}$	4=1	6	
Sheet No. 181	1=1	1	2nd edition.
Sheets Nos. 227, 569, 567 and portion of 583 (in one), and 568 and portion of 584 (in one)	1=1	4	
Central India and Rajputana.			
Sheets Nos. 430, 467 and 478	1=1	3	
Central Provinces.			
Sheets Nos. 24 $\frac{\text{N.E.}}{1}$, $\frac{\text{N.W.}}{2}$, $\frac{\text{S.E.}}{3}$, $\frac{\text{S.W.}}{1}$; 25 $\frac{\text{N.E.}}{1}$, $\frac{\text{N.E.}}{2}$, $\frac{\text{N.E.}}{3}$, $\frac{\text{N.W.}}{1}$, $\frac{\text{N.W.}}{2}$, $\frac{\text{S.E.}}{2}$ and $\frac{\text{S.W.}}{2}$	4=1	11	
Sheets Nos. 31 and 82	1=1	2	
Madras.			
Sheet No. 151	1=1	1	
N.-W. Provinces and Oudh.			
Sheets Nos. 3, 11, 12 and 114	1=1	4	
Sheet No. 100	1=1	1	With additions and corrections to February 1892.
Punjab.			
Sheets Nos. 116, 117, 118, 142, 143, 145, 168, 169, 211, 212, 223, 224, 234, 235, 236, 237, 238, 247, 248, 254, 255, 281, 291, 292, and 316	1=1	25	
Sheet No. 294	1=1	1	2nd edition.
North-Eastern Frontier Series.			
Sheet No. 15 N. E.	1=4	1	2nd edition.
Sheet No. 15 S. E.	1=4	1	4th edition.
Sheet No. 22 S. W.	1=4	1	2nd edition.
Sheet No. 23 N. W.	1=4	1	5th edition.
Sheet No. 23 S. W.	1=4	1	4th edition.
Sheet No. 23 S. W.	1=4	1	5th edition.
Sheet No. 23 S. W.	1=4	1	6th edition.
Sheet No. 15	1=8	1	2nd edition.
Sheet No. 22	1=8	1	3rd edition.
South-Eastern Frontier Series.			
Sheet No. 1 N. E.	1=4	1	4th edition.
Sheet No. 1 N. W.	1=4	1	1st edition.

Title.	Scale.	Number of Sheets.	Remarks.
Standard Maps—*contd.*			
South-Eastern Frontier Series—contd.	In. M.		
Sheet No. 1 N. W.	1=4	1	2nd edition.
Sheet No. 1 S. E.	1=4	1	5th edition.
Sheet No. 2 S. E.	1=4	1	4th edition.
Sheet No. 3 N. E.	1=4	1	3rd edition.
Sheet No. 4 N. E.	1=4	1	3rd edition.
Sheet No. 4 N. W.	1=4	1	4th edition.
Sheet No. 4 S. W.	1=4	1	5th edition.
Sheet No. 4 S. E.	1=4	1	3rd edition.
Sheet No. 5 S. W.	1=4	1	5th edition.
Sheet No. 1	1=8	1	3rd edition.
Plans of Cities and Cantonments.			
Kamptee, 1890	8=1	2	
Satara	8=1	2	With additions and corrections to May 1892.
Dinapore	6=1	2	With additions and corrections to July 1892.
Calcutta	3=1	1	2nd edition.
Index Maps.			
Sheets of the Simla and Kalka Road Survey	1=2	1	With addition of railway.
Standard sheets of Bengal	...	1	Corrected to February 1892.
Statistical Maps.			
India, illustrating the systems of Railway	1=96	1	Corrected to 30th September 1891.
India, showing Telegraphs	1=96	1	Corrected to 31st March 1892.
Administration Report Maps.			
Gurjat States (Chota Nagpur)	1=16	1	
Berar (skeleton)	1=24	1	
Punjab and surrounding countries (skeleton)	1=32	1	With additions and corrections to railways to June 1891.
Upper Burma	1=64	1	With additions and corrections to March 1892.
Bombay Presidency	1=80	1	With additions and corrections to 1891.
Central India Agency	1=80	1	With additions and corrections to 1891.
N.-W. Provinces and Oudh	1=80	1	
Punjab	1=80	1	
Rajputana Agency	1=80	1	With additions and corrections to 1891.
India (Railways)	1=96	1	Corrected to 31st March 1892.
Miscellaneous Maps.			
Kalakad Reserved Forest, Nangunere taluk, Tinnevelly District, Madras	4=1	6	
Papanasam Reserved Forest, Ambasamudram taluk, Tinnevelly District, Madras, 1890—92	4=1	7	
Terku Viravanallur Reserved Forest, Ambasamudram taluk, Tinnevelly District, Madras, 1890-91	4=1	1	
Muragumalai Reserved Forest, Periyakolam taluk, Madura District, Madras	4=1	1	
Palni Hills, Southern Slopes, East Reserved Forest, Palni taluk, Madura District, Madras	4=1	2	
Pambukallar and Kokkuparaikallar Reserved Forests, Palni taluk, Madura District, Madras	4=1	1	
Palni Hills, Northern Slopes, East Reserved Forest, Palni Taluk, Madura District, Madras	4=1	4	
Palni Hills, Northern Slopes, West Reserved Forest, Palni taluk, Madura District, Madras	4=1	4	

Title.	Scale.	Number of Sheets.	Remarks.
Miscellaneous Maps—*contd.*	In. M.		
Senkatampati Reserved Forest, Dindigal Taluk, Madura District, Madras	4=1	1	
Kadonakurichi Reserved Forest, Dindigal Taluk, Madura District, Madras	4=1	1	
Kudiraimalai Teri Reserved Lands, Tenkarai Taluk, Tinnevelly District, Madras	4=1	2	
Hazara Expedition, 1891, parts of Hazara District and Indus Valley	2=1	2	
Portion of coal-field tract, Upper Chindwin District, 1891-92	1=1	1	
Reconnaissance survey of the route followed by Lieutenant Daly's party towards the China Frontier, 1890-91	1=4	1	
Astor and Gilgit with surrounding country	1=4	1	
Ulwar State (Rajputana)	1=4	1	
Rajputana Topographical Survey Degree, Sheet No. IV, parts of Jeypur, Jodhpur, Kishengarh and Tonk States	1=4	1	With addition of railways to March 1892.
Map of Upper Irrawaddy River to illustrate the report on Frontier Expedition of 1890-91	1=8	2	
Map to accompany preliminary report on the Chin-Lushai country, December 1892	1=8	1	
Triangulation Charts.			
Ganjam and Orissa Topographical Survey, portions of Raipur, Bilaspur, etc., 1863-64	1=4	1	
Lushai Survey Expeditionary Force, 1889-90	1=4	1	
North-East Longitudinal Series, G. T. Survey	1=4	7	

APPENDIX.

EXTRACTS

FROM

REPORTS BY EXECUTIVE OFFICERS.

UPPER BURMA TRIANGULATION.

Statement of the out-turn of work executed by No. 24 Party during Season 1891-1892.

Description of details.	
Number of principal stations newly fixed	14
,, ,, figures completed	7
Length of principal series in miles completed	196
,, approximate series in miles in advance	88
Area of principal triangulation in square miles	4,300
Average triangular error in seconds	0″·62
,, probable error of angles in seconds	0″·32
Astronomical azimuths of verification	3
Number of principal stations selected in advance	10
,, platforms constructed for principal stations	12
,, principal stations placed under official protection	12
,, principal stations the elements of which have been computed	14
Area embraced by the triangulation to points exterior to principal triangulation in square miles	900
Number of points fixed by intersection but not visited	7
,, stations and points the heights of which have been determined	21
,, miles of rays and pathways cleared	20
,, preliminary charts of triangulation	2
,, hill-tops cleared of forest or jungle	10
Secondary Series—Approximate work in miles in advance	96
,, ,, Number of triangles completed	1
,, ,, ,, of points fixed by intersection	3

BALUCHISTAN.

ETHNOGRAPHIC AND HISTORICAL NOTES ON MAKRAN.

By COLONEL T. H. HOLDICH, R.E., *Superintendent, 1st grade, in charge No. 15 Party, Season 1891-92.*

The progress of the survey of Southern Baluchistan and Makrán has led to some interesting discoveries in connection with the earlier periods of occupation of that country which may possibly assist to throw light on the ethnography of its present inhabitants and elucidate something of their history.

Doubtless very much confusion prevails in the existing official classification of the tribes of Southern Baluchistan, especially in their sub-divisional sections; and although it is impossible to trace out the exact degrees of relationship that exist amongst them with anything like accuracy in the absence of all local historical record, it may be possible to re-arrange some of the larger tribal features with an approach to probability. The general effect of all enquiries in the inter-tribal relation of the Baluchistanis (*i.e.*, the inhabitants of Baluchistan in contra-distinction to the Baluchis) has been to prove that they are most irregular and indefinite. To find a parallel, we must take the Scottish highland clans of some three centuries ago, which indeed they very much resemble. The larger and more advanced communities, as they rise to ruling positions, absorb the dependent and mixed population around them. The slaves and the half-castes, with some of the weaker sections of other clans who require the protection of a strong arm in the general fight for existence, have cast in their lot with the winning powers, and assumed a genealogy which does not belong to them; and thus a few generations have been sufficient in some cases to establish the position of a powerful border tribe which had no previous existence. It is impossible, for instance, to suppose that all who call themselves Gichkis can be true descendants from that Punjabi adventurer who originated that tribe in the early part of the 17th century. Similarly with the Kambaranis (the ruling tribe of Kalat), amongst whom it would probably be as difficult to pick out a true Kambarani as to select a veritable Mackenzie from amongst the people of that name who form the bulk of the population of three counties of Scotland.

A certain amount of fresh ethnographical information has been obtained which may serve to define the successive waves of immigration into Makrán, and, when taken in connection with recent discoveries of strangely constructed sepulchral monuments, and with the relics of a forgotten commercial age which are found scattered along the coast may throw some light on eastern mediæval history.

It is indeed chiefly in unravelling the commercial history of Makrán that the interest of enquiry lies, for there are some who look for a fresh impetus and fresh direction to be given to the trade of Eastern Persia and Western Afghanistan by the establishment of railway communication between Sistán and the coast, or between Sistán and India; and a study of the commercial past of a country, a past so ancient in this case as to be utterly lost in the mists of antiquity, cannot but be useful in forecasting future possibilities.

What the former extent of the trade that passed through Makrán previous to the discovery of the Cape route to India may have been can only be estimated by the extent of the ruins that are now visible of its great coast ports. It must have been at its zenith in the days when Tiz (near Chahbar in Persian Makrán) and Pasni were large and flourishing cities. These were evidently the days when Siráf (the modern Tahiri, but still known by the old name) commanded the trade of the Persian Gulf, and the Arabs kept the seas. The extraordinary nature of the vast cemeteries at Siráf and Tiz, and the peculiar construction of the tombs, renders it certain that the same people lived and traded in both places. Of Siráf we learn a little from the records of Marco Polo. Of Tiz we have lately learned something by examination of its ruins, and we have found, as it were, traces of successive strata of occupation; Persian, Arabic, Venetian, then Arabic again, and finally, on the submit of this débris of centuries, a few fisherfolk living in mat-built huts under the shade of gigantic trees planted by a people of whom they know nothing.

The earliest written history that exists of Southern Baluchistan and Makrán is said to be that of Herodotus, who describes those countries as included in parts of the fourteenth and seventeenth Persian satrapies four centuries and a half B.C., and which mentions the names of tribes whose descendants can be traced locally to this day. But Makrán possesses an earlier unwritten history than that of Herodotus, and we must go back probably to 2,000 years B.C. to find the origin of those remarkable '*dambs*' or rough stone-built tombs which exist in many parts of the country, examples of which are described by Colonel Mockler, who visited them in 1876. Colonel Mockler was inclined to consider them Scythian, possibly monuments of the ancestors of those Brahui tribes who now occupy Eastern Makrán; but since he wrote we have the results of Mr. Bent's remarkable discoveries in the Persian Gulf, and his identification of the Bahrein Islands with the early home of the Phœnicians, the Tyros of Strabo and Pliny, the Sidodona of Nearchus, possibly the Tyre and Sidon of Biblical record, the centre of that vast maritime trade area from which Solomon's ships collected their gold and ivory, peacocks and apes. That a people who traded as far as the Phœnicians, who colonised as no people have colonised since, except the English, who carried their religious symbolism as far west as Ireland, where it is traced to this day, who, as Druids, erected Stone-henge, and who left

no land unexplored that was within navigable reach, should have neglected the coasts of Persia and Makrán is most improbable; and there is, I think, quite sufficient family likeness between the '*dambs*' of Makrán and the tombs opened by Bent and Durand, to warrant a conjecture that they may belong to the same people, though perhaps of a different age. It is indeed propably to the Phœnicians that we owe the name Beluchistan, the land of Belus, Baal or Bel, their sun-god. The Bahrein tombs (see *R. G. S. Journal* for January 1890) consisted of two chambers, upper and lower; the upper one being covered with rough unhewn limestone slabs, and containing fragments of ornaments and other properties of the deceased, even to the bones of domestic animals. The lower chamber was the real tomb. It was entirely coated with cement, and the ground of it was covered with a "thin brown earth somewhat resembling snuff." This was supposed by Mr. Bent to be the remains of decayed drapery, and in this deposit human bones were found. The whole structure was covered with a mound of earth through which was a passage to the tomb, and the mound preserved the tomb, securing it from the destroying influences of centuries. It was Captain (now Sir Edward) Durand who first disturbed the repose of the people who had been sleeping their quiet sleep in these tombs for about 4,000 years, and Mr. Bent followed, and made exhaustive examination of them. The '*dambs*' of Western Makrán and of the country south of Kharán, where they are very extensive, have no earth-covering to protect them. Those described by Colonel Mockler in his contribution to the Royal Asiatic Society, entitled "On ruins in Makrán" in January 1877, are built on the hard sloping surface of a shelving hill side, and he does not suggest the Phœnician double storey; but the condition of the interior strongly points to the possibility of such a construction, and suggests that the slope of the hill may have been utilized in support of one end of the partition, whilst the position of the doors (facing west, so that the head of the deceased lay eastward); the traces of cement covering the walls completely; the brown snuff-like deposit; the occasional remains of shell ornaments and the few bones, are all indications that those most ancient mariners, the Puni, were the builders of these sepulchres, although the want of earth-covering has led to the more speedy dissolution of the relics. Mr. Bent notes that all the Bahrein tombs were not earth-covered; he states that "miles away, in the direction of Rufaa, we found mounds elevated only a few feet above the level of the desert, and some mere circular heaps of stones. Now, it is a peculiarity of the '*dambs*' of Makrán that where the tombs have subsided, they form "circular heaps of stones." Colonel Mockler says of the '*dambs*' at Damba-koh that "when these '*dambs*,' which are square, fall to ruin, the stones of which they are composed almost invariably form a perfect circle. The lintel of the doorway, or the wall next to it, appears generally to give way first, and the apex of the cone-like roof falls in; the side walls then gradually subside, and eventually all trace (without clearing away the stones very carefully) of the former square shape, or of a doorway, is lost, and a circular ring of stones is formed, with a patch of white clay in the centre."

The Damba-koh monuments.

It is unfortunate that no one observer has as yet visited the Bahrein tombs, the Damba-koh, and the Kharán '*dambs*'; otherwise conjecture might have given way to certainty. There appears to be great probability, to say the least of it, that the origin of them all is the same.

So far it has, I think, been a generally accepted theory that the double-storeyed tomb is a distinctive Phœnician construction, but we have found, in the process of surveying this old world country, a remarkable collection of tombs near Jalk, known locally as the "tombs of the Maliks," built in two storeys and crowned with a cupola. They have been carefully examined by Mr. G. P. Tate, and it seems clear that, whatever may be the prototype of these curious constuctions, they are certainly younger than the '*dambs*' by some thousands of years. These will be described further on; meanwhile, we will follow up from the Damba-koh the first faint indications of the early history of Makrán, indications which, faint as they are, may serve to quicken the inspiration of our modern historians of the Persian Gulf and the Erythræan Sea, and possibly induce an archæologist to turn his attention this way.

Other monuments constructed on Phœnician principles.

The Phœnicians, we know, in later times betook themselves to the less genial but more refreshing climate of the Mediterranean, and entirely forsook the land of their birth. Some of them indeed revisited Makrán in the train of Alexander's army, acting as sutlers and merchants, still retaining a keen eye to the collection of 'myrrh' and 'spikenard.' If we are to believe Arrian, they must have had every reason to congratulate themselves on their intermediate change of climate, for they certainly showed no disposition to remain in the early home of their ancestors. The Alexandrian epoch in Makrán gives us the first solid clue to the character of the people of Makrán (the Mahi-Khurán, or icthyophagi) in the third century B.C. When that great conqueror reluctantly turned his face southward from the Punjab and brought his ships and his armies by the highway of the Indus to the sea, who were the people that he found occupying the country that lay between him and Persia? Who were the *Malli* of the Indus delta, the Oritæ of the Arabius, the Gadrosi, the Arachoti, the Parikanoi and others who barred his progress or swelled his triumphs?

Alexander's epoch in Makrán.

It is curious that after a lapse of 2,300 years we can find representatives for nearly all of them in Southern Baluchistan, and most of them very near where the Greek geographers placed their forefathers.

Identification of tribes mentioned by Greek historians.

The Oritæ, indeed, are not easy to identify. There are no people near the Arabius (if the Arabius has been rightly identified as the Puráli) answering to this Trans-Indus clan. The Hôts of Western Makrán may possibly be their modern representatives, but this conjecture is merely based on the slight similarity of name and the undoubtedly ancient lineage of that tribe. Their change of locality would not be unusual. The bodily transfer of a people from one part of the world to another, which has formed so remarkable a feature in early history from the days of Israel to those of the Mongols, is apt to upset the most ingenious theories of genealogical succession; but we find one guiding rule in India which may generally be trusted in deciding the course of successive waves of occupation in any country. As a rule, the latest arrival will be found to occupy the most productive (and consequently the most attractive) ground, whilst the older residents have been driven, like Kaffirs, Bhils and Gonds, into the most inaccessible wildernesses. The inference indeed is strong that the wild men of the hills are the first owners of the soil. Makrán seems to offer no exception to the rule. Long before the days of Alexander, when Greek settlements were in existence through the length and breadth of high Asia, Makrán had been peopled by successive irruptive hordes from the same unfailing sources in Western and Central Asia that had peopled India, and probably in the same progressive order. First came a Turanian race, possibly the Naga of the earliest Hindu writers. These were displaced by the Aryans. Then followed the nomadic Saka, Sacæ, Saxon, Skythian races from beyond the Hindu Kush. Some of these, in later times, may possibly have formed part of Alexander's army, but they were clearly in occupation of Sistán (Sakastan, according to Latham) and parts of Makrán two centuries before Alexander's time. They have apparently disappeared from Sistán, driven southward by Aryan interlopers, but they are found again under their old names, in the Baluch province of Mushki. In these days the Sakas of Mushki, and the Sakazai, the chief section of the fast diminishing Sajadi clan, all claim to be Brahuis. But the Brahuis are clearly the older Turanian settlers, who have been gradually driven into the more inaccessible and wilder hill districts of the east by Aryan immigration, just as their undoubted Tamil brethren of the Central Provinces and Southern India have been gradually hemmed into the almost unexplored forests of Gondwana and the south; for the Brahuis speak a Dravidian language, and the physical likeness between them and the aboriginal tribes of the Central Provinces is marked enough to any one who has studied them both. Colonel Mockler notices, too, as a curious fact, that there is at least one legend attached to the oldest of the stone monuments in Makrán which is common to the Makráni and the Tamil, who tells the same tale about the monuments in Southern India as the Makráni tells about the Damba-koh. The peculiarity of the legend is such that there can be little doubt about its identity of origin. Another fact pointing to their Turanian extraction is that the chief tribe amongst the Brahuis, indeed the most powerful clan in Southern Baluchistan, is called Mingal, and that Mingal and Mongul are derived from the same Turanian stock, that the two names are in fact identical, is a tradition amongst them which it would be hard to set aside. Possibly, indeed, all Brahuis were originally termed Mingal, and the word Brahui or Ba-rohi, which is a word of Sanscrit origin meaning "hillmen" ('*roh*' being a hill in Pushtu), is a comparatively modern designation. The name appears at least to have been known to the Greek historians, for (according to Dr. Bellew) the word Parikanoi is but a transliteration of the Parakan of Persian and Sanscrit, which has exactly the same meaning, *viz.*, "men of the hills." Thus the Sacæ and the Parikanoi appear to be almost exactly where Alexander found them. The Gadaras too, who gave their name to the country as Gadrosia, are still in their old world haunts in the district of Lus Bela. These Asiatic Ethiopians are said (to quote Dr. Bellew again) to belong to the various Kach, Kaj or Kej tribes, who originated the Kach Gandava and Katch Makrán territorial divisions of Baluchistan. They must not be confounded with the Gadurs, who claim to be Koreish Arabs. The Gadaras may possibly be the Garudas of ancient Sanscrit literature, who were (as eagles) represented as being at constant war with the Nagas (snakes); thus, for aught we know, a Sidi stoker of a P. and O. steamer, who is either a Gadara or a Med, may be able to trace back his descent to the time of Moses. Many of the Sidis are however slaves or half-castes from the coast, and of very doubtful origin.

Sacæ or Saxons.

Brahuis.

Gadaras.

The later Aryan or Tajik stock in Makrán, analogous to the same original strata of society in Afghanistan, is well represented by several tribes, chief of which are the Durzadas. The Durzadas (? Derusiai of Herodotus) speak a pure Persian dialect. They are husbandmen, tillers of the soil, like other Tajiks, and when actually employed as slaves, are called Nakibs. They acknowledge the superiority of the so-called Baluch and Brahui tribes amongst whom they dwell, and in their physical bearing there is strong resemblance to the Tajak of Afghanistan. Closely allied to them are the Dehwars, who, as their name denotes, are likewise husbandmen and cultivators. The Dehwars of Kalat are the people who chiefly arrested the attention of Pottinger; but Mr. Tate, of the Baluchistan Survey, describes in his report a very large tribe indeed in Western Makrán bearing the same name, and numbering some 17 or 18 clans, who consider themselves allied to the Rinds, but who are nevertheless undoubted connections of the Kalat Dehwars whom Pottinger rightly classes as Tajik. The Dehwars and Durzadas are probably all of one common Tajik stock, aboriginal Aryan settlers of later date than the Brahuis.

Tajiks.

Meds.

Amongst the oldest residents in Makrán we must admit the Meds. "They have peculiar religious customs, and are superstitious and immoral." This is the verdict of the official Gazetteer, and it is correct enough only that it is hardly exhaustive. In modern days the Meds are a race of coast fishermen, harmless folk, living in much apparent simplicity in huts made of the Pish palm matting, whose lives are almost amphibious, and whose living is derived entirely from the sea. No sea in the world is probably more prolific than the Arabian Sea. The whole coast of Makrán is impregnated with an atmosphere of fish. Fish dried and salted are stacked at the village ports for exportation to the West Coast of India, where salt duties have interfered with the Home industry. Sharks' fins are exported in tons, chiefly to China, and cuttle fish abound. Every living thing in Makrán lives on fish—men, women, dogs, cats, donkeys, and probably camels. I did not see camels eating fish in Makrán, but I observed that they were trained to that diet on the Arabian coast. It is not difficult to recognize in the Meds the ichthyophagi of Nearchus. But Sir Henry Elliott tells us that the Meds of the Makrán coast once occupied the whole delta of the Indus, and, together with the Jats, the whole Indus Valley; that the Meds may possibly be *Medes;* whilst Lassen states that the Meds and Jats are mentioned in the Mahabharata as Madras and Jartikas, eleven centuries B.C. The Jartikas of the Mahabharata are certainly not to be recognized in the Jata Skythic race, who, we know, displaced the Greeks on the Indus about the same time that, as Goths and Vandals, they surged into Europe. If we apply the theory of looking for the aboriginal race in the most inaccessible regions, we should find the Jadráni of the Jadrán hills, west of Tochi, to be the most likely representative of so remote a people as the Jartika, but an identification of this sort must be purely hypothetical. The Med, there seems good reason to think, represents the Mand or Mandan, who for long centuries disputed with the Jats the possession of the Indus Valley.* They may indeed be the same people as the Mers (Mhairs) and Sir H. Elliott suggests that Mæris, King of Pattala, capital of the Indus delta in Alexander's time, was chief of the Mers, or Meds, or Malli, in the conquest of whose country occurred the stirring episode in which Alexander's life was so narrowly saved by his friends Peucestas and Leonatus. It was the piratical successes of the Meds on the high seas that led to the invasion of Sind by the Arabs in A.D. 705; and some centuries later we find the Arab geographer, Ibn Haukel, writing of the Meds or Mands as being still on the Indus and still holding command of the sea. In the coast fishermen of Makrán, now-a-days, one would hardly recognize the scion of an ancient and famous line of sea-kings who carried piracy and pillage into eastern waters with all the ardour and success of the Danes and Vikings of the west. Into the composition of the Med (said in the "Majmalu-t-tawarik," which gives the first account of them that we possess, to be a descendant of Ham) there doubtless now enters a large admixture of African slave blood. Slavery, as an institution, is happily no longer rampant on the Arabian and Persian coasts. Nevertheless there is still more than a lingering trace of the old slave traffic surviving in these countries; slaves are common enough in every port, and there are at least three villages not far from Chahbar where slaves are bred and reared; neither does it appear quite certain that these slaves are bred and reared solely for the local Persian market.

Bolédis.

Amongst others of the ancient tribes of Baluchistan, traces of whose existence remain to this day, we find the Bolédi mentioned by Ptolemy. The Bolédi, as their name denotes, may possibly be of Assyrian origin, possibly even more anciently connected with the Baal of the Phœnicians than the Bel of the Assyrians. They are stated in the official Gazetteer to be of Arabic origin, and to have dispossessed the ruling Maliks in the 17th century, when they headed what is known as the Baluch confederation. They may indeed have subverted the Kaiani Maliks, but they were undoubtedly the original occupants of the Bolédi valley. They are included amongst Brahuis by Latham, but this seems certainly to be incorrect. Whatever may be their pride of origin and race (and that it is most ancient is indisputable) it has been left to the end of this present century to see the last of the reigning house of Bolédi. There is at present living but one representative of the ruling family of the Bolédis, a lady, named Miriam, who lives on the bounty of the Sultan of Muscat. In the second quarter of the last century the Bolédis were overthrown by the Gichkis, of whom more presently.

Coast configuration in Alexander's time.

Thus we are enabled to trace an outline of the ethnography of Makrán as it existed in Alexander's time, and we see how little it has been affected by subsequent waves of invasion, Arab and Tartar, that have left so deep an impression elsewhere in the history of the East. Three hundred and fifty years B.C. there existed in Makrán, Turanian, Aryan, and Ethiopian tribes, gathered in clans amid the wilderness of low hills and sandy deserts much as they are gathered now. The products of the country then so highly esteemed—the myrrh and spikenard—are still to be found, and the euphorbia of the sandy wastes, and the mangrove of the swamps, are still much as Arrian describes them. Probably no part of Asia has changed so little as have the south-western shores and borders of Makrán. The slow-moving course of the fleet under Nearchus has been traced out by Colonel Mockler from the mouth of the Indus to Sonmiani, Pasni, Gwadur (then called Badara, a flourishing little town, with palms and gardens) and Chahbar, and from thence

* The Mandan are of Jata Skythic origin according to Bellew—the Mada or Medes being Naga.

to the Persian Gulf, with a careful accuracy which places his deductions beyond contention. The great headlands of Pasni and Gwadur have changed little in 2,500 years, and with the exception of the submergence of two islands (Pola and Kerabia), off the east of Gwadur Bay, there is hardly a noticeable point of difference in the broad features of the coast. Another island called Derenbosa has disappeared from the west end of the Gwadur headland, and there is yet another which is even now in process of breaking up off Pasabandar, near Gwadur. But these are comparatively small alterations in the coast configuration, and there is nothing whatever analogous to the enormous geological changes which must almost have reconstituted the climate of High Asia within the same period —changes, some measurable approximation to the extent of which was realized by the scientific officers connected with the Afghan Boundary Commission, and which were referred to by Mr. Howarth at the conclusion of Captain Younghusband's last lecture at the Royal Geographical Society. It is probable that the main rivers have silted and formed deltas for themselves where they were once navigable, and I should be inclined to think that the ruins at Sutkagen Dor, 40 miles to the north-west of Gwadur on the Dasht River, are not ruins of a temple, as suggested by Colonel Mockler, but that they are what local tradition assigns them to be, *i.e.*, the remains of an old ghât, or '*bandar*,' to which boats came up from the sea. It must have been down the Dasht River that Alexander turned to the sea-coast after traversing the long narrow Kej Valley for 150 miles. The Kej Valley, however, must then have been in a far less advanced state of civilization and cultivation than it is at present, and all Southern Baluchistan must have been far more thinly inhabited. Thus far we get a very imperfect, but still far from colourless, view of the Makrán of Alexander. The earliest of the rude stone monuments were there before him, but it is probable that the great dams,' or '*ghorbastas*,' of Panjgur and Kolwah awaited the hands of later builders during the period of Arab occupation. Imperfect as this glimpse of early Makrán may be, it seems that, in parting with the Alexandrian epoch, we lose the clearest light that has ever been thrown on its ethnography. There follows a period of darkest historical confusion for a thousand years or so that filled up the gap between the Greek and Arab invasions, during which we have to account for the advent of the so-called Baluchi into the country; for by a strange irony of fate, the Baluchi of to-day is a comparatively recent arrival in Baluchistan, and has probably little or nothing to say to those Baal worshippers who gave the country its name.

Baluchis.

The three great sections of the inhabitants of Baluchistan who are generally recognized under the term Baluchi are the Rinds, the Naruis, and the Maghzis. The latter are apparently unrepresented in Makrán, and the Rinds and Naruis, who are the two great representative tribes, and have doubtless gathered to themselves a host of minor Khels and clans, now occupy all the fairest and most productive valleys of the country. The Rinds include such well-known tribes as the Rekis, Maris, Bugtis, and Bozdars. The Naruis include Sonjaranis, Rakshanis, Kurds, Mings, Arbabis, and Malikahs, according to local tradition. I cannot say that Survey researches throw much fresh light on the history of those people, although Mr. G. P. Tate has spared no labour to render his account of them as accurate as possible. All of them, Naruis and Rinds alike, delight to consider themselves Khoreish Arabs, and to date their first introduction to the country from the time of the Arab conquests. The Rind tradition of their Syrian extraction is well known. It is to the effect that they were Khoreish Arabs driven from Syria by the persecutions of the Kaliph Yejid at the end of the seventh century A.D. They first settled in Dalgan, and then spread abroad; part of them under Rustom Khan, Chakar, emigrating to the Kachchi, where some of them remained in Shoran, to the north-east of Kalat, whilst others again returned and occupied the country about Dizak and Sib. Pottinger calls them all Turcomans. Latham (the ethnographer) remarks that their language is Jatki, and their appearance 'Indian.' With so much diversity of opinion, and the absence of written record, it would perhaps be safest to accept the evidence of language and appearance, and to assume that they were a part of the great Jata Skythic immigration which superseded the Greek occupation of Baktria and the Indus Valley, and that they occupied Makrán, much in the manner indicated by their traditions at the same time that India and Eastern Europe were inundated by Jat hordes. The Rekis of the desert south of the Helmund (Rekistan) are not mentioned by Pottinger, who wrote early in the present century. They are possibly connected with the Sistáni Shahrekis mentioned by Goldsmith, who considers them as originally emigrants from Western Persia. The Shahrekis were in Sistán centuries ago, together with the Kaiyanis and Sarbandis, but were displaced by Shah Rukh, and emigrated to Hamadan, whence they subsequently returned to Sistán. Whilst it is difficult to set aside the Rind tradition of their Syrian origin, it is impossible to admit that they are Arabs, a tradition which is maintained by the Rekis, as well as the rest of the Rind Family. The Rekis claim to be Rinds, but I consider the claim a doubtful one. They are obviously but recent arrivals in the deserts they now occupy, and they say themselves that they found the monuments and remains of sepulchres near Jalk when they took possession. Some of these monuments are not so very old, as we shall see. Amongst the Rinds, Pottinger classes the Naoshirwanis of Kharán—the most important tribe probably in Southern Baluchistan. This again is obivously incorrect. The Naoshirwanis are Persians, speaking a form of old Persian, and Mr. Tate favours Sir Oliver St. John's view as expressed in his report of the Sistán Boundary Commission, *i.e.*, that they came into Baluchistan from Luristan, whence they were expelled about the time of Shah Abbas.

Rinds.

Naruis.

Of that important section of the Baluchis which is classed under the head Narui very little fresh information is at present forthcoming. Certainly the great Narui tribe does not include all the minor Khels with which it is credited in the official Gazetteer (the Sajidi, for instance), and certainly they do not represent one original horde of immigrants into Baluchistan, but successive waves of a human sea overlapping the northern borders of Makrán, and spreading further and further southwards with the lapse of time. I hardly think that the term Narui is to be traced to Na-rohi, *i. e.*, "*not* men of the hills," or, in other words, 'men of the plains.' This negative form of nomenclature is, to say the least of it, uncommon. The tradition amongst some of the Narui tribes is to the effect that they spread into Dizak and its neighbourhood from the Malik Naro hills. This seems to point to a Sistáni origin, and as we now know that the wide plains of Sarhadd to the south and west of Sekoha are occupied by Naruis, and that they extend north to Kala-Fath on the Helmund it is, at least, probable that the Makráni Narui is but the result of a natural overflow from the north-west. Their language is early Persian. According to the ethnographer Latham they are Kurds, and it will be observed that Kurds are included as a section of the Narui tribe in the Gazetteer, and that their appearance and manners are Kurdish. They are probably comparatively late arrivals in Makrán. Greek writers do not mention them, and their own traditions support the theory of their recent occupation.

Gichkis.

The Gichkis (the ruling tribe at Kej) again are modern innovators descended from one Mai Sing, a Sikh adventurer, who appeared in Makrán about the beginning of the 17th century. They say they remained Hindoo for three generations and then adopted the faith of the country, or rather they started a sect of their own called Zikari. They are allied to the former ruling race at Kej, the Bolédis, whom they deposed. Another tribe said to be descended from a Syud adventurer is the Duzurgada, a powerful clan in Dizak, of which Dilawur Khan is chief. These are interesting examples of the rise of a people from a single individual and illustrate the process of multiplication that takes place in the strength of a clan due to the gradual absorption of weaker tribal surroundings.

Lassis.

The Lassis of Las Bela (who represent the Lumris, and Gadurs, not to be confounded with the Gadaras) form the Rajput element in Southern Baluchistan, and are the only people who are of ancient Hindu stock. Not much is known about them, although they are so contiguous to the Sind frontier, and further investigation into the history of this old offshoot of Hindu race will be most interesting. It may be noted that they occupy the geographical position assigned to the Oritæ by Arrian.

Dark phase of history.

Between the disappearance of the Greeks and the Arab invasion of Makrán early in the 8th century we have no written record, and there intervenes a dark period of history extending over more than a thousand years. Pottinger seems to think (and with good reason) that in the days of the Greek march through Makrán, the northern part of the province was almost desert and unpopulated. It would certainly seem, on examination of the map, that there is but one route by which the Greek armies could have traversed the country from the eastern border to the Dasht river, and that one includes the long narrow Kej valley which runs at a distance of from 30 to 40 miles from the coast parallel to it. No traditions exist, and no record has been found to mark the event, and the Kej valley can hardly be said to answer to Arrian's description of Gadrosia. The sand hills and deserts which impeded the two months' march from the country of the Oritæ to Pura, the capital of Gadrosia, as described by that historian, are such as would distinguish the Mashkhel desert rather than the now comparatively fertile district of Kolwah.

Arab invasion.

The next certain history of Makrán that we arrive at is that of Ferishta, who tells us that the Arabs overran Sistán and Makrán, and that Sind was conquered by Mahomed Kasim, son-in-law of Hajjij about A.D. 705 to 715, or about the same time that Spain was conquered by the Saracens. It was the piratical successes of the Meds that first led to the invasions, and so uncertain were the Arabs of the routes which led through Makrán to India that they adhered as closely as possible to the coast-line during their advance. There is a very old tradition extant in the valley of the Indus, to the effect that the palm-groves of Dera Ghazi Khan and other Indus districts were due to the date stones that the Arabs flung away on their march. Tradition for once seems to be possible history, for it does not appear that the date palm is indigenous either to Makrán or Sind. Very possibly the source of the chief wealth of Makrán, those date groves which form a distinctive feature that must have changed the whole aspect of the country, were not called into existence till as late as the 8th century A.D. It is true that palms are mentioned as flourishing at Gwadur in the days of Alexander, but it is quite possible that the mass of palm vegetation which is now found in Kolwah and Kej had no existence at that time, and that it owes its origin largely to Arab enterprise. The Arabs have left but little trace of their language either in Sind or Makrán. According to Sir H. Elliott (who quotes Ferishta) they never really colonised in Sind. They did not bring their women with them, as was their fashion elsewhere, and their occupation of the Indus valley terminated with Al Kadir in 1031. A few words applied to the geographical features of the country, such as 'Jebel' and 'Wad' or 'Wadi', still survive, but on the Indus, at any rate, Arabic has disappeared as surely as the Greek

tongue, which the Arabs suppressed. Multan was originally an Arab settlement, and from Multan as a trade centre connection was kept up with the rest of the Mahomedan Empire. Sistán was during these dark centuries a well-cultivated country; Kirman and Makrán were full of Arab settlements, and it is to the Arabs almost certainly that Makrán owes those gigantic public works of stones the '*ghorbastas*,' or dams built across the debouchment of hill streams to secure a head of water for irrigation purposes, or such monumental '*bunds*' as that on the Ras Nuh, at Gwadur, which retained their water-supply. The Arabs were great masons, and the ingenuity with which gigantic slabs of stone are toggled and dovetailed together has never been surpassed by any builders in the world. The Arabs indeed changed the face of Makrán from what it was in Alexander's time to something better than it is at present; and then passed away.

Arabic trade.

This unwritten and untold story of the Arab occupation of Sistán and Makrán is of peculiar interest to us, for it seems probable that it was during those misty centuries that a European connection between India and the East was first introduced.

Dawn of European enterprise in the East.

After the overthrow of the Sassanian dynasty in A.D. 641 at the battle of Nahavind, and Yezdigird's flight to Sistán; through the gradual rise and fall of the power of the Kalifs, until Baghdad was taken by Toghrul Beg in 1255, and Arab supremacy was finally broken; we have to grope about in the mists of mediæval twilight for some faint trace of European adventure in these eastern seas. There is little doubt about its existence. It is probable that even those early days saw the first keels laid for sea-going European ships built after an Arab model. Arabia was then mistress of the eastern seas and her mercantile fleets filled the ocean highways and set the fashion of mercantile exploration to the western world. No one who has studied the shape and make of our earliest ocean-going ships, and has compared them with the 'buggalos' and 'dhows' which dot the Arab and Persian coasts, can fail to detect indications of the origin of our lines for wooden ship-building. Even our nautical terms are many of them Arabic. What else is the derivation of "cutter," dinghy" and "barge"? The prototype of our "*Henry VIII*" and "*Royal Sovereign*" of the 16th century may be seen any day hauled up for repairs on the sands at Muscat or Koweit, even as the Arab prototype may itself be found on the Euphrates, built of 'shesham' and 'pitched within and without' with petroleum. The Arabs occupied Makrán and part of the Persian coast long after the last of the Kalifs had been starved in his treasury at Baghdad, for we have the evidence of Marco Polo, writing about 1290 of the kingdom of Kez Macorán, that "the most part of the people are Saracens. They live by merchandise and industry, for they are professed traders and carry on much traffic by sea and land." The largest and most flourishing port of Kez Macorán in those days was undoubtedly Tiz, near Chahbar, and we now have evidence enough to prove the closeness of the connection between Tiz Siráf (the modern Tahiri), which was then a large trade port on the Persian coast, and was flourishing in an age contemporary with Hormuz. This was at a time when Hormuz was as yet undevastated by the Tartar, and was still on the mainland. The epidemic of Tartar and Turk invasion had set in three centuries before Polo's time, beginning with Mahmud of Ghuzni at the commencement of the 11th century, but Hormuz and Siráf still held their own on the mainland. There was hardly a corner of Persia unvisited by the Moghul even then, and Moghuls held all Asia and Eastern Europe. Kublai was "great Kaan," whilst a Turk, Nasr-udin, ruled at Delhi. The Dravidian kingdoms of Southern India were untouched, but all Northern India was in the hands of the Turk. The greatest avenger of all, Timour, had yet to come. He came in 1387, and his exploits are still the tradition of the country side in Sistán and Makrán. It was probably Timour who finally broke the power of the Arabs in Makrán and on the northern shores of the Persian Gulf.

Origin of the lines of English ships.

Marco Polo's time and previous.

During last winter I visited both Siráf and Tiz. Both places are now but uneven masses of heaped up ruins, spreading over a mile or two of the coast, and shadowed by sandstone or clay cliffs which steeply scarp the sides of the rough unvegetated hills. There is much in the conformation of these hills, and in the nature of the narrow valleys running up from the sea, with their unusual display of mighty and aged shade trees (banyan and peepul), that is common to both places. Especially noticeable is the gigantic cemetery which is formed out of the overshadowing hills. Every yard of these hills is occupied by a grave. There are tiers of them on the hill face, which spread into acres on the hill summit; and they are all alike, whether in Siráf or Tiz—from 3 to 4 feet deep, by about 2 feet wide, and 6 or 7 in length. There is this remarkable feature about them. A ledge is cut about 2 feet from the bottom of the grave, which extends the whole length of one side of it. Thus slabs of rough unhewn stones can rest slantwise, one edge fitting into the angle formed by the bottom and side of the grave on that side opposite the ledge; the other edge resting on the ledge itself, forming a neat little recess beneath, of triangular section, in which the body rests. Above the slabs the grave was apparently filled in with earth (at least we found nothing else), and below the slab were only the bones of a body apparently laid on its side at full length.

Siráf and Tiz.

Earlier explorations in Siráf by Captain Townsend, of the Indo-European telegraph steamer "*Patrick Stewart*," had led to the discovery of a tombstone, of which the inscription was finally deciphered at the British Museum, and which proved beyond doubt the

Arabic character of the settlement, and confirmed Polo's assertion that at the end of the 13th century the occupants of Tiz and Siráf were Saracen. But in Saracenic times we know from Ibn Haukel (writing about 1000 A.D.) that the infidel and the Mussulman traded together, and that trade concessions were occasionally interchanged. "In the middle ages (says Elliott) it was only the power and political influence of the Amalfitans, Venetians, Pisans, and Genoese that were sometimes able to extort from the reluctant Mussulman concessions that were willingly granted by the more easy and indifferent Crusaders and Greeks," and "this intercourse with the Saracens was not merely subject to these formal restrictions, but was strongly and honestly reprobated by sincere believers—and not without reason, when we reflect that some of these traders, *especially the Venetians*, disgraced their honor and their faith by supplying the Egyptian market with Circassian slaves, and even rendered their necessary assistance in driving the Crusaders from Acre." So here we have the Venetians in the field, engaged too in the lucrative pursuit of slave-dealing, as early as the 9th century A.D., and apparently intimately associated with the Arabs in those commercial enterprises which linked the East and West by Persian and Mesopotamian routes, and which existed on a scale the extent of which is very little comprehended at the present day. It is a curious and possibly significant fact that the European nation which possessed command of the great overland trade route on which Sistán and Makrán were not unimportant links, was the first commercial nation in the world so long as it held them. It is true that this was before the discovery of the Cape route to the east, whilst as yet the overland route was the only one known to civilized Europe. But with the new links that are being slowly but certainly forged by means of railways between West and East, the old order of supremacy will as certainly revive. The strength of Makrán may yet again be recognized in that geographical position which for many centuries must have enabled her to command a vast share in the trade of Southern Asia.

Arabic and Venetian trade convention.

It appears, then, to be probable that for four or five centuries, whilst Arabia dominated the East, and Venice was mistress of the Mediterranean, whilst as yet Alexandria was the great emporium of the West, Venetians and Arabs were intimately associated in perhaps the greatest trade confederation of the world. If so, we should expect to find evidences of Arab and Venetian occupation of the coast ports of Persia and Makrán more or less intermixed amongst the relics of the past. In Makrán, at any rate, we do so find them. It has long been known that Venetian ducats passed current amongst the coast people, although I have never actually seen them. In excavating the Miri at Quetta for defensive purposes, some of these ducats were discovered by Sir James Browne, and they are now in the British Museum. It may be interesting to mention here that in the same Miri (a mud mound of volcanic origin, which formed a convenient and commanding position for the principal fort in Quetta), a small bronze statue of Hercules was subsequently unearthed by Captain Mackenzie, R.E., an interesting relic of the march of Craterus through Quetta and Kandahar. During last winter, Mr. G. White, of the Indo-European Telegraph Department, discovered at Tiz a gold Venetian ducat of the same value as those found at Quetta, and with the coin were two or three seals cut in agate and cornelian, apparently representing at least two distinct epochs of Arab occupation, one being comparatively modern, and the others (apparently) in cufic character.* Additional evidence exists in the vast quantity of glass ornaments, and the peculiar pottery which are to be found exposed on the surface of the ground amongst the ruins of the old Makrán cities of Pasni and Tiz after heavy rainfall. This glass has not the filmy glaze of the earliest Egyptian glass. It exists in various forms, none of which are entirely transparent. Occasionally fragments are found encrusted with a secondary glaze of glass of different color: or a glass bangle may be found intertwisted with colored threads; or (prettiest of all) small colored ornaments of crude design are applied to a black or dark colored base. The pottery of Siráf and Tiz is very varied, and none of it of oriental design, as we use that term in India. There is a vast quantity of pale sage green celadon, magnificently glazed with a double glaze (inside and out), and a few fragments of ordinary unglazed clay which have been cast in a mould of most elaborate western ornamentation, the figures of which are in high relief. It might be suggested that all the glass and pottery were trade importations, but this theory is upset (as pointed out by Mr. Lockwood Kipling, of the Lahore Museum) by the discovery of part of a jeweller's mould, and of a small tripod arrangement on which pottery rests during the process of baking. Mr. Kipling is inclined to support my opinion that the glass is far more probably due to Venetian rather than Phœnician artists, and that it is of local manufacture.

Arabic and Venetian relics.

The history of Venetian trade supremacy in the East would be of absorbing interest if it could be efficiently recorded. It must have existed through those centuries during which Asia and most of Europe were convulsed with the gigantic conquests of Turks and Mongols. It must have been uninterruptedly maintained in the high seas and along the coasts that fringed the scenes of savage warfare and almost incredible devastation, with a serenity that has left no local record, and but little trace of its existence. The chequered career of Portugese occupation of this Eastern world was but a passing incident compared to that of the Venetians. Even our three centuries of gradually extending influence in India are less in point of time than the Venetians, if we are to judge by the few indications which are now before us.

* I have been unable to get them deciphered.

The tombs of the Maliks.

Amongst the many relics of bye-gone ages throwing snatches of light into some of the darkest corners of history that have been discovered by our surveyors, not the least curious and instructive are the double-storeyed sepulchres, surmounted with cupolas, which are locally known as the "tombs of the Maliks," at Guachig, near Jalk. I am indebted to Mr. Tate for the illustration and description of these curious buildings. These illustrations explain themselves. It only remains to add that they are built of burnt brick and mud cement. The bricks are flat, about 10 inches square and 2 inches thick. The tiles which cover the buildings are square, about 1 foot to 14 inches. The designs on them (some of which are described as exceedingly quaint) are on relief, scraped out from the surface (so Mr. Tate thinks) with an iron tool. Nur Mahomed Khan, brother of the Sirdar of Mashkhel, says that there are similar tiles at Kala-i-Fath on the Helmund, the ancient capital of the Kaiani kingdom which included Sistán. I cannot say that I recollect seeing any when visiting Kala-i-Fath with the Boundary Commission, but they may exist in the interior of the Fort citadel, into which I did not penetrate. The peculiarity of the tombs consisted in the double chamber, which is evidently a later development of the Phœnician tombs of the Bahrein islands. One very curious similarity between these tombs and those examined by Captain Durand, and subsequently by Mr. Bent, lies on the recesses marked *b-b-b* in Mr. Tate's drawing. In the Royal Geographical Society's "Proceedings" of January 1890 we read that in the upper chamber of the Bahrein tomb there were "at the four corners four recesses, two feet ten inches in depth." This in itself marks a distinct connection between the tombs of Guachig and Bahrein. In the Guachig tombs, however, the sarcophagus is in the upper, not the lower, storey; and it is the lower storey which is filled with the bones of the human dependants of the chief who occupies the upper chamber. Of these bones and the wrappings which cover them Mr. Tate remarks that "the grave-clothes were in fairly good condition, and the same below as above. The bones were exceedingly large and in excellent condition."

There can be little doubt that these structures are what they claim to be, *i.e.*, the "tombs of the Maliks."

Subsequently to the Peshdadi, Kaiani, and Sassanian dynasties which closed with the battle of Nahavind in 61, A.D., Sistán fell under the rule of the Kalifs. To them followed the Ghaznavi dynasty, and finally the rule of Turks and Tartars that carry us down to the end of the 14th century. In 1460 Shah Ismail, Safavi, conquered Khorasan, Sistán, and Makrán, and founded the dynasty which lasted to Nadir Shah's time. The Government of Sistán under the Safavi dynasty was invested in the Kaiani Maliks, who claimed descent from the royal house of Kai. Malik Mahomed, Kaiani, was Prince at the time of the Afghan invasion of Nadir Shah.

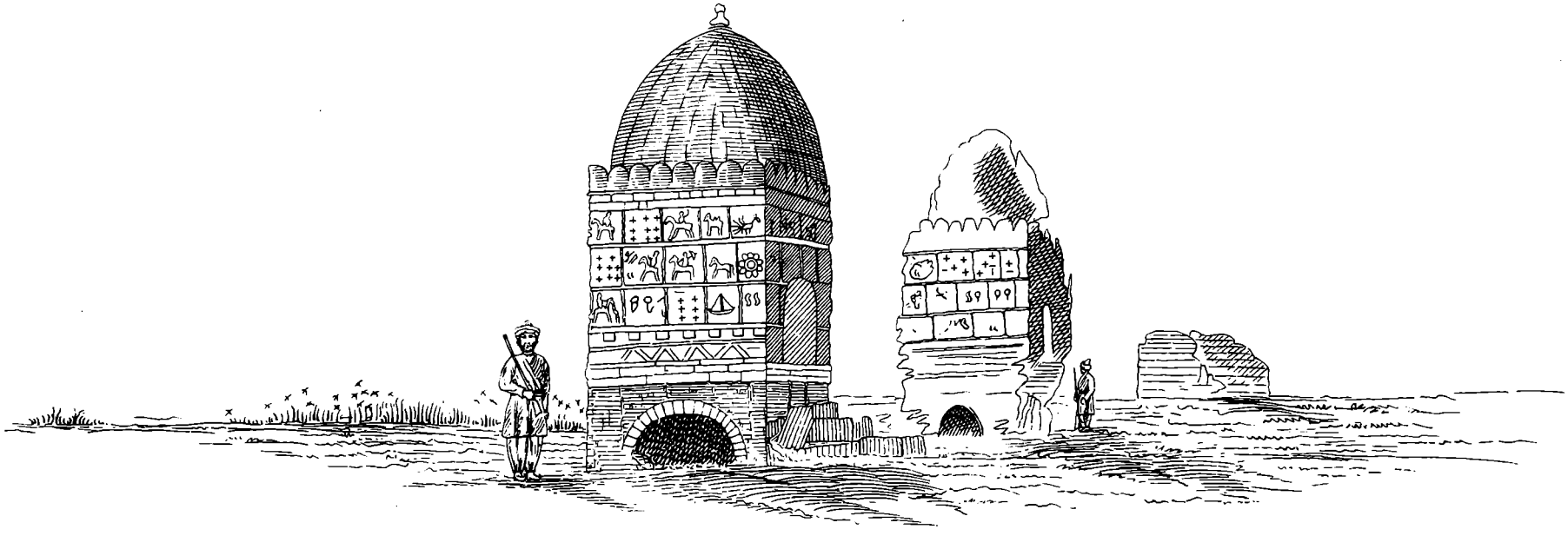
The Kaianis resisted Nadir and his nephew Ali, and finally had to retreat to Koh-i-Khwaja on their defeat. On the death of Nadir (170 years ago) Sistán became Afghan. Thus, these tombs were in all probability built between the years 1460 and 1720, and the excellent state of preservation in which the relics were found is thus accounted for. But what was the connection between the ancient house of Kai and the early Phœnician Gulf traders? Is the adoption of the Phœnician form of sepulture merely imitation, or is it a traditional custom establishing a Phœnician origin for the "Royal house of Kai?" Who, too, were the gigantic race whose bones fill the lower chamber in these tombs? Further examination of this interesting corner of Baluchistan, of which Jalk (known as Gulshán, until its destruction by Nadir Shah's General, Pir Mahomed) is the centre, and, perchance, a translation of the rock-cut inscriptions at Jhalwar, which have hardly yet been examined, may throw new light on this rather obscure subject.

Interest of Saracenic period.

The interest of Makrán history centres, doubtless, in that busy period of Arabian supremacy which extended from early pre-Mahomedan centuries until the Kalifs gave way to the Turks, ere these were again supplanted by the Portuguese after the discovery of the Cape route by Vasco de Gama. It was when the heavy-prowed, square-sterned Arab dhows and buggalos were busy bringing gold and ivory from the African coasts, or carrying spices, spikenard and myrrh, from Makrán, or gold brocades, purple and fine linen from India to the great central marts of Egypt, that in all probability Zimbabwe, the gigantic old world city of Mashonaland, was a flourishing Arab possession. It was then, too most likely that the "ghorbastas," the great stone 'bunds' of Makrán, were built, for these show the same skill in uncemented masonry as the walls of Zimbabwe; and about the contemporary cities of Tiz and Pasni are found the same extraordinary wealth of relics in celadon, china and Persian pottery as are described by Mr. Bent amongst the African ruins.

Portuguese epoch.

Next in interest comes the period of Portuguese supremacy. It is true that there is little evidence that the Portuguese actually occupied any part of Makrán. From Colonel Miles' most excellent history of the Portuguese occupation of the Gulf we learn that in 1580 when the Portuguese Commander Almeyda was sent from Hormuz to destroy the Turkish fleet under Ali Beg, who had just sacked Muscat, he employed his time in looting Pasni, Gwadur, and Tiz instead of the Turks. Further than this, it is not easy to trace any connection between the Portuguese and Baluchistan or Makrán. The moral of history lies in the fact that it was on these seas that in 1554 the Turkish naval power was first broken by the Portuguese in that fight of which Haji Khalifa so quaintly relates that "the battle was even greater than that between Khair-u-din and Andrea Dorea. Few soldiers are known to have ever been

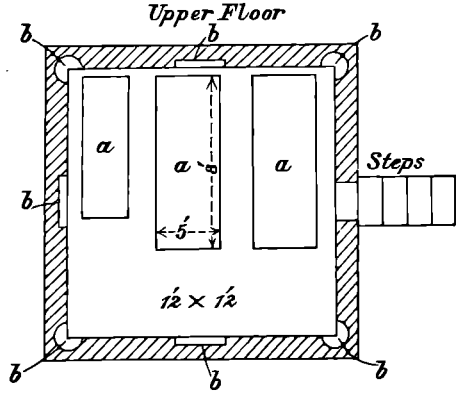


The ruins at Guachig in Dehwar near the Mashkel Hamun

From memory.

NORTH.

Walls of upper storey about 2½ to 3′ thick.
Lower storey walls appear much thicker.



Half way up the wall of the upper storey there is a little window facing North, the door being always to the East.

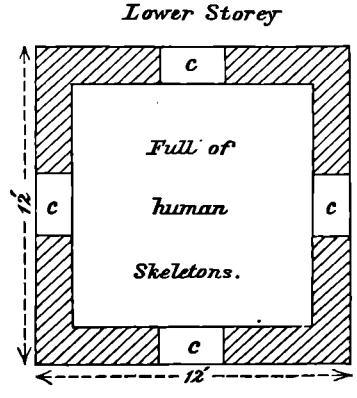
a a a Tombs built up from the floor, and the sides of the sarcophagus ornamented.

Heads of tombs pointing North.

These tombs are built of sun-dried brick, and resemble sarcophage in general appearance.

b b b Alcoves or recesses in the wall; bottom 2 to 3 inches off the floor and height about 8 to 10 feet. From 10 inches to 1 foot in depth.

WEST.



c c c c Low arches, forming what are apparently vaults. The inside of the ground floor or lower storey is full of skeletons. The arches appear to have been built up with brick and mud mortar after the corpses were placed inside.

SOUTH.

engaged in such a fight." Those who know the climate of Muscat, and who can picture to themselves that hard-fought battle raging through the length of an August day, will agree with the historian that it must have been warm work. This battle diverted the whole trade of the East into new channels, and practically created a new epoch for Asiatic commerce. Yet once again was the fate of Asian trade decided by a naval engagement in these waters. This time it was off Jask, on the Makrán coast, that the "*London*," the "*Eagle*," and two other ships finally established British supremacy in 1620, and broke the power of the Portuguese for ever. For three centuries has England held her own, and now perchance it is time again to reckon up the value of this Asiatic trade that seems almost as if it were slipping from her; to count how much of it may be reached from the Makrán coast; what are the means of reaching it; and in whose hands the means now lie.

Extract from a Report by MR. T. E. M. CLAUDIUS, *Extra Assistant Superintendent, No. 15 Party, on his Survey Operations in* MAKRAN, *Season 1891-92.*

I reached Bela on the 18th December 1891 and after making postal arrangements and settling a few other matters connected with transport, etc., I marched for Kolwah *viâ* the Jhao Lak. On reaching Jhao, I despatched Duffadar Gopal Singh in a northerly direction to take up the revision work required in one of the sheets, and then went on to Duffadar Jaganath's portion, and worked with him for a few days, as the soldier-surveyor had done no work on the ¼-inch scale previously. After being satisfied that he had a good idea of what he was to do, I marched for Kolwah and reached Chambor on the last day of December. On the 1st January I commenced the reconnaissance for my triangulation from the side Sagár-Hôr. This part of the work occupied me about 20 days. After identifying two stations of the Gwadar triangulation, Sami-Pidark, which formed the side on which I was to effect a junction, and also two points on the north, Taptap-Sobajik, of Major Talbot's triangulation executed during Sir Robert Sandeman's mission in 1883-84, I started my observations about the end of January and completed the same on the 22nd of February. During this time, ten stations, most difficult of approach and access, were observed at; a junction was effected both on the north and west with previous work, and a number of intersected points fixed on the south down to the sea coast. The observations were speedily computed out, and the data supplied to the plane-tablers most needing them.

The extension of the Makrán series was carried principally across the portion of Makrán called Kolwah, which was well described by Mr. Graham in his report in 1890-91, and there is little of importance to add to that report. The highest and most conspicuous summits of the two ranges of hills which flank the Kolwah plain, north and south, were chosen for stations, and the only signals which could be adopted were cairns. Fortunately the inhabitants, unlike the Mingals of the Zidi and Bela districts, did not destroy the signals.

The country plane-tabled by Yusuf Sharif and Sheikh Mohiudin had not been previously traversed by any triangulator, and the following is a description from a few notes supplied to me by the latter.

The most important rivers are the Hingol and Basol. The former has its source a few miles south of Kalat and running almost due south, empties itself into the Arabian Sea about 50 miles west of Sonmiani. Its total length is nearly 250 miles, and its drainage has an area of nearly 8,000 square miles. Having an easy gradient almost throughout its whole course, with open ground generally along both banks, it is supposed to be well suited for any line of railway to follow. The Basol river empties itself into the sea about 24 miles west of the large and important village of Órmara. It takes its source from the well-known hills of Bhairi Hól and Girdánk. Its total length would be about 60 miles, and along its whole course it has a plentiful supply of sweet water. It drains an area of about 2,400 square miles. An inlet of the sea called Kalmat is considered to be well adapted for a harbour. It lies about 40 miles west of Órmara.

One of the principal highways is the one that follows the course of the Hingol river. It is well utilised by the Brahuis of Kalat, and is an easy route for laden camels; it is in fact the most direct and easiest connection between Kalat and the sea coast.

The road from Kurrachee, leading westwards along the coast, passes through the important villages of Sonmiani and Órmara of the Bela district, and thence on to Pasni and Gwadar; the Bazi *kotal*, the only obstacle that has to be crossed, is 32 miles due west of Sonmiani; good water along the route is very scarce. From Chambor of Kolwah a road strikes southwards leading to Órmara; this follows the Basol river nearly along its whole course, and is practicable for laden animals of all descriptions. A great trade is carried on along this route between the inhabitants of Kolwah and Órmara, the former bartering *ghi* and barley for fish and wheat.

Ormara is a large village standing at the northern base of a great flat hill surrounded on three sides by the sea, the connection on the north with the main coast being a narrow strip of land. The hill is scarped on all sides, the summit having an area of nearly eight square miles. At Órmara there is a telegraph office in connection with the Indo-European line. It is not a regular port, but the Government steamers doing duty with the above touch there. The anchorage is within 400 yards of the village. A very large trade is carried on here in fish, the revenue for the same collected by the Jam of Las Bela

being over Rs. 20,000 per annum. Dried fish are exported in every direction—to Kurrachee, Bombay, and even to China. There are about 30 *banias* in this village, and provisions such as wheat, *ghi*, *jawar*, and sugar are always to be had in large quantities. Pasni is another large and important village on the coast. It lies between Gwadar and Órmara and close to the mouth of the Bhairi river. It is similar to Órmara in many respects, but the fish trade is not nearly as extensive.

The Island of Haft Tallar or Astola is in latitude 25° 7′ 12″ and longitude 63° 52′ 9″ and lies about sixteen miles from the coast. It is about three miles long and nearly half a mile in width, standing 213 feet above the surrounding water, uninhabited and perfectly barren.

ARABIA.

Extract from the Report on the Survey Operations in the DISTRICTS IN THE NEIGHBOURHOOD OF ADEN *by* CAPTAIN R. A. WAHAB, R.E., *Season 1891-92.*

The country triangulated consists of a belt of lowland, much of which is sandy desert, extending along the whole length of the coast, and varying in width from 6 to 30 miles; several isolated hills, evidently of volcanic origin, crop out at intervals along the coast line, the principal ones being Aden itself, Jabal Ihsan or Little Aden, Ras Imran, and Jabal Kharaz, the last-named attaining an altitude of nearly 3,000 feet above the sea. The existence of these hills, it need hardly be said, greatly facilitated the work of triangulation, and subsequently of detail survey. Beyond this desert zone lies the mountainous country, leading up to the Yaman highlands, rising steadily to the northward, where several peaks on the borders of the season's work exceed 10,000 feet. It is drained by several considerable streams, of which the Tiban, the Bana, and the Hasan rise on the Yaman plateau, 100 miles or more from the coast, and are eventually absorbed in the irrigation of the fertile plains of Lahej and Abyán.

The inhabitants are Arabs, divided into various tribes and sub-tribes, independent as far as their internal affairs are concerned, but in receipt of allowances from Government of larger or smaller amount, in consideration for which they engage to abstain from raids on British territory and on *kafilas* trading between Aden and the interior. Those tribes in the neighbourhood of Aden, such as the 'Abdali, and some sections of the Subaihi and Fadthli, are amenable to British influence, but those inhabiting the more remote and inaccessible hills have little or no respect for our power.

Of the various tribes inhabiting the district around Aden, the most important, from its proximity to the British border, is the 'Abdali, estimated to number some 10,000. They occupy the delta of the Tiban river and part of the desert tract east and west of it, extending some 30 miles north from the coast to the borders of the Haushabi country. Their principal town is Lahej, the residence of the Sultan, with a population of 4,000, situated in the Tiban delta, 26 miles from Aden. It differs little in appearance from an Indian town of its size. The principal building is the Sultan's palace, an imposing structure of sundried brick, whitewashed, covering with its out-buildings a considerable area. There is also a rest-house for Europeans, and a small house belonging to the native Assistant Resident. The town stands in the richest part of the oasis, surrounded on all sides by fields of *jawar*, yielding three and sometimes four crops in the year. The date-palm is also grown, though not very extensively, and Indian corn and European vegetables of various sorts are grown for the Aden market. The soil is extremely rich and is irrigated by skilfully-made canals from the Tiban river. Waht and Fiyush are among the principal villages, and numerous hamlets are scattered about throughout the oasis.

The Sultan receives a stipend from Government of 20,000 dollars, and in addition derives a large revenue from his private lands and from transit dues on all goods passing through his territory to and from Aden, estimated at 50,000 dollars more. He is entitled to a salute of 9 guns on visiting Aden. The dollar, it should be mentioned, is here, as throughout Arabia, from the Syrian desert to the Persian Gulf, the standard of value, and curiously enough the 'Maria Theresa '(Austrian) dollar is still looked on as the only genuine one.

East of the 'Abdali, and extending about 100 miles along the coast east of Aden, is the territory of the Fadthli tribe, estimated at 20,000. The Sultan, who resides at Shukra, a small coast town 70 miles from Aden, has a stipend of $2,160, and, like the 'Abdali chief, entitled to a salute of 9 guns. The present chief has, however, little or no influence with the majority of the tribe. The country consists, in its western and southern part, of the plain lying between the hills and the coast, part of which, the Abyán district, is a fertile tract watered by the Suhebiya Bana and Hasan rivers, the remainder being a sandy desert. East and north-east is a mountainous tract occupied by the Markashi and other warlike and practically independent sub-tribes. The Fadthli villages (in the low country at least) show none of the signs of prosperity apparent in the 'Abdali country; much of the cultivable soil lies waste for want of water, which the Yafi'i, who command the Bana and Hasan rivers, divert on to their own fields. Shukra, the capital, is a small place of some 500 inhabitants, depending chiefly on petty coasting trade; Asala, described by Hunter as a town of 600 houses, does not now contain over 30. Tairan, formerly a large village, is quite deserted, and the Abyán villages, Jawala, Al Kaur, Al 'Amudiya, etc., are mere hamlets of a few huts. Little is known of the hill country or of the tribes occupying

it, who form five-sixths of the whole. The Markashi and other hill tribes are at constant feud with the Sultan, and as stated above are practically independent.

Immediately west of Aden are the 'Akrabi, a small tribe not exceeding 1,000, formerly a section of the 'Abdali, but independent for several generations, and recognised by Government as a separate tribe. Their principal village is Bir Ahmad, 14 miles west of Aden, on the right bank of the Wadi al Kabir, here a dry water-course; and except in its immediate neighbourhood, they have no cultivable land. The rest of their territory, which extends along the coast as far west as Ras 'Imran, and for some 10 miles inland, is desert, but not without value for the wood and camel-grazing it furnishes.

The Haushabi are an important tribe, numbering about 7,000, occupying the hill country to the north of the 'Abdali, and extending northwards and westwards to the Turkish border. On the east they are conterminous with the 'Alawi and the Dthambari. This country is for the most part mountainous and barren; the hill ranges in the north rising to over 7,000 feet above sea-level, but there are fertile strips of land in the valleys of the Tiban and Suhebiya which produce excellent crops. The Sultan resides at Musemir, on the left bank of the Tiban, 59 miles north-west of Aden, not far from the foot of the lofty Jabal Warwa, whose conical peak is a conspicuous land-mark for many miles. His residence is a solid-looking house, built of stone, set in mud, at a little distance from the village, which is merely a collection of grass huts. The only other places of any importance are Raha, comprising several scattered villages in the Suhebiya valley, and Harur, some 20 miles further east on the left bank of the same river. Dar-ad-daula, in the Raha district, was formerly the residence of the Sultans, but owing to the difficulty of controlling his subjects in the distant hilly country to the west the last chief moved to Musemir. Harur is a village of 50 houses with a large extent of cultivable land to the east and south-east irrigated by the Suhebiya river; its chief, though a near relation of the Sultan, considers himself more an ally than a subject and is practically independent.

The Haushabi Sultan is an energetic and capable ruler, and has his tribesmen well in hand. He gave every assistance in his power to the survey party, inflicting summary punishment in one or two cases that were reported to him of obstruction on the part of his officials and subjects. He receives a stipend from Government, and has in addition a revenue of about $5,000 derived from land tax and transit dues.

The 'Alawi are a small tribe located in the Suhebiya valley, between the Haushabi on the west and the Kotaibi and Dthambari on the east. Their total numbers do not exceed 1,500. A considerable proportion of their country is cultivable, and their villages, Jimil, As Sanda, Dthanib, Al Kash'a and several smaller hamlets are picturesquely situated on the low hills at the western foot of the Radfan range. Al Kash'a, a village of 500 inhabitants, is the principal place and the residence of the Shekh, who receives a stipend from Government of $60 per annum. He has, besides, a revenue of some $2,500 made up from land tax and transit dues.

The Kotaibi, Bakri, Dairi and Dthambari tribes occupy the Radfan range, a mass of hills lying between the Suhebiya and Bana rivers, attaining a height of 6,000 feet above the sea.

The Kotaibi are the most important, as they command the high road from Aden to Dthala between Jimil and Al Kafla Owing to their hostile attitude to the survey party, the military escort was strengthened considerably, and Captain Domvile, whose troop was detailed for the protection of the survey camps, remained with Mr. Graham and accompanied him daily on his work until the survey of the Kotaibi hills was completed.

The Dthambari, who occupy the south-western part of the Radfan range, at first behaved in a friendly manner and invited Colonel Stace, the First Assistant Resident, and myself to visit Nakhlain at the southern base of the range; on arrival there, however, they refused to allow the party to proceed further except on terms which the Resident could not have acceded to, and negotiations were therefore broken off.

East of the Radfan range, in the valley of the Bana and the hills east and north of it, are the Yafi'i, a tribe which as yet has come but little under British influence. They are divided into the Yafi' us Sufla and Yafi' ul 'Ulya, or upper and lower Yafi'i. The latter, whose territory adjoins that of the Fadthli, number probably 20,000, and their chief, though not bound to us by treaty, is on friendly terms with the Aden Residency and occasionally visits Aden. The upper Yafi'i tribe is estimated to exceed in number 15,000 men. Their country, which consists of high plateaux and fertile valleys, produces large quantities of coffee, cotton, wheat, barley and wax.

The lower Yafi'i country is bounded on the south by the Fadthli, on the east by the Hadramaut, and on the west by the tribes of the Radfan hills and the territory of the Amir of Dthála. Except the small portion of it which lies in the Abyán between Masána and Khanfar little is known of it, except that it is mountainous, with numerous fertile valleys producing grapes, *jawar*, coffee and madder. In winter the cold is sufficient to freeze the streams. (Hunter's "Account of the Arab Tribes.")

The principal town and residence of the Sultan is Al Kahira, situated among the higher hills, some four days journey from Khanfar, the border village on the south-west, 40 miles from Aden. The present Sultan has generally shown himself well disposed to our Government, and it was expected that no objection would be made to the survey of the lower part, at any rate, of his country. It was not, however, till quite the end of the season that any reply was received to the Resident's letters acquainting him with the objects of the survey and requesting his assistance, and though he then protested his willingness to

assist, his officials refused Mr. Graham permission to enter Yafi'i territory, and put him off from day to-day with excuses, under pretence of referring to the Sultan himself for orders. Mr. Graham, however, succeeded in surveying all the country from Masána downwards, and it is doubtful whether the Sultan would have agreed to allow the surveyors to enter his country above that place.

The territory of the Amir of Dthála lies in the extreme north of the country surveyed, immediately bordering on Turkish Arabia, by which it is bounded on the north and west; on the east its boundary is somewhat indefinite, where the Halmain and other tribes have practically thrown off their allegiance to the Amir, though still nominally his subjects. The Amiri country is a high plateau averaging 5,000 feet above the sea, forming the first step, so to speak, between the low country and the Yaman highlands. The climate is temperate and healthy, the thermometer at Dthála in the winter months ranging between 45° and 70° Fahr., while the summer heat is tempered by a regular but not excessive rainfall. There is a considerable area under cultivation, the principal crops being wheat, Indian corn, *jawar* and *bajra;* irrigation is not resorted to, the rainfall being sufficient in most seasons.

The principal towns are Dthála, the residence of the Amir, Dthubaiyyat, a Saiyad settlement about 8 miles to the south, and Harir about the same distance to the east situated on a flat-topped hill 7,000 feet above the sea. Kafla Zubed, Al Husen, Al Wa'ra and Dthi Harrán are among the principal villages on the plateau; and Al Hamra, Ar Rado Al Markula and Al Khuraiba in the Hardaba valley to the south.

Dthàla is situated in the south-west corner of the plain at the foot of a low hill on which the Amir's fort stands. The town is an irregularly-built collection of stone huts with numerous substantial two and three-storeyed towers. There are several shops, chiefly kept by Jews, who, in spite of oppression and ill usage from their Muslim rulers, manage to keep most of the trade of the country in their own hands, and on market days the place is thronged with buyers and sellers from the whole country side, when supplies of all sorts, grain, vegetables, cloth, live stock, and even kerosine oil, candles and matches, are obtainable. The population is given in Hunter's "Account of the Arab Tribes" at 2,000.

Dthubaiyyat is a large Saiyad village on the remarkable flat-topped hill which forms the southern buttress of the Dthála plateau. A mile to the east, on the highest point of the hill, is the *ziarat* of Wali Hasan, the white dome of which is visible on a clear day from Aden, 70 miles distant. Its elevation is 5,800 feet above the sea, and some 3,000 feet above the country at its southern base. The change in climate from the trying heat of the plains to the cool mountain air of the Amiri hills is very marked, the difference in the temperatures at Jimil, 10 miles from Dthubaiyyat, and on the plateau above being as much as 20° from the observations taken during the winter months. The difference is said to be still more in summer.

Last among the tribes whose lands came under survey during the season are the Subaihi, a large tribe numbering 12,000, occupying the maritime plain from Ras 'Imran, 16 miles west of Aden, to the Straits of Bab-al-Mandab, and the lower slopes of the hill ranges bordering the plain on the north.

The tribe is sub-divided into a number of sections, some of which are subsidized by Government, and some are under Turkish control; but the greater number are independent and do not even own the authority of their nominal chiefs. They were at one time placed under the control of the 'Abdali Sultan, but this arrangement was found unsatisfactory, and the sections subsidized now receive their allowances direct from the Aden Residency.

The greater part of their country is desert, though it affords pasture to numerous flocks of sheep and goats belonging to the nomad families who are always to be met with near the various wells. These are generally found along the dry torrent beds which cross the plain at intervals of 10 to 20 miles, and in several places on the sea shore itself within a few feet of high water-mark. The nomad sections of the tribe have no permanent settlements, but move about with their flocks wherever pasture and water are to be found. There is no cultivation to speak of.

The portion of the Subaihi country lying on the hills bordering the desert, though comparatively small in area, contains probably five-sixths of the entire numbers of the tribe. A fair proportion of it, especially that part watered by the Wadi Ma'adin and its tributaries, is fertile and well populated. There are also several villages and forts on the Am Dukhail river near its exit from the hills. Owing to the hostile attitude of the inhabitants, who twice attacked the surveyors while working near the foot of the hills, the survey of that part of the country was left incomplete.

The only trade routes of any importance are those leading north and north-west from Aden towards Sana', the capital of Yaman, and Ta'iz, the chief town of the Turkish district of that name, respectively. The routes running east and west along the coast are of little importance, the small local traffic between Aden and the coast towns being more easily carried by sea.

The Sana' road leaves British territory at Shekh Othman, a large settlement of Somalis and other miscellaneous nationalities employed as labourers in Aden, and for 10 miles further crosses a desert tract, over hard, sandy ground with occasional patches of thorn jungle till, at about 20 miles from Aden, the beginning of the Lahej oasis is reached, and at 26 miles the town itself, standing in the midst of a highly cultivated plain covered with crops at all seasons. Above Lahej, the road follows the bank of the Tiban river as far as the small fort of Al'Anad, the border post of the Haushabi Sultan. Here the

character of the country changes; the open plain stretching away to the coast is left behind, and the path now runs up a dry torrent bed and through low rocky hills for the next 25 miles to Jimil, where it strikes the Suhebiya valley in 'Audhali territory. From Jimil, the road follows the Hardaba stream (a branch of the Suhebiya) passing close under the lofty Dthubaiyyat mountain, and winding along the river bed, sometimes through the running stream between banks covered with tamarisk, thickly overgrown with luxuriant creepers, sometimes over the fields on either bank, past villages and towers perched on the rocky spurs above, till the pass or *nakil* of Al Khuraiba is reached, leading up to the Dthála plateau. The path, here a roughly paved, stepped causeway, one of the few monuments of the former civilisation of Yaman, leads up the rocky gorge, rising 400 feet in the first quarter of a mile. Thence still ascending but at an easy gradient, it emerges a mile further on to the Dthála plain. Looking northward from the head of the pass, the broad cultivated valley dotted with trees and villages slopes gently to the foot of the Mares range, 10 miles distant, which rises in a steep scarp 2,000 feet above the plain; to the right is a lofty flat-topped hill, on the summit of which the tower of Harir, 7,100 feet above the sea, stands out conspicuously, and to the left front is Jabal Jihaf, with towers crowning its highest peaks, and villages and terraced fields lying on its lower slopes. The road to Sana' leads on northward through Ka'taba, the Turkish frontier post, near which the steep ascent of the Mares range commences; that to Dthála turns westward, and passing the village of Jaleli on the right, the Amiri capital is reached some 5 miles from the head of the pass. The total distance from Aden to Dthála is 87 miles by this route, and it is usually covered by *kafilas* in three days.

The Ta'iz route diverges from the above road at Al'Anad, from which point it follows the left bank of the Tiban up to Musemir, the Haushabi capital, 59 miles north-west of Aden; thence through hilly country to the foot of the Am Amma range, which is crossed by a pass probably over 6,000 feet in height, and a few miles further reaching Mávia, a considerable town in Turkish territory. From Mávia to Ta'iz the direction of the road is more west or southwest. Ta'iz is the residence of the Turkish Governor of south-western Yaman, and is a place of some importance as an *entrepôt* for trade between the coast towns of Mokha and Hadeda and the interior; its distance from Aden is 106 miles.

The principal rivers are the Tiban, the Bana, and the Hasan. The Tiban rises in the highlands between Dthála and Sana' about 120 miles from the sea. Its course was surveyed from a point a few miles north of Musemir, where it emerges from a rugged gorge among high mountains; 5 miles below Musemir it receives two tributaries—the Warezán rising in the Am Amma range, and the Akkán from the Kubáti hills, both perennial streams; for the next twenty miles it runs in a south-easterly direction through a valley, one to four miles in width, bounded by barren stony ranges of no great altitude. During this part of its course the banks are gravel or conglomerate, 50 to 100 feet in height and 300 or 400 yards apart; the strips of alluvial soil in the river bed between the actual channel and the high banks are cultivated wherever practicable and irrigated by channels taken off from the stream at suitable points. At Al'Anad the high banks disappear, and the river enters the alluvial plain; 2 miles below Zaida it bifurcates, and the delta so formed constitutes the Lahej oasis.

The western or larger of the two branches, the Wadi al Kabir, finds its way to the sea a few miles west of Shekh Othman; the eastern branch, the Wadi-as-Saghir, loses itself in the low marshy ground between 'Imad and the coast. A large proportion of the water from the Tiban is taken up by canals for irrigating the fertile country around Shaka' and Zaida, and in the delta; the area commanded by the canals is about 20 square miles. In heavy floods, a large quantity of water reaches the sea by the Wadi al Kabir, but as a rule all that is not used up in irrigation is absorbed in the sandy bed some miles before reaching the coast.

The Bana river also rises in the Yaman highlands, and like the Tiban drains a large area of mountainous country. A branch of it is crossed on the road to Sana', two marches north of Ka'taba, where it is already a considerable stream. Its course for some distance is easterly, till it enters the Yafi'i country where it turns south, and skirting the eastern foot of the Radfan range, it finally enters the plains at AlMasána near the border of the Yafi'i and Fadthli lands.

The Hasan river enters the plain near Masána within a mile of the Bana, but follows a separate course to the sea; both rivers have a constant stream of water down to their exit from the hills, where all available water is taken off for irrigation. Unfortunately, owing to constant feuds between the Yafi'i and Fadthli, much of the fertile tract of land in Abiyán, which depends on these streams for irrigation, now lies waste for want of water. Endeavours have been made by the political authorities at Aden to effect some agreement between the two tribes regarding the distribution of the water, but with little success.

UPPER BURMA.

Description of the country surveyed by No. 3 Party in Season 1891-92,

SAGAING DISTRICT.

The Sagaing district lies between Lat. 21° 40′ and 22° 10′ and Long. 95° 10′ and 96° 0′. It is divided by the Irrawaddy river into two sections. The lower section, or Ava sub-divi-

sion, is bordered on the east by the Kyaukse district and on the south and west by the Myingyan district: the northern section extends westward from the Irrawaddy to the Chindwin river, and is divided into two sub-divisions, Sagaing and Myin Mu, separated from each other by the Mu river. On the north, the Sagaing sub-division is bounded by the Shwebo district, and the Myin Mu sub-division by the Lower Chindwin district. Each sub-division is again divided into two townships, and the whole comprises 175 circles or *taiks* These have now again been sub-divided into 1,150 *kwins* or *ywas*, though each *kwin* does not necessarily contain a village site; in fact, it is an arbitrary division, lately adopted for administrative purposes, and was unknown here before. The actual number of *ywas*, or true villages, is only 546, though several consist of two or three hamlets of the same or different names.

The Irrawaddy river, after running south between the Mandalay and Sagaing districts for 25 miles, turns westward between the towns of Ava and Sagaing, and taking a semi-circular sweep, again resumes a southerly course before its junction with the Chindwin. For the greater part of its course, it runs between high banks, about a mile apart, which are only occasionally overflooded when the river rises to an unusual height. But at intervals, where water-courses run into the river from the interior, the water rises into them, and creeks are formed, which, in their turn, fill large depressions which occur at intervals, turning them into small lakes or marshes, known as *ins*, in which the water is dammed up and subsequently used for irrigation. These marshes and the irrigated lands round them were, as a rule, held as service lands and fisheries free of rent, by families who supplied rowers for the king's war boats. As this service is no longer needed, these now pay rent to Government and are a source of considerable income. As it approaches the Chindwin river, the Irrawaddy throws off several lesser channels which cross the prolonged fork between the rivers, and when flooded irrigate a large tract of country in which rice crops are raised. The Chindwin, which bounds the district on the west, is about three quarters of a mile wide from bank to bank. During the rains, the entire bed is covered, and farther north, where it twists and turns considerably, navigation becomes dangerous. But in the dry season the small steamers drawing only 18 inches often strike on the sand banks owing to the small supply of water.

The Mu river, which winds across the upper section of the district and falls into the Irrawaddy about 20 miles below Sagaing, is only about 250 yards across, and during the dry weather has a very slender stream of water in it. But it becomes unfordable at times when heavy rain falls on the hills of Wuntho at its source. These are the only rivers in the district, and there are no streams of importance, though numerous dry water-courses fall from the various groups of hills.

A low range of rocky hills skirts the Irrawaddy opposite the Mandalay district, rising in height at the northern end at Mingun to 1,340 feet, and descending to hillocks near Sagaing. The descent on the east to the Irrawaddy is steep and rugged, the small strips lying between the hills and river being covered with *phayas* and *phoongyi kyoungs* (pagodas and monasteries), one being the huge unfinished structure at Mingun, famous for its large, now useless, bell. The descent on the western side is more easy, and the country gradually falls away to the plains over which the railway line is carried. One long undulation rolls westward north of Sagaing across the district, sometimes rising into groups of hills, at others falling to the level of the surrounding country. From these hills and uplands numerous water-courses and ravines break into the plains with gently sloping spurs between. Near the bases of these slopes, the villagers raise long low dams or *kazins* of mud and thereby collect and store the rainfall, such as it is, some 20 inches in the year, in *kans* or tanks, whence it is afterwards gradually drawn off to irrigate patches of adjacent country, for rice cultivation. With an increase of population, this system could be almost indefinitely extended over the district.

In the Ava sub-division a group of hills lies to the south of the district, rising at Mozataung, a station of the Great Trigonometrical Survey, to 1,474 feet in height. There are also two or three more minor groups and undulating downs across the country, as in the northern section, where also the rainfall is utilised as above described.

Except in the lands irrigated by *ins* and *kans*, where rice is cultivated, the chief crops raised are *jawar*, sessamum, gram, peas, and cotton. The last is brought in large quantities to the store of a Chinaman in the village of Ywathitgyi, 13 miles below Sagaing. Here it is cleaned by women and girls, of whom from two to three hundred are employed constantly. It is then pressed into bales and sent on board the Irrawaddy Flotilla Company's cargo boats, chiefly to Bhamo, for the China market, or to Rangoon.

A large portion of the district is very dry and covered with thorny scrub, acacias, plums, and other hard woods, with cacti, prickly pear, and numerous creepers, which bind the whole together and render line-clearing very difficult.

Only about half of the entire area surveyed is or has been cultivated, but there is no reason why a much larger area should not be brought under the plough with an increase of population. Near the rivers may be seen several large mango groves, but, as a rule, the district is painfully bare of timber and fruit trees.

The villages are, as a rule, small collections of thatched bamboo huts surrounded by thorny fences and provided with gates for the prevention of cattle lifting, for which the district was notorious not long ago. Sagaing and Ava might rank as towns, though the latter is rather a mass of ruins interspersed with huts.

Ywathitgyi, where the camp was pitched during the field season, is a large village, occupied partly by Buddhists, partly by Mahomedan Burmans. One peculiarity of the

latter noticed by our Indian Moslems was, that the women as well as men learned to read and recite from the Koran, and attended worship in the *musjids*. There are numerous *phayas*, *kyoungs* and *zayats* scattered all over the district, many nicely built of teak; in those last our men were always accorded ready accommodation, which I am happy to say was seldom abused.

Near Chaungoo are two villages of what are now practically Burman Roman Catholics, the descendants of Portuguese captives brought from Syriam by Aloungphya (or Alompra) when he captured Pegu. They had to a great extent adhered to the Catholic form of worship when found by the priest, who has since taken charge of the community.

There was practically no rainfall, and great scarcity of water in parts of the district during the dry months, but the rain in May staved off what might have been a very serious water famine. There are very few district roads, but numerous cattle tracks cross the country in all directions; so there are no transport difficulties during the dry months, and good riding ground everywhere.

Game abounds in parts, especially along the rivers, including geese, ducks, snipe, jungle fowl, partridge and quail, a large and small species of deer, boars, and leopards. Otters of a very large size and with a splendid skin are found along the river banks.

Chindwin Coal Tracts.

The Chindwin coal tracts lie between Lat. 23° and 24° and Long. 94° 15′ and 94° 20 between the Myitha valley and the Chindwin river. The seams, judging from the outcrop, run almost exactly north and south, and vary in thickness from a few inches to in one case 12 feet. Of the entire tract, only the portion lying between the first and second ranges of hills west of the Chindwin was surveyed.

The entire tract is a mass of rugged hills, covered with dense jungle, and, except near the Kalwa stream, entirely uninhabited. The section surveyed is divided into three small valleys, known respectively as the Paluswa, the Nautahin and the Kale, each drained by a main stream, which, after collecting all the drainage from the high range to the west, known as the Noebetaong or Yoma, breaks through rugged defiles in the outer range and flows into the Chindwin. The Noebetaong rises to about 3,000 feet above sea-level; its farther slopes are an intricate mass of forest covered spurs which were not surveyed. Its eastern slopes fall into the valleys named above, sometimes in long spurs, at others in precipitous rocky crags. The latter are quite inaccessible; the former may be ascended by keeping along the crests, but even so are difficult, as at intervals they are broken by sudden precipices of smooth-faced rock, 40 to 50 feet in height, which can only be passed by proceeding down one side of them to the nearest water-course and then climbing back under them again to the crest, and following that till the next precipice has to be flanked in the same way. Sometimes these tiresome *détours* are saved where a slight coating of clay has fallen and overlies the rock, when with care a direct descent can be made. Between the spurs, narrow water-courses fall over large boulders, and are fringed by dense forest and undergrowth, making them quite inaccessible as a rule. There are a few fir trees on the Noebetaoung stream, and the Bombay-Burma Trading Company's agents at times cut and bring down timber from the hill-sides, the logs being washed down the water-courses to the main streams, from which they are dragged away by elephants with immense labour. But the greater portion of the trees are small and not valuable, and a considerable area is covered with bamboos. During the rains, the streams are roaring torrents and are quite impracticable for man or beast. During the dry months, the stream beds may be ascended with much labour over the boulders, but the few people who enter the valleys, usually ascend by pathways which cross the crest of the outer range from Matu and other villages near the Chindwin, which river is here 900 feet above sea-level. These after crossing the open country near the river, ascend by zigzag routes, crossing lesser water-courses and several spurs, then over passes averaging about 2,000 feet above sea-level: they next descend through equally rough tracts to the central streams, which are about 1,500 feet above the sea, and continue up various spurs to the passes on the Noebetaoung. In one of these passes I remarked rude cuttings on the rocks, indicating the routes taken by a party of Chin marauders some years ago which burst on some small Burmese villages in the low country and killed or carried away every inhabitant and all their cattle.

The coal seams appear in the beds of the main and lesser water-courses at intervals, for some three miles in breadth, the rocks between the various seams being grey shale, sandstone, and slate. The total breadth of all the seven seams that appear above the surface in the Nautahin valley aggregate only 11 feet 10 inches of good coal, and the two seams in the Sadwin, a feeder of the Nautahin, are respectively 4 and 12 feet in width according to Dr. Noetling's report.

These have been, for a length of 3 miles, included in the blocks demarcated for the Buckland Syndicate; similar blocks may hereafter be available in the Paluswa and Kale valleys when needed. But until a good road is cut from Kalewa, running north, through Kale, Nautahin and Paluswa to the Chindwin below Kindat, the coal is quite cut off from the river: and, even then, the rush of water in the rains would soon flood all works in the beds of the valleys. So, as Dr. Noetling remarks, it will probably be necessary to cut a tunnel 5,000 feet long from the base of the hills opposite Matu to get at the coal in the Nautahin. After getting the coal to the rivers, the question of its transport on the

small steamers that ply on the Chindwin must be considered. During the rains, the navigation is perilous owing to the violence of the current when swirling round rocky ends of spurs that abut on the river. During the dry weather, the vessels stick often in 18 inches of water. Local labour was practically not to be had, and even the usually patient and docile Hazaribagh *khalásis* at one time struck work.

All food had to be carried by the men themselves from the villages on the banks, Matu and Massein, where fortunately rice of good quality was obtainable at prices not much in excess of those prevailing at the time in Mandalay.

Elephant tracks were seen in several places, but these were probably those of the Bombay-Burma Trading Company's animals. There were also tracks of wild buffaloes and leopards. *Hooluks* (Gibbon) howled in the wilder recesses, and the ordinary jungle fowl and deer abound. Water is abundant, clear and sweet in every stream. The tract is said to be very feverish after the rains, but in the winter months the climate was excellent, and only one serious case of fever occurred among the native establishment, though both the European officers suffered.

ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

Extract from the Narrative Report of CAPTAIN S. G. BURRARD, R.E., *in charge No. 22 Party (Astronomical), Season 1891-92.*

The arcs of longitude assigned for measurement during the season were as follows:—

(1) Calcutta-Waltair.
(2) Waltair-Jubbulpore.
(3) Waltair-Madras.
(4) Waltair-Bolarum.
(5) Bolarum-Bombay.
(6) Fyzabad-Dehra.

In 1877 two arcs had been measured from Vizagapatam, *viz.*, Vizagapatam-Madras and Vizagapatam-Bellary, Colonel Heaviside observing at the Vizagapatam terminal of each.

On my arrival at Vizagapatam, I found that a Roman Catholic mission school had been built over Colonel Heaviside's station, and that his site was not only no longer available for an observatory, but that it could not be discovered without damage to the school house. I accordingly selected a new longitude station at Waltair, which was within three miles of Colonel Heaviside's, and which fulfilled all necessary conditions admirably.

If the old station at Vizagapatam had been still available, it would this season have been connected with Calcutta, Jubbulpore, and Bolarum only; but as Waltair had to be substituted, it was considered advisable to not only observe the Calcutta-Waltair, Waltair-Jubbulpore, and Waltair-Bolarum arcs, but to also measure the arc Waltair-Madras, and to reject the old arc, Vizagapatam-Madras. The two Vizagapatam arcs of Volume IX, Great Trigonometrical Survey, have therefore been excluded from the final reduction of the Indian longitudes.

We commenced work on the Calcutta-Waltair arc on 6th December and completed it on 12th December 1891. The telegraph line for the greater part of its length followed the coast line of the Bay of Bengal, and, owing to the humidity of the air and the bad condition of the line, the insulation was most defective, and signals very difficult to receive. On the next arc, Waltair-Jubbulpore, the telegraph wire ran *viâ* Calcutta, so that our currents had not only to pass over the same 550 miles of coast line as they had in the previous arc, but also over an additional length of 750 miles from Calcutta to Jubbulpore. As was to be expected, we failed entirely to pass any signals through, and we were compelled to introduce a translating station at Cuttack.

The retardation of the current on this arc was found to be 0·191 of a second, a quantity almost double in amount the largest value hitherto obtained and more than four times in amount the average value of the retardation on an ordinary arc.

FINAL RESULTS OF THE SEASON'S WORK.

The values of the arcs measured during the season 1891-92 are here given in tabular form.

Arcs.	Telegraphic value of Longitude.			Geodetic value of Longitude.			Telegraphic *minus* Geodetic.
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*s.*
1. Calcutta-Waltair	0	20	9·194	0	20	9·684	−0·490
2. Waltair-Jubbulpore	0	13	28·501	0	13	28·060	+0·441
3. Waltair-Madras	0	12	16·868	0	12	16·612	+0·256
4. Waltair-Bolarum	0	19	11·525	0	19	11·482	+0·043
5. Bolarum-Bombay	0	22	48·785	0	22	49·480	−0·695
6. Fyzabad-Dehra	0	16	20·700	0	16	19·007	+1·637

The correctness of the telegraphic values of our arcs may be tested as follows :—

		m.	s.
(i)	Calcutta-Waltair	= 20	9·194
	Waltair-Jubbulpore	= 13	28·501
	Their sum gives the value of the arc, Calcutta-Jubbulpore .	= 33	37·695
	Calcutta-Jubbulpore, as observed in 1882-83	= 33	37·702
	Closing errror . . .	= 0	0·007
(ii)	Waltair-Jubbulpore	= 13	28·501
	Waltair Bolarum	= 19	11·525
	Their difference gives the value of arc, Jubbulpore-Bolarum .	= 5	43·024
	Jubbulpore-Bolarum, as observed in 1880-81	= 5	42·935
	Closing error . . .	= 0	0·089
(iii)	Waltair-Bolarum	= 19	11·525
	Waltair-Madras	= 12	16·868
	Their difference gives the value of the arc, Madras-Bolarum .	= 6	54·657
	Madras-Bolarum, as observed in 1875-76	= 6	54·615
	Closing error . . .	= 0	0·042
(iv)	Waltair-Madras as observed in 1891-92	= 12	16·868
	Deduct geodetic difference of longitude between the longitude stations at Vizagapatam and Waltair, as obtained by triangulation	= 0	6·913
	The remainder should give value of Vizagapatam-Madras arc (provided that local attraction at Waltair and Vizagapatam is the same)	= 12	9·955
	Vizagapatam-Madras arc as observed by Colonel Heaviside in 1875-76	= 12	9·935
	Discrepancy .	0	0·020
(v)	Fyzabad-Agra, as measured in 1882-83	= 16	27·995
	Dehra-Agra, as measured in 1885-86	= 0	7·233
	Their difference should give the value of the arc, Fyzabad-Dehra	= 16	20.762
	Fyzabad-Dehra, as measured in 1891-92	= 16	20·704
	Closing error . .	= 0	0·058
(vi)	Mean circuit error for the season 1891-92	= 0	0·049

Retardation.

On any arc measured between stations E and W, let the retardation of the current from E to W be t' and from W to E be t''. Let the value of the arc of longitude, as found by observations with E clock, be ΔL_E, and when determined by observations with W clock ΔL_W, and let ΔL be the true difference of longitude required. Then $\Delta L = \Delta L^E + t' = \Delta L_W - t''$.

ΔL_E and ΔL_W are known quantities given by observation, and their difference is equal to $(t' + t'')$. The value of $\left(\frac{t'+t''}{2}\right)$ is here given for each of the arcs measured during 1891-92 ; it will be seen to be unusually large throughout the season, and attains its maximum value (as was pointed out before) on the "translation" arc, Waltair-Jubbulpore.

Arcs.	ΔL_E		ΔL_W		$t'+t''$.	$\frac{t'+t''}{2}=\rho$
	m.	*s.*	*m.*	*s.*	*s.*	*s.*
1. Calcutta-Waltair	20	9·081	20	9·306	0·225	0·113
2. Waltair-Jubbulpore	13	28·310	13	28·692	0·382	0·191
3. Waltair-Madras	12	16·764	12	16·971	0·207	0·104
4. Waltair-Bolarum	19	11·418	19	11·631	0·213	0·107
5. Bolarum-Bombay	22	48·699	22	48·871	0·172	0·086
6. Fyzabad-Dehra	16	20·621	16	20·786	0·165	0·083

Experiments on the Object Glasses.

First series of experiments.

The first experiments that were carried out were as follows:—The two collimators were set up and most carefully aligned upon one another, great caution being also taken that the cube of the telescope did not partially obscure mutual vision: the value of C_o was then determined. The collimators were then moved laterally through half an inch, and C_o again determined. They were then raised half an inch, and C_o again determined: in all positions their optical axes remained parallel to their original position. In these experiments the object glasses of the two collimators remained accurately aligned and superimposed, but at each determination of C_o a different position of the object glass of the telescope was brought into play, and it was expected that this difference would cause a change in the value of C_o, but no alteration in the value of C_o was observed, and no difference between C_E and C_W detected.

The diameter of the object glass of the telescope is five inches, that of the aperture in the cube $3\frac{1}{4}$ inches, and that of the object glass of a collimator $2\frac{1}{2}$ inches. As it is essential that mutual vision between the collimators should be obtained without any interruption by the telescope, the extreme lateral movement possible is three-quarters of an inch, and in practice not more than half an inch. Although, therefore, the object glass of the telescope has an area of 20 square inches, only a circular portion of it (the size of the collimating aperture) about seven or eight square inches in area, at the centre, is available to experiment on.

Second series of experiments.

The second series of experiments carried out were as follows:—C_o was first determined from horizontal collimators, then from vertical collimators, and then from collimators inclined to the horizon. The object glasses of the collimators were most carefully aligned and superimposed in every case, and the collimating hole was placed truly between them. No alteration in the value of C_o was observed, and no difference between C_E and C_W detected, whether the collimators were horizontal, vertical or inclined.

Third series of experiments.

The third series of experiments was as follows:—The telescope was first placed in position, and in intersecting the cross of the northern collimator with the vertical wire of the southern, view was obtained through the collimating aperture; with these conditions holding, four readings were taken and recorded. The telescope was then removed and four readings obtained with uninterrupted vision. The process was repeated four times in each pivot position of both telescopes. It was found that if the collimating aperture be carefully aligned between the two collimators, no change in the reading of the collimator cross will be caused by the removal of the telescope; in other words, the interposition of the telescope between the collimators has no effect. But if alignment is not careful, and portions of the object glasses of the collimators be rendered ineffective by the interruption of the telescope, the removal of the telescope will cause an alteration of perhaps one or two divisions in the reading of the collimator cross. In regular longitude work no great care in alignment is ever taken, and the position of the collimating hole might easily be shifted laterally through a quarter of an inch at change of pivot.

Fourth series of experiments.

The quantity C_o is too complex a quantity to experiment on. It depends on no less than four different readings, *viz.*, A, B, D and E, and its formula is $C_o = \frac{D+E}{2} \mp \left(\frac{A-B}{2}\right)m$. Now, say, we determine C_o, and then move the collimators and re-determine it: moving and re-adjusting collimators occupies much time, and we are fortunate if we get three or four values of C_o in one night, if they have been taken under quite different conditions When we have obtained them, we learn nothing. In moving the collimators we alter three out of the four readings, *viz.*, A, D, and E by large amounts, so that if two successive values of C_o do differ, all we know is that the complex formula $\frac{D+E}{2} \mp \left(\frac{A-B}{2}\right)m$ has changed in its result, but we cannot

put our finger on the exact term of the formula, and say to which of the numbers A, D, E the change is due. So that even when we do succeed in changing C_o, as I did in 1890, by tilting my collimators, all we know is that C_o has changed as a whole, but we are ignorant as to what elementary term in C_o has changed. In moving collimators, D and E will be changed by 200 or perhaps 400 divisions, and A by possibly 150 divisions, whereas variations in C_o are confined within limits of 10 divisions. What happens as often as not, too, is that variations in A, D and E tend to cancel, and though each may be suspected of change, the resulting value of C_o remains the same.

For these reasons we were led to give up experimenting on so complex a quantity as C_o, for it became quite clear that the only chance of success lay in attacking the three elementary quantities A, D and E themselves. (B is the reading of the cross of the south collimator on its own micrometer when intersected with its own vertical wire, and so is independent of all external influences.)

The new plan we were gradually led to adopt was this: Suppose we have two telescopes, Y and Z, pointing at one another exactly, their object glasses close together, each telescope being provided with a cross wire at its eye end. The telescope Y has a micrometer, and with it we measure the horizontal distance between the two crosses. We then with a semi-circular cardboard disc cover up the western half of the object glass of telescope Z and re-measure the horizontal distance between the two crosses. We then with the same disc cover up the eastern half of the object glass of telescope Z, then the lower half, then the upper half, reading the crosses each time. Now if the reading is different, when the western half of the object glass of Z is obscured, to what it is when the eastern half is obscured, there is a tendency to think (especially when the two telescopes are 30 feet apart as our collimators are) that the object glass of Z is at fault, but this is not necessarily the case. However far the telescopes are apart, provided they are properly aligned, in covering up the western half of the object glass of Z, we in reality cover up the western half of *both* telescopes, for, as far as mutual vision is concerned, only the eastern half of both is in play, and we are only dealing with parallel rays. So that any change in the reading of the cross of Z on Y's micrometer may be due to a defect in either object glass or both.

In our present experiments we have three telescopes, and experimenting with them two at a time we get three pairs with which to operate.

1st pair.—North and south collimators. Reading of north collimator cross on south collimator micrometer called A

2nd pair.—North collimator and transit instrument. Reading of north collimator on telescope micrometer called D.

3rd pair.—South collimator and transit instrument. Reading of south collimator on telescope micrometer called E.

I append tables of results, being values of A, D and E taken with different parts of the object glasses obscured. In all cases vision was very fair, but in some cases better than in others. On regular work I have frequently had worse vision of the north collimator cross in the south collimator than I had in any one of these cases, where half the object glass was obscured each time.

We aligned the three telescopes as follows: We put a white cardboard disc over the object glass of the telescope, and threw the light from the lamps at the back of the collimators on to this disc: the collimators focussed the light from their lamps and threw a highly illuminated circle (of the same diameter as the object glass of the collimators) on to the white disc. We moved the collimators until this circle of light in each instance was at the centre of the disc, when the telescope was horizontal. When this had been done, there was mutual vision between the collimators. We then took this white disc and cut out from its centre an aperture of the same size as the object glass of the collimators. In reading D or E with the telescope, the results should have been the same, whether this annular disc was inserted in the object glass of the telescope or not, for, even when it was inserted, all that portion of the glass that intercepted parallel rays from the collimator was still exposed towards the collimators.

The second disc necessary was a semi-circle of cardboard of half the size of the object glass of the collimators. With this semi-circular disc we could obscure not only half the object glass of each collimator, but it would also close up half the aperture in the telescopic disc.

In the experiments on the readings of A, only the north and south collimators are introduced: we covered up in turn the western half, the eastern, the lower and the upper of each collimator.

In the readings of D and E the telescope comes in. In these cases we began with both object glasses wholly unobscured: we then placed the annular disc in the telescope and left it there throughout the remaining experiments. The experiments on D and E consisted in obscuring parts of the object glass of the collimator and parts of the aperture in the annular disc alternately. Alignment being good, the insertion of the annular disc should not alter the readings of D and E from what they were with the whole object glass of the telescope, as no parts of either object glass in play are obscured: the insertion of the annular disc (*vide* Table II) altered D from 1767·5 to 1767·4, and E from 1448·0 to 1448·3. Again, alignment being good, the readings of D and E should be unaffected, whether the semi-circular disc be inserted over half the collimator or over the corresponding half of the aperture in the telescopic disc.

TABLE I.—VALUES OF A (TELESCOPE NO. 1.)

A is the reading of the south collimator micrometer when the vertical wire of the south collimator is intersecting the cross of the north collimator. The collimators were pointing exactly opposite each other; the disc was of cardboard and semi-circular, being exactly half the size of the object glass of either collimator.

	Object Glasses of both collimators open.	Eastern half of Object Glasses unobscured.		Western half of Object Glasses unobscured.		Upper half of Object Glasses unobscured.		Lower half of Object Glasses unobscured.		
	No disc inserted at all.	Disc inserted in North collimator.	Disc inserted in in South collimator.	Disc inserted in North collimator.	Disc inserted in South collimator.	Disc inserted in North collimator.	Disc inserted in South collimator.	Disc inserted in North collimator.	Disc inserted in South collimator.	
Each of the readings in these columns is the mean of two, one taken by Captain Burrard and one by Lieutenant Conyingham	58·2	58·7	59·2	53·9	53·6	57·5	58·0	58·5	59·2	At the end of the experiments A was read again with no disc inserted at all to see that no movement had taken place.
	56·8	58·7	60·2	54·2	54·0	57·5	57·2	59·0	57·0	
	57·0	59·0	57·7	54·2	56·0	59·1	57·3	59·8	56·6	
	58·2	60·2	59·3	55·3	53·0	58·5	57·3	61·0	57·5	
	...	...	...	...	54·3	...	...	...	...	
Means	57·6	59·2	59·1	54·4	54·2	58·2	57·5	59·6	57·6	
Final means	A_o=57·6	A_E=59·2		A_W=54·3		A_U=57·9		A_L=58·6		

The five different values of A are—

- A_o =57·6 with full aperture in use.
- A_E =59·2 „ Eastern half of object glass in use.
- A_W=54·3 „ Western „ „ „ „
- A_U =57·9 „ Upper „ „ „ „
- A_L =58·6 „ Lower „ „ „ „

N.B.—A is in divisions of collimator micrometer; D, E, and C_2 are always in divisions of telescope micrometer. To convert A (or differences between two values of A) into divisions of telescope micrometer they must be multiplied by 1·666.

TABLE II.—VALUES OF D (TELESCOPE NO. 1.)

D is the reading of the telescope micrometer, when the centre vertical wire is intersecting the cross of the north collimator. Two discs had to be used for the telescope, the first was an annulus, and covered up the object glass of the telescope, with the exception of a circular portion of the same size as the object glass of the collimator; the second disc was semi-circular, and half the size of the object glass of the collimator.

	Object Glasses of Telescope and Collimator open.		Eastern half of Object Glasses unobscured.		Western half of Object Glasses unobscured.		Upper half of Object Glasses unobscured.		Lower half of Object Glasses unobscured.		
	No disc inserted at all.	Circular disc with aperture inserted in telescope.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	
Means of two readings, one by Captain Burrard and one by Lieutenant Conyingham.	1767·3	1767·5	1769·3	1768·5	1764·2	1766·2	1764·9	1765·0	1771·5	1770·0	At the end D was read again with no disc inserted in either object glass to see that no movement had taken place of either collimator or telescope during the experiments.
	66·9	68·5	69·7	69·7	63·6	65·5	65·7	64·1	69·3	70·8	
	68·0	66·4	68·0	69·0	63·2	64·7	66·0	66·1	69·0	70·0	
	67·8	67·0	68·2	69·1	62·9	65·4	66·0	65·0	69·0	70·4	
Means	1767·5	1767·4	1768·8	1769·1	1763·5	1765·5	1765·7	1765·1	1769·7	1770·3	
Final Means	D_o =1767·5		D_E =1769·0		D_W=1764·5		D_U =1765·4		D_L =1770·0		

The five different values of D are—

- D_o =1767·5 with no obscuration.
- D_E =1769·0 „ Eastern half of object glass of collimator in use.
- D_W=1764·5 „ Western „ „ „ „
- D_U =1765·4 „ Upper „ „ „ „
- D_L =1770·0 „ Lower „ „ „ „

Table III.—Value of E (Telescope No. I).

E is the reading of the telescope micrometer, when the centre vertical wire is intersecting the cross of the south collimator. Two discs were used for the telescope, the first fitted the object glass of the telescope, but had an aperture in it of the same size as the object-glass of the collimator; this aperture was placed exactly opposite the collimator. The second disc was semi-circular and the same as in Table I, being half the size of the object glass of the collimator.

	Object glasses of Telescope and Collimator open.		Eastern half of Object glasses unobscured.		Western half of Object glasses unobscured.		Upper half of Object glasses unobscured.		Lower half of Object glasses unobscured.		
	No disc inserted at all.	Circular disc with aperture inserted in telescope.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	Semi-circular disc inserted in collimator.	Aperture in disc of telescope half covered.	
Means of two readings, one by Captain Burrard, and one by Lieutenant Conyngham.	1448·2	1448·6	1450·6	1450·4	1447·3	1444·9	1450·7	1450·5	1448·0	1449·0	At the end E was read again with no disc inserted at all to see that no movement had taken place.
	47·5	49·9	50·5	50·0	46·8	45·9	50·7	51·0	45·8	48·2	
	47·7	47·3	50·7	49·7	47·3	46·2	50·4	51·8	47·9	49.0	
	48·5	48·1	50·3	49·9	48·5	45·8	50·6	51·2	47·4	48·5	
Means . .	1 48·0	1448·3	1450·5	1450·0	1447·5	1445·7	1450·6	1451·1	1447·3	1448 7	
Final Means .	E_O = 1448·0		E_E = 1450·3		E_W = 1446·6		E_U = 1450·9		E_L = 1448·0		

The five different values of E are

E_O = 1448·2 with object-glass of collimator full in use.

E_E = 1450·3 „ Eastern half of object-glass of collimator only in use.

E_W = 1446·6 „ Western „ „ „ „

E_U = 1450·9 „ Upper „ „ „ „

E_L = 1448·0 „ Lower „ „ „ „

From the Tables it will be seen that D_W differs from D_E by no less than $4\frac{1}{2}$ divisions, and D_L from D_U by a similar amount. E_W differs from E_E by 3·7 divisions, and E_L from E_U by 2·9 divisions.

It is when we come to A, that we get the most extraordinary difference. The readings of A are in divisions of the collimator micrometer, and have to be multiplied by 1·666 to be brought into terms of the telescope micrometer: as C_o D and E are in terms of the latter, this conversion must always be effected. Now A_W = 59·2 and A_E = 54·3; difference = 4·9, collimator divisions = 8·2 divisions of the telescope micrometer. This means to say that the value of A will differ by 8·2 divisions according to whether the western or eastern half of the object-glasses is obscured, the image of the intersected cross remaining clear, distinct, and good throughout.

In the experiments on the reading of A, in which the great discrepancy of 8·2 divisions appears, the telescope does not enter at all, and so this discrepancy must be due to one or both collimators.

Whether the variations in D and E are due to the object-glass of the telescope or those of the collimators cannot be positively stated from the above results, but all the evidence tends to acquit the telescope.

In the first place we are testing the object-glass of the telescope by means of collimators, whose object-glasses are themselves bad, as proved by the changes in A. Variations then in D and E are therefore only to be expected owing to the badness of the collimators, and these variations are no evidence whatever against the object-glass of the telescope.

Secondly, all the old discrepancies between C_E and C_W are at once explained, if we admit A to be erroneously determined.

$$C_E = \frac{D+E}{2} + \left(\frac{A-B}{2}\right) m \text{ and}$$

$$C_W = \frac{D+E}{2} - \left(\frac{A-B}{2}\right) m$$

C_E will therefore differ from C_W by the amount that A is in error, as half this amount is additive in one case and subtractive in the other.

Thirdly, in adding $D_W - D_E$ to $E_W - E_E$ or $D_L - D_U$ to $E_L - E_U$, any effect of the object glass of the *telescope* should be cancelled, as its effect should be opposite on the two collimators. Now $D_W - D_E = +4{\cdot}5$ and $E_W - E = +3\,7$: their sum $= +8{\cdot}2$, and this is the exact value of $A_W - A_E$. Again $D_L - D_U = -4{\cdot}6$ and $E_L - E_U = +2{\cdot}9$: their sum $= -1{\cdot}7$, whilst the value of $A_L - A_U = -0{\cdot}7 \times 1{\cdot}666 = -1{\cdot}2$.

If the object-glass of the telescope be faultless the values of D and E will not in practice be erroneously determined, however bad the object-glass of the collimator is, for though in regular work the collimators may point towards different portions of the object-glass of the telescope, the alignment can never be so bad as to throw a portion of the object-glass of the collimator outside the object-glass of the telescope altogether.

If a reading is not altered by bringing a different portion of the object-glass of the telescope into play, then as long as the projection of the object-glass of the collimator is wholly within the object-glass of the telescope, no change in D and E will take place whatever portion of the telescopic object-glass is opposed to the collimator. On the other hand, if any portion of the object-glass of the collimator is thrown out of use from bad alignment, variations will ensue. Though these experiments on D and E are useful in proving the badness of the collimators, yet in practice no portion of the object-glass of the collimators can well remain obscured during the reading of D and E, and so unless the object-glass of the telescope is bad too, the readings of D and E are likely to be correct in all positions; in other words, variations in C_o cannot be attributed to D and E.

In the formula for C_o the quantity that seems most likely to be wrong is A. This quantity is shewn to vary according to the portion of the object-glasses that is obscured. Now in practice it is most unlikely that the object-glasses of the two collimators should be exactly opposed. No steps are ever taken to attain this object: the observer is satisfied if he gets good mutual vision, and good mutual vision with an excellent image can be obtained with only one-third of the object-glasses in play. The collimators have such small object-glasses and are so far apart in practice, that what generally happens is that their object-glasses, instead of being exactly opposed, merely overlap.

The aperture in the cube of the telescope has also to be taken into account. The collimators besides being mutually opposed have to be exactly opposite this aperture: in practice they are not, and further portions of the object-glasses of the collimators are shut out from use by the cube of the telescope.

My belief then is that owing to faulty object-glasses the reading of A is determined wrongly, and as shewn before any error in the determination of A will be the exact amount that C_E will differ from C_W. If A_o in the Table is the *correct* value of A, but A_E and A_W are used in the formula for C_O, then C_E will differ from C_W by 8·2 divisions.

These experiments, however, practically left the question of the faultiness of the object-glass of the telescope untouched: in this matter there was still no proof, though there was evidence on which to form opinions. It was anyhow clear that if the object-glass of the telescope was to be tested, some other means must be devised than by collimators. At Dehra I took advantage of a distant meridian mark to abolish the collimators. I intersected the mark and took the micrometer reading several times, obscuring different portions of the object-glass of the telescope in turn. No constant difference between the readings, when different portions of the object-glass were obscured, could be detected, but these results did not deserve much weight as owing to the haze the observed mark was very unsteady and the observations very bad.

I finally decided that the best test to which to subject the telescopic object-glass was to take the reading of M with different portions of the object-glass obscured in turn. The telescope was thus pointed to the nadir, and the reading of the reflection in mercury of the centre wire taken, portions of the object-glass being obscured in turn. No difference whatever could be detected with telescope No. 1 in the reading of M, whether that reading were taken with the whole object-glass open, or with its eastern, western, northern, or southern half only.

All that has been written so far has only to do with No. 1 Telescope and its collimators. It was not till Lieutenant Lenox-Conyngham joined me in Dehra in April 1892, that we commenced experiments on his equipment, *viz.*, No. 2 Telescope and its collimators.

We first of all took the readings of A, D, and E in the same way as we had done with telescope No. 1. The readings of each shewed similarly large discrepancies when different portions of the object-glasses were obscured. As in the case of telescope No. 1, the discrepancies shewed that the object-glasses of both the collimators were certainly at fault, but we could not tell whether the telescopic object-glass was faultless or not.

To test the telescopic object-glass we took readings as before of the meridian mark, but were again prevented from attaching any weight to the results by the unsteadiness of

the image of the mark. Subsequent experiments, however, on the reflected image of wires in mercury seem to shew that the object-glass of No. 2 Telescope is by no means perfect. The results of these experiments are given in the following Table.

TABLE IV.—READINGS OF M.

M is the reading of the telescope micrometer when its direct and reflected images are coincident—

	Whole object-glass in use.	Northern half in use only.	Southern half in use only.	Western half in use only.	Eastern half in use only.
First set	1518·3	1517·9	1519·1	1519·0	1515·4
	18·5	17·3	17·3	19·5	16·6
	17·0	17·2	18·0	19·5	15·2
	17·5	18·0	19·0	19·8	14·1
	18·4				
Means	1517·9	1517·6	1518·4	1519·5	1515·3
Second set	1518·1	1519·0	1519·0	1521·2	1516·5
	17·8	19·0	18·5	20·4	16·4
	18·8	19·0	18·1	19·0	15·9
	18·9	19·0	18·9	20·0	16·5
Means	1518·4	1519·0	1518·6	1520·2	1516·3
General means	$M_O = 1518·2$	$M_N = 1518·3$	$M_S = 1518·5$	$M_W = 1519·9$	$M_E = 1515·8$

I may sum up the results of our experiments as follows :—

(1). However the collimators are set up, whether vertical, horizontal, or inclined, no change in C_o will occur and no difference between C_E and C_W be met with, provided the object-glasses of the two collimators and the collimating aperture are carefully aligned.

(2) If the collimators are not exactly opposed, or if the collimating aperture obscures portions of the object-glasses. C_E will be found to differ from C_W.

(3) If the collimators are slightly tilted, a change in C_o will occur, because fresh portions of the object-glasses become obscured by tilting.

(4) The former mysterious circuit errors were certainly caused by the observers not taking sufficient precautions in aligning their collimators.

(5) The faultiness in the object-glasses of the collimators belonging to either telescope is such as would cause errors of 8 divisions in the determination of C_o, if half the object-glasses of the collimators happened to be ineffective during the determination.

(6) The faultiness in the object-glass of No. 2 telescope might cause an error of 3 divisions in a reading, if half its area were obscured (which is impossible in practice).

(7) No signs of faultiness have so far been detected in the object-glass of No. 1 Telescope.

As stated previously the alignment of the collimators has never in practice been considered of any consequence so long as good vision of the wires was obtained, nor has any record been kept of their actual positions; it is, therefore impossible to correct old observations on account of errors from faulty alignment. It, however, fortunately happens that the adoption of a mean C_o (or of any value of C_o so long as it is the same for I. P. E. and I. P. W.) cancels all errors arising from faulty object-glasses of the collimators.

Experience has shewn that $\frac{C_E+C_W}{2}$ is a fairly accurate value of C_o, and I do not at present see any method of obtaining a more accurate determination. However C_E and C_W vary, and they can be made to vary easily through 6 divisions, the mean $\frac{C_E+C_W}{2}$ will be found to remain constant. Thus at Kurrachee in 1890, 5 values of C_E and C_W were taken as follows, the collimators being moved after each pair :—

C_E	C_W	Mean $= C_o$
1720·6	1724·3	1722·5
22·5	24·0	1723·3
25·8	22·1	1723·9
26·0	20·1	1723·1

Again at Waltair in 1891, C_E and C_W were determined once each on five successive nights, the collimators being wholly removed after each night's work, and set up again on the following night. The following were the results :—

C_E	C_W	Mean $= C_o$
1484·4	1473·6	1479·0
1482·2	1476·9	1479·6
1481·3	1477·8	1479·6
1484·8	1473·2	1479·0
1478·0	1482·3	1480·2

Again at Dehra in 1892 the same process was gone through four times with the following results :—

C_E	C_W	Mean $= C_o$
1512·1	1520·1	1516·1
1515·1	1516·7	1515·9
1515·5	1515·7	1515·6
1516·1	1514·8	1515·5

Extract from the Narrative Report of LIEUTENANT G. P. LENOX-CONYNGHAM, R.E., *in charge No. 23 Party, Astronomical, Season 1891-92.*

A new station for the longitude observations had to be selected at Calcutta, the old one having been destroyed at the time when the new Mathematical Instrument Office was built. Some little difficulty was experienced in finding a suitable site, and it was found necessary, in order to secure a view to the north, to build the pillars on the road which runs along the face of the Mathematical Instrument Office. The position is 32 feet 9 inches north and 31 feet 4½ inches east of the latitude pillar. There being no telegraph wire to the Survey Offices, a short length of special line had to be constructed for my use, starting from the Park Street telegraph office. This was readily undertaken and rapidly executed by the Telegraph Department.

All observers who have had occasion to level an instrument by means of reflection in mercury at Calcutta have complained of the extreme difficulty of getting a distinct image owing to the constant tremors of the soil. I was so fortunate as to have been provided with a new pattern of trough, the use of which entirely overcame the difficulty. A description of it may not be out of place.

The trough consists of a plate of copper about 9 inches in diameter and $\frac{1}{4}$ of an inch thick, the upper surface of which is slightly concave ; the depth at the centre being about $\frac{1}{20}$th of an inch. To prepare it for use, a few drops of mercury are poured upon it and then rubbed over the surface with a rag saturated in dilute sulphuric acid. This process causes the mercury to amalgamate with the copper, and instead of remaining free, it, so to speak, wets the surface, and to a certain extent adheres to it ; if now more mercury be added until there is a pool covering the plate, it will be found to have become more or less viscid, so that while its surface takes up a horizontal position quite as readily as in the ordinary trough, it is yet not liable to tremors. The pool of mercury is of course very shallow, so that a fairly level place must be prepared for the trough to rest on, but that is a very trifling disadvantage. As a matter of convenience, a gutter is cut all round the trough, near its outer edge, which catches any drops of mercury which may be spilled in filling.

So far as I am aware, all previous attempts to do away with the difficulty of obtaining a distinct image had been directed towards a more complete isolation of the trough from the surface of the ground,—springs, india-rubber buffers, floating vessels and the like being tried, but all without any effect; so that the originality of the invention under discussion, attacking, as it does, the mercury itself, and overcoming its liability to tremors, as well as its complete and unqualified success, render it well worthy of note. By its aid I was able to get as clear images of my spider lines while vehicles were passing within a hundred yards of my telescope, as I was at Kalianpur in 1889, where probably not a cart was moving within 10 miles, and I feel that I owe the inventor a heavy debt of gratitude.

The longitude station at Waltair is in the compound of the office of the Superintending Engineer, Public Works Department, which adjoins the Telegraph Office. The original station is marked by a stone bearing the letters $\frac{\text{LS}}{\text{GTS}}$ and surrounded by an iron railing. Owing to the erection of a small building close to it, the view to the north is cut off, and it was necessary to select a new station. This is 16 feet $4\frac{3}{4}$ inches west and 24 feet 2 inches south of the old one.

On the 10th of April both parties returned to recess quarters and commenced the computation of the season's work.

The results obtained were as follows :—

Arcs.	m. s.
Calcutta—Waltair	ΔL 20-9·194
Waltair—Jubbulpore	ΔL 13-28·501
Waltair—Madras	ΔL 12-16·868
Waltair—Bolarum	ΔL 19-11·525
Bolarum—Bombay	ΔL 22-48·785
Fyzabad—Dehra Dun	ΔL 16-20·704

These arcs complete the longitude work of India proper, and consequently the simultaneous reduction, by minimum squares, of all arcs measured, was undertaken.

It is satisfactory to note that the mean circuit error, taken from the equations of condition used in the reduction, amounts only to 0.04 of a second. The bulk of the work of the reduction was undertaken by Babu Kali Mohun Ghose, whose long experience of work of this nature rendered his assistance extremely valuable.

The health of the party was good throughout and, the members of it worked satisfactorily. Babu Hanuman Prosad proved himself an expert recorder.

As on previous occasions, every one connected with the Telegraph Department gave us the most cordial assistance.

TIDAL AND LEVELLING OPERATIONS.

Extract from the Narrative Report of LIEUTENANT-COLONEL J. HILL, R.E., *in charge No. 25 Party,—Season 1891-92.*

TIDAL OPERATIONS.

During the survey year under review, tidal observations, by means of self-registering gauges, were carried on at fourteen stations, namely, *Aden*, *Kurrachee*, Bhávnagar, *Apollo Bandar Bombay*, Prince's Dock Bombay, Cochin, Minicoy, Tuticorin, Trincomalee, *Kidderpore*, Akyab, *Rangoon*, Mergui, and *Port Blair*. The eight 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 period of observations lasts for nineteen years, and where observations should continue to be taken until the work at all the stations is completed. In addition to the automatic observations taken at the stations enumerated above, personal tidal observations to

graduated staves were taken daily, with the object of comparing the actual heights and times of high and low water with those predicted in the Tide Tables.

This was done at the following tidal stations, at all of which the tidal observatories are closed:—Cochin, Cocanada, Chittagong, Akyab, and Moulmein.

At Cochin, the tidal observatory was closed on the 20th March, and at Akyab on the 23rd May, six and five years' observations, respectively, having been completed at theses stations: the reason why an extra year's observations were taken at Cochin will be found in the description of the work of that observatory further on.

No new tidal observatory was established during the year.

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 19 (including Madras) have been closed on the completion of their registrations, and 12 are now in operation.

During the survey year 1892-93, tidal observations will be continued at the following stations, where they are now in progress, *viz*: Aden, Kurrachee, Bhávnagar, Apollo Bandar and Prince's Dock Bombay, Minicoy, Tuticorin, Trincomalee, Kidderpore, Rangoon, Mergui, and Port Blair; of which Tuticorin will be closed in June 1893, on the completion of the required series of tidal registrations. The resumption of tidal observations at Madras will, I hope, be permitted, and it is expected that tidal observatories will be opened at the four following new stations:—Muscat in Arabia, Bushire in Persia, Port Albert Victor in Kathiawar, and Diamond Island in Burma.

At Muscat, the preparations are complete, and I have arranged to send Mr. Belcham to start the tidal observations as early as possible in the ensuing field season. The tidal observatory clerk from Cochin will be in charge of the observatory.

At Bushire the masonry portion of the tidal observatory has been finished under the direction of Mr. R. H. New, Assistant Superintendent of Telegraphs, to whom my thanks are due for the great amount of trouble he has taken in carrying out the work under many difficulties. Mr. Belcham will proceed to Bushire to put up the tidal observatory and start the observations before proceeding to Muscat. In consultation with the Director of the Persian Gulf Section of the Indo-European Telegraph Department, I have arranged that the tidal observations shall be carried on in connection with the Reshire Telegraph Office, the observatory clerk's duties being performed by one of the telegraph employés, who will be supervised by the telegraph officer in charge My arrangements for Muscat and Bushire have been greatly facilitated by Mr. W. W. Squire, the Engineer to the Bombay Port Trust, who had the necessary timber observatory houses, float-cylinders, feed pipe, etc, made under his personal supervision and forwarded to their destinations; for which acts of kindness I feel very grateful to him.

At Port Albert Victor preliminary arrangements are in progress: the tidal observatory clerk will be appointed by the Bhávnagar State Engineer.

In my last Annual Report I mentioned that it was intended to commence taking tidal observations at Diamond Island tidal observatory which was then being constructed by the Executive Engineer of Bassein, who expected to finish it about the end of December (1891). The work, however, proved more difficult, tedious and expensive than he had anticipated, and when December came he estimated that it might be completed in March. In February he reported that there was great difficulty in the rock-cutting, and that no labour was to be had, except at exorbitant rates. Mr. Belcham, who selected the site in April 1890, revisited it finally in March and reported that "though the Executive Engineer has done his utmost to push on the work, by keeping his assistant on the island for weeks together and going down himself very frequently, I fear there is very little hope of the observatory being completed this season." In April Mr. Belcham reported that the work was stopped by bad weather, and that it could not be resumed until December (1892), that there only remained "some 20 feet of blasting to bring the excavation out of the rock," and that the Executive Engineer said "that the length of rock-cutting still remaining will not take long to complete when he once begins operations again." I hope this anticipation will be realised and that it will be possible during the coming field season to commence tidal observations at Diamond Island. The results derived from them cannot be combined or connected with or assist our levelling operations; but I hope they will be useful to navigators and interesting to scientific theorists, and will more than justify the great labour and expense which will have been incurred in obtaining them. In my Annual Report for 1886-87 I stated that it seemed doubtful whether a tidal observatory would be established at Diamond Island, at the mouth of the Bassein River, as "the difficulty of communicating with it during the rainy season would probably neutralise its advantages." I hope that what I had in my mind then may not occur, and that the tidal observations may never break down during the heavy weather in the south-west monsoon, at which time I could not undertake to re-start them. The cost of the maintenance of the Diamond Island tidal observatory will be borne by the Bassein Port Fund, and it is proposed that the Diamond Island Telegraph Master shall perform the duties of tidal observatory clerk.

I shall now describe briefly the working of each tidal observatory, commencing with Aden and following the order of the stations round the coasts to Burma; including in this survey those stations where, in lieu of automatic tidal observations, personal observations to a graduated staff are taken daily in order to furnish comparisons between the actual and the predicted heights and times of high and low water.

Aden.—The last two annual reports on this important permanent station were very unfavourable. It is now a pleasure to me to be able to state that the tidal registrations have returned to their former satisfactory condition. The Port Officer's supervision of them is efficient, and the tidal observatory clerk is performing his duties correctly. The tide-gauge has worked almost uninterruptedly throughout the year. The longest break in its registrations was one of 50 hours' duration which occurred in July, and was due to the stoppage of the driving clock; another stoppage due to the same cause, but lasting only 6 hours, took place during the same month; and only one other slight mishap happened in June, when on one occasion the pencil failed to mark the tidal curve for 7 hours.

A new pattern tide-gauge with 'regulator clock' was substituted for the old one in May 1890. The clock rate from the first was not uniform, and the clock, as mentioned in my last report, was damaged through tampering with it in order to regulate it. Although the clerk has since then abstained from meddling unnecessarily with the clock, the time kept by it has not been regular.

It was therefore removed on July 25th, and a spare pendulum clock, sent from Poona, was substituted for it, with the result that excellent time has been kept ever since, and no failure of any kind has been reported. The auxiliary instruments have worked very satisfactorily, and their readings have been correctly taken by the observatory clerk. An inspection of the observatory was made by Mr Belcham between the 13th and 23rd May, when the instruments were all cleaned and put into working order. He reported that the piles supporting the observatory were found to be very much worm-eaten. I therefore, early in June, addressed to the Political Resident a request that he would take immediate measures to have them renewed, mentioning certain precautions necessary to secure the continuity of the tidal registrations.

I stated in my last report that one whole year's tidal registrations, except for the purpose of making a few comparisons between actual and predicted tides, had to be rejected. I am beginning to hope that so serious a gap in the hitherto unbroken series of years' observations may after all be avoided; and although I cannot say more in this report, I hope that in my next I may be able to state that my expectations have been realised.

Kurrachee.—At this station, which is one of the permanent tidal stations, the record of the year's work has as usual been very satisfactory—a fact due to the excellent arrangements of Mr. Morris, the Port Engineer, to whom my thanks are due for the efficient working of the observatory. There has not been a single break in the continuity of the tidal registrations during the year; and the record of the auxiliary instruments is almost equally perfect, one interruption only having occurred in the registrations of the anemometer in March, while that instrument was being repaired. I inspected the observatory in February, and found all the instruments in good order except the anemometer, several parts of which required renewal. I brought this to Mr. Morris's notice, and the instrument, which is the property of the Port Trust, was repaired under his direction during the following month.

During March and April, near the time of new moon, the tidal curve exhibited a peculiar distortion at high water springs.

On March 1st, the midnight tidal curve rose regularly until it attained a maximum height of 12·0 feet above the zero of the gauge at 11-30 P.M.; it kept at that height for 12 minutes and then fell until midnight exactly, by which time it had sunk 2 inches; it paused at this height for 25 minutes, and then began to rise again until it returned at 0-40 A.M. to its maximum height of 12·0 feet, at which it remained for 5 minutes, and then sank gradually and without further distortion towards low water. At the same time the barometer read 29·9 inches continuously; there was a high wind blowing from west-south-west, and the water at the tidal observatory was rough. New moon occurred two days previously, *viz*, on February 28th at 8-15 A.M. The other abnormal curves of which I now give the particulars were very similar.

On March 29th the first pause of the tidal curve at the maximum height of 12·0 feet above zero of gauge lasted from 10 P.M. to 10-10 P.M.; its next pause after falling 3 inches lasted from 10-50 to 11-10 P.M.; its last pause after rising again to the maximum of 12·0 feet lasted from 11-35 to 11-40 P.M. The barometer remained at 29·8 inches. There was a brisk gale from south-south-west, and the water at the tidal observatory was rough. New moon occurred on March 28th at 5-46 P.M.

On April 27th the first pause of the tidal curve at the maximum height of 12·0 feet above zero of gauge lasted from 9-25 P.M. to 9-30 P.M; its next pause after falling 2½ inches lasted from 10-20 to 10-40 P.M.; its last pause after rising again to the maximum of 12·0 feet lasted from 11-5 to 11-15 P.M. The barometer remained at 29·9 inches. There was a brisk gale from south-south-west, and the water at the tidal observatory was rough. New moon occurred on April 27th at 2-14 A.M.

On the following day, April 28th, there were two of these abnormal registrations. During the first, the tidal curve first paused at the maximum height of 12·0 feet above zero of gauge from 10-40 A.M. to 10-50 A.M.; its next pause after falling 3½ inches was from 11-30 to 11-45 A.M.; its last pause after rising again to the maximum of 12·0 feet was from 0-25 P.M. to 0-30 P.M. The barometer remained at 30 inches. There was a brisk gale from the south-west, and the water at the tidal observatory was rough. During the second, the curve first paused at the maximum height of 12·0 feet above zero of gauge

from 10-20 P.M. to 10-40 P.M.; its next pause after falling 1-inch was from 10-57 to 11-2 P.M.; its last pause after rising again to the maximum of 12·0 feet was from 11-5 to 11-35 P.M. The barometer remained at 29·9 inches. There was a brisk gale from the south-west, and the water at the tidal observatory was rough. No other tidal curves similar to those just described occurred during the year, nor have I any record of any like departure from the normal type of tidal curve at Kurrachee during past years. I may remark that the maximum height of 12 feet above the zero of the gauge, which is so noticeable in the foregoing descriptions, happens to be about the maximum for the whole year under report. It has been exceeded, however, in other years in several instances; but on such occasions the tidal curve was regular, whereas in the instances just described the curve was depressed just at the time when highest water was expected.

The peculiarity that all these abnormal curves attained a maximum of 12 feet above the zero of the gauge instead of rising above that height, as they would have done had they remained regular, seems to point to something faulty in the mechanism of the tide gauge, such as a lowering of the counterpoise weight of the float or a shortening of the counterpoise chain of the float band; but nothing of this nature has been reported or is known to have occurred The first three abnormal curves passed without notice in the tidal observatory; but the clerk noted the last two in his daily reports for the 28th and 29th April, and attributed their distortion to "imperfect communication;" he also submitted measurements of these tides, which he stated were taken to the observatory graduated staff at intervals of 5 minutes about the times of high water, and which exhibit the tide rising above the 12 feet limit in a normal manner. An inspection of the curves negatives the idea that there was imperfect communication, and certain peculiarities of the clerk's staff measurements throw some doubt on their authenticity, and they cannot at present be accepted The next inspection of the tidal observatory ought to be made before the time when, according to calculation, the tide will rise again to the height of 12 feet above the zero of the gauge. It will then, I hope, be possible to discover the true explanation of these abnormal curves.

Bhávnagar.—At this station, the tidal registrations may be said to be satisfactory on the whole. During the first four months of the survey year the rules regarding the flushing of the cylinder were not properly observed, but since February there has been greater regularity in this respect, although there is still room for improvement. The cylinder ought to be flushed once a fortnight, but during the last three months of the year under report this duty has been performed only four times. In addition to the unavoidable interruptions to the tidal registrations so caused, there were a few short interruptions due to slight accidents to the communication pipe and air-cock, to the pencil failing to mark, and to the stoppage of the driving clock; but in all these cases the broken curves were easily completed by interpolation. The Bhávnagar tidal observatory clerk requires close and careful supervision. Some of the interruptions I have referred to were not only not reported by him, but he attempted to conceal them In my last Annual Report I mentioned that the self-registering aneroid barometer had been working imperfectly: it continued to do so until January, when I inspected the observatory. The instrument in question and a mercurial barometer, both the property of the Government of India, were set up at Bhávnagar during an inspection of the tidal observatory in August 1890 by Mr. Wood, who took the aneroid and mercurial barometers belonging to the observatory to Poona for repair. The latter instruments, which for some time had been working well at Poona, were replaced in the observatory during my above-mentioned inspection, and their substitutes removed, with good results at first; but soon the repaired aneroid returned to its former unsatisfactory state, and its records are practically worthless. The readings of the standard mercurial barometer, however, which are taken daily at 7 A.M., 10 A.M., 4 P.M., and 6 P.M., are complete for the year, and partially supply the necessary barometric information. The anemometer has worked very satisfactorily throughout the year.

My inspection of the tidal observatory in January, already referred to, took place towards the end of that month, when the tide gauge and anemometer were cleaned, and certain of the auxiliary instruments were removed and replaced by others, as already mentioned.

I am indebted to Mr. Proctor-Sims for his cordial co-operation, which has secured the success of the tidal operations in Bhávnagar. My thanks are also due to his Nautical Assistant, Captain F. M. Godrich, to whom he has entrusted the supervision of the tidal observatory, and who takes a great interest in the work.

Apollo Bandar, Bombay.—At this most satisfactory tidal observatory the tide-gauge has worked uninterruptedly throughout the year.

In my last annual report I mentioned that I had recommended the removal of the graduated staff used for comparing the level of the water outside the cylinder, with the level of the water within it as indicated by the tide-gauge, and the substitution for the graduated staff of another of a different construction. This has been done; but the new graduated staff is only working experimentally as yet.

The observatory was inspected by me in January, when the gauge was found in very good order apparently. On testing its balance, however, before cleaning it, the preponderance on the float side was found to be in defect, which pointed to a breakage of the counterpoise chain on the float side. On dismantling the instrument, it was found that the counterpoise chain had corroded and parted near the float, and a length of 15 feet of chain had to be renewed.

Auxiliary instruments are not employed at either of the Bombay tidal observatories, as the necessary meteorological observations are taken at the Colaba Observatory.

Prince's Dock, Bombay.—The small scale tide-gauge with upright recording drum, which has been at work for four years at this observatory, continues to supply very satisfactory records on the whole. The few short interruptions and irregularities in the registrations which occurred during the year are not in any respect the fault of the observatory clerk, but are due to slight imperfections in the design of the instrument. The interruptions referred to were caused by the float band sticking to the studs of the stud-wheel, and the other faults consisted in the zero pencil piercing and tearing the diagram paper, and in the latter twisting at the top on one occasion.

In former Annual Reports mention has been made of the twisting of the diagram paper, of interruptions caused by the float band sticking on the stud wheel by the breakage of the float band, the stoppage of the clock, etc. I inspected this observatory in January, and on that occasion made the following remarks on the design of the tide-gauge in the observatory inspection book : —

As the float band is a very long and thin copper ribbon, it is apt to twist. Much inconvenience is caused by the tearing of the diagram paper by the zero pencil. The arrangement of this pencil must be changed. Its position is between the recording drum over which the diagram paper passes and the cylindrical roll from which that paper unwinds. It therefore acts on a part of the paper which is not supported behind. As the unwinding roll pays out the paper, the diameter of the roll diminishes, and the unsupported surface of the paper comes gradually forward and presses more and more on the point of the zero pencil, until at last a tear is made. This pattern of tide-gauge appears inferior to that in general use at Indian tidal observatories (Newman's pattern with long horizontal drum). It is more complicated and liable to get out of order. It is not so easily cleaned. The scale on which it registers the tidal curve is small and cannot be changed. The float band, pencil wire and some other parts are too frail. There is no arrangement for adjusting the height of the curve-recording pencil; so that setting to zero is both troublesome and tedious. Measurements cannot be taken from the diagram while the instrument is working, as may often be desired. Interruptions to the registrations, damage to the diagram paper, such as tears caused by the zero pencil, etc., may not become known until the paper is removed, for the faulty or damaged parts may have been rolled up on the receiving cylinder and have become concealed during the absence of the clerk from the observatory.

At the same inspection I left directions regarding the fitting of a simple contrivance to hinder the float-band from twisting, and I attached to the gauge a new zero pencil-holder designed specially to avoid tearing the diagram paper.

I am much indebted to Mr. W. W. Squire, the Engineer to the Port Trust, for the assistance he has given to the tidal operations at both of the Bombay observatories. In many other ways also he has helped us in our operations from time to time, and I feel very much obliged to him.

Cochin.—At this station the tide-gauge has worked very satisfactorily; its registrations having been continuous throughout the year, with the exception of three short interruptions, none of which lasted longer than 8 hours. The registrations of the aneroid and anemometer have also been very satisfactory. Those of the former were continuous, except for 2 hours, on the 20th November, while those of the latter were absolutely uninterrupted.

In the appendix to the General Report for 1886-87, page xxxii, it was mentioned that an unexpected accumulation of sand formed near the observatory and embedded the rose of the communication pipe, thus preventing the free passage of the water in and out of the cylinder and rendering the registrations inaccurate. The curves were inaccurate and interrupted from the 4th April to the 26th May 1887, and for this reason it was thought desirable to continue the observations for one year beyond the usual period. Six years' observations were completed on the 3rd February, and the observatory was inspected and then dismantled and closed by Surveyor Dhondu Venayak on the 20th March, who before leaving Cochin packed all the instruments carefully and left them in charge of the Port Officer for transhipment, when required, to Bushire, and attached a graduated staff of the usual pattern to one of the outer piles of the Port Officer's jetty. Since the removal of the tide-gauge, tidal readings to this staff (the zero of which coincides with that of the Tide Tables) are being taken daily under the Port Officer's direction, who sends them to my office monthly, compared with the corresponding predictions given in the Tide Tables. Captain Winckler, the Port Officer, has had the kindness to supervise the tidal observatory at Cochin during the whole time that it remained open, and during that period of more than six years his interest in the work and his willingness to assist it could always be relied on. The monthly comparisons he is now sending to my office are most useful, and I feel greatly obliged to him for his long-continued co-operation.

Minicoy.—At this station the tide-gauge worked most satisfactorily, the only accidental interruption to its records being one of 6 hours, when the pencil was out of adjustment. The clerk also stopped the gauge on two occasions to flush the cylinder, the unavoidable interruptions so caused lasting in the first instance 1 hour 51 minutes and in the second 50 minutes only.

The aneroid observations experienced only two short interruptions, one of 12 hours' and the other of 20 hours' duration.

The anemometer also worked very satisfactorily. On one day the spirals, owing to their not being sufficiently lowered, failed to mark the diagram. The only other interruption to the observations occurred during stormy weather, lasting from the 1st to the 5th November. This began at 10-30 A.M., November 1st (the date of the Port Blair cyclone), the wind blowing from the north at about 33 miles an hour (barometer 30 inches), and keeping at that velocity until noon. The wind then increased to 50 miles an hour, and

blew at this strength from the north-east until 4-50 P.M., when it slackened to 30 miles an hour (barometer 29·9 inches). At 6-45 P.M the anemometer clock stopped (presumably from oscillation caused by the wind), and the registrations were suspended until 9 A.M. next morning, when the clock was re-started. From this time until 9-30 P.M. the wind was blowing from the north-north-east with a velocity of 30 miles an hour (barometer 29·7 inches); it then increased to about 55 miles an hour, and while maintaining this velocity changed its direction gradually until it blew from south-east by south at 4 A.M., November 3rd. The wind then began to drop, and at 8 A.M. its velocity was 25 miles an hour (barometer 29·9 inches), from which it fell to about 12 miles an hour, its direction being still from south-east by south. On the following day (November 4th) the wind was from the south-south-west at 2 P.M.; it then freshened and continued its change of direction until at 4 P.M. it was blowing from the south-west with a velocity of 30 miles an hour. It maintained this strength and direction until 8 A.M. on the 5th, when it began to decline, and gradually fell to 12 miles an hour, the barometer all the while reading between 29·9 and 30·0 inches. During this stormy weather the tide-gauge worked perfectly well, and the tidal curves showed no irregularity; there was only a slight sea at the tidal observatory, which is situated within the lagoon, except on November 2nd, when, according to the clerk's report, the sea was very rough and 4·01 inches of rain were registered. The rainfall the preceding day was 5·53 inches, and the day before that 2·49 inches, and the clerk reported that the rain flooded the lower parts of the island to a depth of from 3 to 4 feet, and the storm destroyed many trees and houses, but no lives were lost.

I mentioned in last year's report that meteorological records are sent by the clerk to the Meteorological Reporter to the Government of India. He gained much credit for the observations he took all through the stormy weather just mentioned, and received from the Meteorological Reporter a reward of R20.

I inspected the tidal observatory from the 6th to the 11th December, having, through the courtesy of the Director of the Royal Indian Marine, obtained a passage to Minicoy and Ceylon in H. M.'s I. M. S. "Investigator," commanded by the late Commander R. F. Hoskyn, R.N., then in charge of the Marine Survey of India. I found the site of the tidal observatory well chosen, the observatory well built, and that all the instruments had worked very satisfactorily; but water had collected at the bottom of the anemometer shaft, and the clerk received orders to examine the instrument periodically and keep it free from water. As stated in my last report, the anemometer is set up about a mile north of the village, where there is an open space free from trees; it is about 2 miles north of the tidal observatory, and this is rather an inconvenient distance. It would be an improvement to have a strong braced stand, 60 feet high, near the observatory to carry the anemometer, which would then receive the wind unobstructed by the trees; and if a favourable opportunity should present itself, I shall have this done according to plans already prepared in my office. But as there are two tidal observatory clerks at Minicoy (*vide* appendix to General Report for 1890-91, page xv) the inconvenience of the present arrangement is much less than it would be if only one were employed. The clerks were found to be proficient in their duties, including all the chronometer and clock comparisons. The comparisons made between the standard sun-dial and the chronometer show that the rate of the latter is very uniform and agrees well with Mr. Belcham's original determination. We are greatly indebted to Lieutenant Channer, R.N., the Superintendent of Light-houses, for his continued assistance in bringing away the records and reports from the observatory, and carrying letters, etc., to the clerks, at his periodical visits to the island.

Our thanks are also due to the Collector of Malabar for the arrangements he made for the comfort of the observatory clerks by building a substantial house for their accommodation, which was approaching completion at the time of my inspection, and which has since then been finished and handed over to us at the small rental of R2 a month.

Descriptions of the Island of Minicoy will be found in—

(*a*) Captain Basevi's narrative report printed in the appendix to G.T.S. General Report for 1869-70.

(*b*) My narrative report contained in the appendix to this Department General Report for 1890-91.

(*c*) The Malabar Manual.

(*d*) An article in two parts by W.L., entitled "Minicoy: the Island of Women" in Blackwood's Edinburgh Magazine for February and March 1889, pp. 197 and 307.

(*e*) A series of four unsigned articles in *The Times of India* newspaper of the 2nd, 9th, 23rd, and 30th June 1892, entitled "Memorials of a Maritime Microcosm," the writer of which mentions incidentally that he was one of our party on board the "Investigator."

Tuticorin.—The working of the tide-gauge at this station has been perfect throughout the year, no interruption to its registrations having occurred. The aneroid also worked uninterruptedly, and the barometric diurnal variation is correctly shown on all the diagrams. The anemometer worked satisfactorily until November 4th, when the direction of the wind began to be registered incorrectly. The clerk then noticed that the endless screw of the steering-vanes was much worn away, and its condition got worse and worse until, on the 16th of the same month, the direction of the wind was not marked at all. A new endless screw was fixed to the instrument on the 30th March (during the inspection of

the observatory), and since then no failures of any kind have been reported; but although the records of the direction of the wind are thus incomplete, its velocity has been continuously registered during the whole year. The observatory was inspected by Surveyor Dhondu Venayak from the 29th March to the 1st April, when all the instruments were cleaned and left in good working order. Our thanks are due to Captain Baker, the Port Officer, for his continued supervision of the observatory.

In last year's Report I mentioned that during the spring-tides towards the end of June, which were accompanied by strong south-west winds, the water fell to a remarkably low level. I have now to notice an equally remarkable circumstance that occurred during neap tides on the night of the 11th and morning of the 12th October. On the former date the wind, which had been blowing gently, at the rate of about 5 miles an hour, from S. E. by S., changed to E. and began to blow from that quarter at a velocity of over 20 miles per hour at about 10 P.M., which was the time of low water. The tide rose for about an hour and a half, at an ordinary rate of about 1½ inches an hour, and then in the space of an hour rose rapidly through a further height of 1 foot, attaining at 0-40 A.M. of the 12th a height of 2 feet 9 inches above the zero of the gauge, or a height of about 11 inches above its proper level. After this the wind began to drop, and the tide fell in an hour to a height of 1 foot above zero, thus sustaining a sudden fall of 1 foot 9 inches at a place where the mean yearly range of the tide is less than two feet. After touching the depth just mentioned the tide rose again with a rapidity about equal to that of its abnormal fall, and resumed its interrupted motion, while the wind moved southwards and fell to a gentle breeze.

I should like to correct here a clerical error in the paragraph at the end of the notice of the Tuticorin tidal observations, contained in my last Annual Report. When bringing to notice a peculiarity of the tides in the Gulf of Manar mention was made of the "south-east monsoon." This of course should have been the *north-east* monsoon, during which, contrary to what might be expected, the general level of the sea is considerably higher than during the south-west monsoon.

Trincomalee.—At this station there have been only three short accidental interruptions to the registrations of the tide-gauge, two caused by the pencil failing to mark the diagram, and a third by a stoppage of the driving clock. This stoppage, which occurred on the 23rd July, prior to which the rate of the clock had been regular, lasted 19 hours, during 7 of which tidal records were supplied by means of observations to the graduated staff. Being unable at the time of the stoppage to obtain telegraph time, the clerk first set the clock by the anemometer clock, and afterwards tried to correct it by the aneroid clock. On the afternoon of the 26th he obtained telegraph time and set the clock, but found it 7 minutes slow the next morning. He appears to have been either unable to set it properly, or to keep it to right time until the last day of the month, since when the rate of the clock, as checked by telegraph time, has remained satisfactory.

The aneroid has worked continuously throughout the year, and the barometric diurnal variation is well shown on all the diagrams.

The record of the anemometer experienced seven interruptions, each lasting about a day. They were due to ordinary accidents, such as the breaking of the cord of the clock weight, the stoppage of the clock, and the insufficient lowering of the recording spirals.

I inspected the observatory from the 20th to the 24th December and found the instruments in good order, with the exception of the anemometer, which was so clogged with coal dust that the rate of the clock was retarded two hours daily. The present position of the anemometer on top of the tidal observatory is not a good one, as it is not exposed to the free action of the wind, and it is impossible to keep it clean owing to the coaling which goes on in the vicinity. I have therefore arranged to remove the instrument to the highest point of Fort Ostenburg immediately above the Naval Store Yard. It will be put up in a small wooden house that is now being prepared, and its removal to the new site will take place at the next inspection.

The present clerk, who was appointed on the 23rd March 1891, was examined in his duties and found to understand and perform them well. There could be no doubt that the Telegraph Department at Colombo were not in the habit of telegraphing Madras time to Trincomalee with sufficient regularity or correctness for our purposes, and I therefore propose to put up at the observatory one of Colonel G. Strahan's standard sundials, so as to be independent of telegraph time. During the inspection Captain Paterson, R.E., very kindly obliged me by photographing the aneroid with its clock face removed, and gave me the negative, which I sent to Mr. Eccles at Dehra Dun, to enable him to prepare a plate of the instrument, which is of Légé's newest pattern, for the Tidal Volume.

Mr. De Ridder, the Naval Store-keeper, supervised the observations until the 29th February, on which day Mr. Millett took over that duty, and our thanks are due to both for their assistance and their interest in the work.

During the north-east monsoon the weather on the east coast of Ceylon is not favourable for making tidal observatory inspections. When I inspected the Trincomalee observatory in December, my work was much impeded by constant and heavy rain; but having obtained a passage in H. M.'s I. M. S. "Investigator" to Minicoy and Ceylon, I did not like, after being landed at Colombo, to leave Ceylon without inspecting the Trincomalee observatory. I was advised not to travel from Colombo to Trincomalee by the land route, as, owing to the rain, the roads were at the time nearly impassable, and the journey would probably have taken several days, which would have been passed in great discomfort.

I therefore went by sea in the coasting steamer, the "Lady Havelock," and arrived at Trincomalee in a little less than three days. I had arranged with Captain Hoskyn that the "Investigator" should take me on to Madras when my work was finished at Trincomalee; but owing to the cholera, which was severe at the latter place, she was not allowed to run the risk of touching there, and I therefore availed myself of a B. I. S. N. Co.'s steamer, the "Rajputana," and was taken in her *viâ* Jafnapatam to Negapatam, where I landed, and whence I proceeded by rail to Madras. Owing to bad weather the journey from Trincomalee to Negapatam lasted for the greater part of four days, a considerable time being spent at anchor, waiting for the weather to clear sufficiently to allow land-marks to be recognised. During the north-east monsoon navigation along these coasts is often difficult, for, owing to the shoals, it is necessary to see land in order to steer correctly. The Commander of the 'Rajputana" told me that conspicuous pagodas, which would be excellent marks for determining a ship's position if they were shown on the Admiralty charts, are not entered on them, and my own experience of the latest charts of the north-east coast of Ceylon I have been able to obtain, goes to prove that they require revision and bringing up to date. The best month for visiting Trincomalee is February.

Madras.—I arrived in Madras on December 30th, and left for Poona on the following day. On the day of my arrival I saw the Chief Engineer and Secretary to Government in the Public Works Department, and explained to him my views regarding the resumption of tidal observations at this port. He promised to try to arrange the matter with the proper authorities if I sent him copies of the necessary letters. I did so, adding suggestions as to where and how the observatory should be built; but as yet I have nothing further to report regarding the matter.

Cocanada.—Since this station was closed in 1891, tidal observations at high and low water have been taken daily during daylight to a graduated staff, under the superintendence of Captain Wicks, the Port Officer, to whom I am much obliged for his kind co-operation. During spring tides on September 21st and 22nd, the actual heights of the tide so measured were considerably higher than those predicted in this year's Tide Tables. The greatest discrepancy was at low water on the afternoon of the 21st, when the actual height exceeded the predicted by 2 feet 1 inch. This is a considerable difference at a station where the mean range of the tidal springs is 5·2 feet. Captain Wicks in his report on this subject attributed the abnormal height of the water to a storm the centre of which on these days was close to the coast south-east of Cocanada, and moving slowly westwards, according to telegrams received from the Meteorological Reporter to the Government of Bengal.

Kidderpore.—At this station there have been only 3 interruptions to the tidal registrations during the year. The first, which occurred in November, was a trivial one of less than 3 hours' duration due to the vibration of the observatory stopping the driving-clock of the tide-gauge. The other two occurred in consequence of the absence of the clerks through illness; the first of the interruptions so caused was on the 22nd and 23rd December and lasted 30 hours; the second was on the 9th and 10th August and lasted 18 hours. Kedar Nath Das, who had been the observatory clerk ever since the tidal observations were commenced in 1881, fell ill on December 20th, and was relieved by the present clerk, Sarada Prasad Das, on December 23rd, who had been clerk at the Dublat tidal observatory up to the time of its destruction in 1886.

The aneroid worked continuously until June 16th, when it had to be sent to the Mathematical Instrument Office for examination and repair. It was brought back and set up on July 7th, since which date no failure of any kind has been reported. For the time the aneroid was not at work the readings of the standard mercurial barometer taken daily at 7 A.M., 10 A.M., 4 P.M., and 6 P.M., partially supply the necessary barometric information. The anemometer, like the tide-gauge, had its registrations interrupted twice while the clerks were ill: otherwise it has worked most satisfactorily. The observatory was inspected by Mr. Belcham from the 21st to the 26th April. He found the instruments, especially the anemometer, to be very dirty, and before leaving had them cleaned thoroughly and put into proper condition. He reported that the observatory was in good order, and that it had been recently connected by a substantial wooden bridge with the wooden pier on the west side of the new dock, with the result that it is less liable to oscillation now than formerly. He also reported that the present clerk knows his duties thoroughly, but that he had not kept the instruments sufficiently clean; and that he warned him to take more care of them in future.

My thanks are due to Lieutenant Petley, R.N., the Port Officer, who continues to supervise the working of the observatory.

Chittagong.—Since this station was closed in 1891 tidal observations at high and low water have been taken daily during daylight to a graduated staff under the superintendence of Mr. Good, the Port Officer, to whom I am much obliged for his kind co-operation.

Akyab.—At Akyab the tide-gauge has worked most satisfactorily, and practically without interruption, during the year under report, the only flaws being two short stoppages of the clock, each of two hours' duration only. The auxiliary instruments also have worked very satisfactorily, only one short stoppage of the aneroid clock and two short stoppages of the anemometer clock having occurred during the same period. Two inspections of the observatory were made. The first was a hasty inspection made by Mr. Belcham on April 15th, while the steamer in which he was travelling stopped at Akyab. He found

everything in good order. The second and final inspection was on the occasion of closing the tidal observatory on the completion of its period of observations. This period terminated on May 15th. Surveyor Dhondu Venayak was directed to close the observatory. After inspecting all the instruments, which he found clean and in good working order, and taking the necessary levels, measurements, and tests, all of which proved satisfactory, he dismantled the instruments on May 23rd, and after packing them carefully in their cases left them in charge of the Port Officer, who has stored them in the Custom House godown until such time as I may require them. While the observatory was being closed, a new graduated staff, divided to feet and inches, was set up at the north-west corner of the T head of the iron pier, its zero being made to coincide with the datum of the Tide Tables.

Observations to this staff are taken regularly twice a day during daylight under the direction of Captain Pryce, the Port Officer, who sends them to my office. My thanks are due to him not only for his kindness in this respect, but for the great interest he has always evinced in the tidal operations.

At the time when Surveyor Dhondu Venayak left Akyab after closing the tidal observatory, the two bench marks of reference (A and B) were in good preservation.

It is very satisfactory to be able to state that from the commencement to the close of the 5 years' period of tidal observations at Akyab no interruption of any importance occurred in the working either of the tide-gauge or of the auxiliary instruments. This is very creditable to the observatory clerk.

Rangoon.—At this station the registrations of the tide-gauge have been most satisfactory throughout the year. Only one unimportant interruption occurred on the 6th March, when the pencil failed to mark the diagram. The registrations of the aneriod have been fairly continuous, but unfortunately they are worthless, for the diagrams shew no automatically registered diurnal variation during the whole year, thus proving the insensitiveness of the instrument. The readings of the mercurial barometer taken at 7 A.M., 10 A.M., 4 P.M., and 6 P.M. daily are, however, complete. The record of the anemometer is not very satisfactory. Its registrations suffered the following interruptions :—One of fourteen days in January, while the driving clock was being repaired ; another of five days in June, while a new endless screw for attachment to the steering-vanes was being made to replace the old one, which had broken ; and four minor interruptions, which occurred in the months of October, December, March, and August, and which were all due to the stoppage of the driving-clock. The record for the 10th March is also missing, owing to that day's diagram having been stolen.

The auxiliary instruments are still at work in the positions specified in last Annual Report, but they will be removed, when the necessary data can be supplied from the meteorological observatory, which, as I remarked, was being constructed in the compound of the Port Engineer's Office.

The observatory was inspected by Mr. Belcham in February, who reported that the lower bracing of the piles, mentioned in last Report as being incomplete, had been completed, with the result that the observatory has become more stable ; but there is still a little oscillation, which, though not sufficient to interfere with the working of the tide-gauge "regulator" clock, caused the "pendulum" clock of the aneroid barometer to stop occasionally. During the inspection the instruments were thoroughly cleaned and all put into good working order, with the exception of the aneroid, which, although it was fitted with a new hair-spring and attended to constantly by the assistant mechanic who accompanied Mr. Belcham, could not be restored to its former state of efficiency.

My acknowledgments are due to Mr. Darlington, the Vice-Chairman of the Port Commissioners, and to Mr. Reichenbach, the Port Engineer, for their continued assistance and the interest they take in the tidal operations.

Until recently there were almost inappreciable differences between the datum lines in use in Rangoon These small differences are now adjusted, and all heights will consequently be referred to Graham Smith's datum, which corresponds to the zero of the tide-gauge, to the zero of the graduated staff at Brooking Street wharf, to "low water of spring tides of the dry season (December to April)," the Marine Survey of India datum for Rangoon, and to the datum of the River Surveyor's charts.

Moulmein.—This tidal observatory was closed in April 1886, ever since which time Captain Dodd, the Port Officer, has had the kindness to send me monthly, with the greatest regularity, statements of the actual times and heights of the tides observed daily under his direction, compared with the predictions contained in the Tide Tables. The last of these statements received from him refers to the month of August 1892; in the letter accompanying it he says: "I would beg to point out that the great difference between the actual and predicted low water tides for nearly the whole of the month must be due to the almost entire cessation of the rains, which during August is most unusual, while the total rainfall to the end of August has been much below (some 27 inches) the average of the past 10 years." The statement he sends shows that at low-water in August 1892 the predicted height of the tide was invariably higher than the actual height, the minimum discrepancy being 1 foot 5 inches, the maximum discrepancy 4 feet 2 inches, and the average discrepancy 3 feet. I believe the large errors in the predictions to be partly due to the cause assigned by Captain Dodd; but I believe them to be also partly due to the comparisons contained in his statements not having been sufficiently brought into use to modify the August group of observations for the years 1880 to 1886, on which the

predictions for August, contained in the Tide Tables depend—*vide* preface to the Tide Tables for the Moulmein River for 1888. It will be seen from the following table that since 1886, the predicted heights of the tide at low water have, during every August without exception, been in excess of the actual heights:—

			Ft.	In.
1887	August . .	Average excess . .	1	10
1888	,, . .	ditto . .	0	2
1889	,, . .	ditto . .	2	2
1890	,, . .	ditto . .	1	9
1891	,, . .	ditto . .	2	2
1892	,, . .	ditto . .	3	0

Mergui.—At Mergui the tidal registrations may be considered satisfactory as there were no serious interruptions to them during the year. The interruptions that occurred were as follows: three caused by the stoppage of the tide-gauge driving-clock, and lasting 20, 12, and 5 hours respectively, six lasting from 1 to 5 hours, caused by the breakage, through corrosion, of the counterpoise chain of the float band, and 16, lasting from 1 to 7 hours, caused by the failure of the pencil to mark the diagram.

The last-mentioned species of failure would appear to be due to the observatory clerk not having kept the inside of the pencil-holder sufficiently clean and smooth.

The aneroid barometer worked steadily, with but one interruption, until February 28th, when the bar connecting the driving-clock with the drum got out of gear and prevented the drum from revolving. This was set right during the inspection of the observatory (which took place in the following month) since when no failure has been reported.

In the record of the anemometer there were twelve interruptions, lasting from 7 to 24 hours, caused by the stoppage of the driving-clock. This instrument was cleaned and regulated during the inspection in March, and no more stoppages occurred.

In January Mr. C. Wood, to whom I am much obliged for his thoughtfulness, wrote to me saying he would be in Mergui about the end of the following month and kindly volunteering to take the error of the tidal observatory chronometer and compare it with the standard sun-dial. After arriving at Mergui he took time observations with his theodolite on February 20th and 21st, and found that the observatory time on the former day was 17 minutes 15 seconds fast of local mean time, which has necessited a proportional correction to the time lines on the tidal diagrams for a whole year. The accumulation of this large time error is not creditable to the observatory clerk, who persistently neglected to compare his chronometer with the standard sun-dial, which Mr. Wood found in its box, covered with cobwebs. The clerk does not appear to have even taken the trouble to ask any one at the port for the correct time.

The tidal observatory was regularly inspected by Mr. Belcham in March, when the tide-gauge, aneroid and anemometer were cleaned and attended to in every particular; and the float-band having corroded to about half its original thickness, and the counterpoise chain being in two pieces and very weak, they were replaced by new ones.

At the same time the accurracy of the setting of the standard sun-dial was tested by comparing the mean time obtained from its readings with the mean time obtained from observations to the sun with a theodolite, with the result that its time was found to be 3½ minutes slow. The standard sun-dial was adjusted accordingly, and the clerk was reinstructed in the method of finding correct mean time from it. His observations since then have been taken, as a rule, every fortnight and submitted to my office, and they show that the tide-gauge clock is being kept to correct time.

I am indebted to Mr. Batten, the Deputy Commissioner of Mergui, for kindly continuing his supervision of the observatory.

Port Blair.—I was able to give a favourable notice of this tidal observatory in my last Annual Report. When I wrote it, everything was going on very satisfactorily, and we had every reason to hope for a continuance of that pleasant state of things. But on November 12th, 1891, I received the following communication from Mr. Brookes, the Port Officer, dated the 4th of the same month:—

"I have the honor to report that this Settlement was visited by a most violent cyclone, which took place on Sunday, the 1st, and Monday, the 2nd instant. It began from the north-east and veered round to the southward early on the morning of the 2nd. The severity of the storm was so great that not a house or tree on the Island escaped damage. Great destruction and loss of life took place on the northern and southern districts, and H. M.'s I. M. S. "Enterprise" was totally lost, all her officers and crew being drowned with the exception of six natives, who were thrown on shore at South Point. I regret to have to report that the tidal observatory has suffered in the storm. The brick wall was washed away and the drum was displaced and carried away by the sea. All the instruments in the observatory have been injured, and the anemometer on the European Infantry Barracks destroyed. All operations have been stopped, and the whole observatory will have to be put up *de novo*, and this can only be done by your department. I have learnt that the drum of the observatory has been washed ashore at North Bay and is saved: of course all the records in the building have been lost. I am told that the last observation taken at the Ross Hospital showed a force of 245 miles an hour. You can form some idea of the destructive nature of the storm, when I tell you that the dense forest appears as if burnt out by fire, nothing left standing but the stems of the large trees, all the branches having been blown away."

On receiving this report, I addressed a letter to the Chief Commissioner of the Andamans, asking when it would be convenient to him to have the observatory re-erected,

and I made arrangements for sending a complete set of instruments and a float cylinder to Port Blair.

He replied that the observatory would be ready before the arrival of the mail steamer, which was timed to leave Calcutta for Port Blair on the 1st of January. I therefore sent Mr. Belcham by that steamer, and he, and the float cylinder (which had been made in Calcutta), and the instruments reached Port Blair on the 4th of January. He set to work immediately on landing, and the following is his report on his operations :—

"I found the tidal observatory and the tide-gauge were seriously damaged, and the aneroid barometer, the anemometer, and all the diagrams between the 21st September and 1st November were totally destroyed. Strange to say, the mercurial barometer, which was fixed to one of the posts of the observatory, remained undamaged, although it was made very dirty by being drenched with sea water. The rain-gauge, though much battered, was still repairable. The parallel bars of the tide-gauge had been wrenched off, and the drum, float, and float cylinder had been washed into the sea, but they were picked up. The other parts of the tide-gauge, including the clock, remained standing and are uninjured. With the ready help received from the Port Blair Public Works Department, the tidal observatory, which had to be partly renewed and thoroughly repaired, was set up as before against the sea-wall adjoining the Port Officer's house, which is on the west side of Ross Island. The eastern side of the framework of the observatory is secured to the sea-wall, while the western is supported on two stout piles, driven well into the ground. The observatory is built entirely of wood, and is 12½ feet by 10 feet inside measurement, and 10 feet high at the eaves: there is a door-way facing east and a large window on the west side. The float cylinder is of ¼ inch wrought iron, 14 feet long and 3 feet internal diameter: it is in two lengths of 7 feet each, bolted together The upper flange of the cylinder rests on the observatory floor, while the bottom rests on a circular stone 3 feet 2 inches in diameter. There are three inlet holes, ½ inch in diameter, 6 inches above the bottom, and three more of the same size 1 foot 6 inches above the bottom. The space included between the supporting piles and the sea wall has been strongly planked in, leaving about an inch waterway between the planks, thus affording protection to the cylinder, and also regulating the flow of water in and out of the barrier so made.

The tide-gauge set up in this observatory is of the old pattern by Adie, modified by Légé and Co., and before modification it had been at work at Aden. Its registrations at Port Blair commenced on the 30th January.

The anemometer, which had been in the Poona Office, and which is of the old pattern by Adie, started work on January 25th at the site occupied by the old instrument on the top of the European Barracks. The aneroid, which had also been in the Poona Office, and is of the old pattern by Adie, started work on February 10th in the tidal observatory.

The mercurial barometer, which had been formerly in use at Elephant Point, was set up in the tidal observatory, and its readings were taken from the date on which tidal observations were resumed.

The time kept in the observatory is checked by comparing the observatory chronometer with the chronometers on the Mail Steamers: but to make more certain of correct mean time being kept, a sun-dial of Colonel Strahan's pattern has been made by the Mathematical Instrument Office, which can be set up at the next inspection of the observatory.

A graduated staff, the zero of which agrees with that of the tide-gauge, has been set up against the pile at the north-west corner of the observatory, to check the height of the water inside the cylinder with that outside.

The rain-gauge, after being repaired, was set up again on its original stand near the flag-staff at the European Barracks. After making a full inspection of the observatory, I left Port Blair on the 17th of February for Rangoon, taking with me the mercurial barometer, which had escaped damage, to be utilised at Diamond Island after comparison with a standard. The disabled instruments, namely, the tide-gauge, and remains of the aneroid and anemometer, were sent to Poona."

From the foregoing it will be seen that between the 21st September 1891 (the diagrams in the observatory at the time of the cyclone going back to that date) and the 30th January 1892, when tidal observations were resumed, there are no original tidal records, but as the hourly tidal readings entered in the daily reports are forthcoming up to October 29th, the break in the observations is practically reduced to one of 3 months. Since the re-establishment of the observatory the tide-gauge has worked very satisfactorily. The only accidental suspension of its records took place one night in February, when the pencil failed to mark the diagram for the short period of 8 hours. The aneroid has worked continuously; but its record is unsatisfactory from the 5th April, since which date the barometric diurnal variation has not been correctly indicated: the readings of the mercurial barometer taken daily at 7 A. M., 10 A. M., 4 P. M., and 6 P. M. give, however, the required information. The anemometer, which, as Mr. Belcham reports, started work on January 25th, is the instrument that was damaged by a rifle shot on the 17th December 1890 at Port Blair, as mentioned in my last Annual Report. It worked well for only about six weeks after its re-establishment. The clerk reported that on March 15th he found a toothed wheel in the upper part of the machine, connected with the velocity spiral, worn out; and he had a spare one, left by Mr. Belcham, substituted for it by a local mechanic on March 17th. From this date the instrument worked very imperfectly until April 20th, and then ceased to work at all. It has been sent for again and will be repaired in my office, if possible, and another anemometer will be taken to Port Blair, and set up at the next inspection. Our thanks are due to the Meteorological Department who have been kindly helping us to keep our auxiliary data complete by furnishing the clerk with the daily velocity and general direction of the wind as registered at their own observatory. We are also greatly indebted to Colonel Cadell, V.C., the Chief Commissioner of the Andamans, and his Public Works and Port staff for their prompt and energetic help, especially at a time when they must have had many other urgent calls upon their attention.

The records of the movements of the wind at Port Blair, as indeed at other places, are not as free from uncertainty as could be wished. Comparisons of the wind velocity at Port Blair, as recorded by our instrument (an anemograph) and the Meteorological Department's dial instrument, showed great discrepancies. Between the 3rd and 11th February 1892,

for example, while the wind was blowing from the north-east, our instrument recorded a velocity varying from 1½ to more than 3 times the velocity registered by the other. When this was noticed, a comparison of the record of the two instruments between the 6th and 14th June 1891, while the wind was blowing from the south-west, was made, and showed that the dial instrument then gave the greater readings, though only slightly the greater. With regard to the respective positions of the two instruments, Mr. Belcham reported:—"Our anemometer was at work on the top of the European barracks, which is situated on the ridge at the north-east extremity of Ross Island, while the instrument belonging to the Meteorological Department was on the Station Hospital on the south-west end of the ridge, but not on quite as elevated a position, and about 500 yards from the barracks. Our anemometer catches the full force of the wind from the north-east, but not from the south-west, as the Chief Commissioner's house, which is on the highest point, cuts it off to some extent; the Meteorological Department's instrument, on the other hand, catches fully the wind from the south-west and not so much of that from the north-east." Very close agreement between the readings of the two instruments could not, perhaps, be expected under such conditions; but discrepancies so wide suggest that, even if the instruments had been under exactly the same influences, they would not have read accordantly. Anemometers do not seem to me to be very satisfactory instruments. They appear to be generally accepted on faith, just as they are received from the maker, and I know of no certain means available to me of testing the accuracy of their registration of wind velocity. In the pattern we use there is a considerable amount of friction between the parts, and the toothed wheels and spirals, consequently, are continually wearing out and have to be renewed. Even assuming such an instrument to have been a true recorder of wind-velocity originally, there is no certainty that it continues so, after such repairs.

I have already given two instances of the corrosive influence of the sea water on the tide-gauge apparatus. This influence is remarkable at five of the tidal stations, namely, Bombay, Galle, Amherst, Mergui, and Port Blair; but it is not noticeable at the other stations. At Bombay, owing to the corrosive action of the sea, the copper float had to be renewed in 1886, the new float had to be repaired twice in 1887, and the counterpoise chain broke in 1892. At Galle, owing to the same cause, the iron cylinder had to be repaired twice and renewed once in six years, and the copper float band had to be renewed twice, and the counterpoise chain three times in the same peried. At Amherst, similarly, holes were eaten through the cylinder, and the copper band broke three times in six years. At Mergui, since the commencement of tidal observations there in 1889, the corrosive action of the sea has rendered necessary the renewal of the copper float band once, and the repair of the counterpoise chain seven times. At Port Blair, during the eleven years from 1880 to 1891, three iron cylinders and three copper float bands were used up in a similar way, and the fourth cylinder and band were destroyed in the cyclone of November 1st.

How the sea acts so detrimentally on iron and copper at these exceptional stations, or whether, or how far, its action may be assisted by marine animals, I do not know.

The loss of three months' observations at Port Blair is a matter of great regret. If this heavy loss be excepted, I think I am entitled to report that the tidal operations of the year have been very successful.

Reduction of the Tidal Observations and Extra Tidal Work.

The observations for one year at 14 tidal stations have been reduced, and the tabulated values of the tidal constants so obtained are appended.

I again take the opportunity to remark that 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 observatories for tidal purposes, three years' observations at Kárwár 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 1891. The letters A. P. in the table indicate that the actual times and heights of high and low water have been measured from the tidal diagrams or graduated staves and compared with their predicted values published in the tide tables. The actual amount of the usual 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 Marine Survey of India with the value of the datum for Minicoy and the establishment of the port: in settling, in consultation with the officer in charge of that survey, the final datum lines for several Indian ports, to be adopted both in the Marine charts and in the tide tables: in supplying the Officer Commanding the Royal Artillery in the Rangoon District with the height of mean tide level at Rangoon above the River Surveyor's datum for the eleven years 1880-1891: in miscellaneous work and correspondence connected with the preparation of the Tidal volume: and in submitting reports, as before, on the tidal operations carried on in the Bombay Presidency and in Burma, to the Local Governments.

State of the ordinary reductions of the yearly tidal registrations at the beginning and end of the Survey year 1891-92.

Tidal Observatory.	State at end of September 1891.	State at end of September 1892.
ADEN . . .	1889-90., calculations completed. 1890-91, observations rejected in part. A. P. 1890.	1891-92, calculations completed. A. P. 1891.
KURRACHEE . .	1889-90, calculations completed. 1890-91, calculations completed. A. P. 1890.	1891-92, calculations completed. A. P. 1891.
BHAVNAGAR . .	1890, calculations completed. A. P. 1890.	1891, calculations completed. A. P. 1891.
BOMBAY (Apollo Bandar).	1890, calculations completed. A. P. 1890.	1891, calculations completed. A P. 1891.
BOMBAY (Prince's Dock).	1890, calculations completed. A. P. 1890.	1891, calculations completed. A. P. 1891.
COCHIN (closed 20th March 1892).	1890-91, calculations completed. A. P. 1890.	1891, calculations completed. A. P. 1891.
MINICOY (started 12th January 1891).	Newly started observatory.	1891, calculations completed.
COLOMBO (closed 29th March 1890).	A. P. 1890.	*Nil.*
GALLLE (closed 11th April 1890).	A. P. 1890.	*Nil.*
TRINCOMALEE (started 10th November 1890).	Newly started observatory.	1891-92, calculations completed.
TUTICORIN . .	1890-91, calculations completed. A. P. 1890.	1891-92, calculations completed. A. P. 1891.
MADRAS (closed 10th October 1890).	1889-90, calculations completed. A. P. 1890.	*Nil.*
COCANADA (closed 18th April 1891).	1890-91, calculations completed. A. P. 1890.	A. P. 1891.
KIDDERPORE . .	1889-90, calculations completed. 1890-91, calculations completed.	1891-92, calculations completed. A. P. 1891.
CHITTAGONG (closed 22nd July 1891).	1890-91, calculations completed. A. P. 1890.	A. P. 1891.
AKYAB (closed 23rd May 1892).	1890-01, calculations completed. A. P. 1890.	1891-92, calculations completed. A. P. 1891.
RANGOON . . .	1889-90, calculations completed. 1890-91, calculations completed.	1891-92, calculations completed. A. P. 1891.
MOULMEIN . .	A. P. 1890.	A. P. 1891
MERGUI . . .	1890-91, calculations completed.	1891-92, calculations completed. A. P. 1891.
PORT BLAIR . .	1890-91, calculations completed. A. P. 1890.	1890-91, new calculations ending October 29, 1891, necessitated by cyclone.

Particulars of the completed tidal diagrams sent for safe custody to the Surveyor-General's Office Calcutta, are given in the following table:—

Tidal Observatory.	Serial number and date of Tidal Diagram.
ADEN . . .	No. 1, dated March 3, 1879, to No. 296, dated March 22, 1886.
KURRACHEE . .	No. 1, dated December 26, 1880, to No. 225, dated February 14, 1887.
BOMBAY (Apollo Bandar)	No. 1 A., dated December 26, 1877, to No. 292 dated January 16, 1890.
MORMUGÃO . . .	No. 1 R., dated March 12, 1884, to No. 54, dated January 1, 1886.* No. 91, dated January 4, 1887, to No. 106, dated March 27, 1889.
KÁRWÁR . . .	Complete series from No. 1, dated February 18, 1878, to No. 270, dated April 16, 1883.
BEYPORE . . .	Complete series from No. 1, dated November 1, 1878, to No. 330, dated March 14, 1885.
COCHIN . . .	No. 1, dated January 25, 1886, to No. 137, dated December 30, 1889.
TUTICORIN . . .	No. 1, dated May 30, 1888, to No. 71, dated October 7, 1889.
GALLE	Complete series from No. 1, dated March 23, 1884, to No. 143, dated December 15, 1886 † No. 148, dated January 17, 1887, to No. 316, dated April 11, 1890.
COLOMBO . . .	Complete series from No. 1 A., dated January 25, 1884, to No. 328, dated March 29, 1890.
PAUMBEN . . .	Complete series from No. 1, dated September 25, 1878, to No. 222, dated December 27, 1882.
NEGAPATAM . . .	Complete series from No. 1, dated November 1, 1881, to No. 325, dated April 9, 1888.
MADRAS . . .	Complete series from No. 1 R, dated February 3, 1879, to No. 23 R., dated July 14, 1879; and from No. 2, dated January 26, 1880, to No. 395, dated October 10, 5890.‡
COCANADA . . .	Complete series from No. 1, dated March 31, 1886, to No. 132, dated April 18, 1891.
VIZAGAPATAM .	No. 1 R., dated August 3, 1878, to No 18 R., dated December 7, 1878.
DIAMOND HARBOUR .	No. 48, dated March 31, 1884, to No. 123, dated April 11, 1886.§
CHITTAGONG . . .	No. 1, dated June 6, 1886, to No. 108 dated June 23, 1890.
AKYAB	No. 1, dated May 9, 1887, to No. 97, dated December 15, 1890.
ELEPHANT POINT (new site.)	No. 1, dated December 29, 1883, to No. 50, dated January 19, 1885.
MERGUI . . .	No 1, dated March 21, 1889, to No. 20, dated December 23, 1889.

* No. 55 to 90 kept for the present in Poona.
† No. 144 to 147 being blank were not sent.
‡ There are no diagrams for the interval July 14, 1879, to January 26, 1880.
§ The other diagrams are kept for the present in Poona.

Values of the Tidal Constants, Aden, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Aden; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

A_0=5·845 feet.

S_1	H=R=	·101	M_6	R=	·002	Q_1	R=	·171	T_2	R=	...
	κ=ζ=	169°·91		ζ=	243°·44		ζ=	30°·19		ζ=	...
S_2	H=R=	·656		H=	·002		H=	·155		H=	...
	κ=ζ=	244°·36		κ=	33°·44		κ=	43°·56		κ=	...
S_4	H=R=	·006	M_8	R=	·001	L_2	R=	·037	$(MS)_4$	R=	·016
	κ=ζ=	245°·56		ζ=	284°·04		ζ=	271°·39		ζ=	9°·83
S_6	H=R=	·005		H=	·001		H=	·059		H=	·016
	κ=ζ=	193°·17		κ=	244°·04		κ=	193°·27		κ=	179°·83
S_8	H=R=	·000	O_1	R=	·723	N_2	R=	·404	$(2SM)_2$	R=	·023
	κ=ζ=	161°·57		ζ=	107°·35		ζ=	328°·64		ζ=	266°·77
				H=	·652		H=	·411		H=	·024
				κ=	36°·61		κ=	218°·76		κ=	96°·77
M_1	R=	·108	K_1	R=	1·396	λ_2	R=	...	$2N_2$	R=	·073
	ζ=	48°·09		ζ=	150°·15		ζ=	...		ζ=	224°·05
	H=	·050		H=	1·309		H=	...		H=	·074
	κ=	36°·20		κ=	33°·88		κ=	...		κ=	194°·28
M_2	R=	1·547	K_2	R=	·223	υ_2	R=	·060	$(M_2N)_4$	R=	·024
	ζ=	55°·79		ζ=	288°·35		ζ=	20°·14		ζ=	34°·47
	H=	1·576		H=	·192		H=	·061		H=	·024
	κ=	225°·79		κ=	235°·26		κ=	281°·89		κ=	94°·59
M_3	R=	·016	P_1	R=	·373	μ_2	R=	·078	$(M_2K_1)_3$	R=	·034
	ζ=	307°·52		ζ=	281°·05		ζ=	216°·24		ζ=	286°·38
	H=	·017		H=	·373		H=	·080		H=	·032
	κ=	202°·52		κ=	30°·20		κ=	196°·24		κ=	340°·12
M_4	R=	·004	J_1	R=	·149	R_2	R=	...	$(2M_2K_1)_3$	R=	·009
	ζ=	340°·25		ζ=	240°·84		ζ=	...		ζ=	241°·89
	H=	·005		H=	·135		H=	...		H=	·008
	κ=	320°·25		κ=	41°·48		κ=	...		κ=	338°·15

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . .	·029	86°·48	·031	6°·36
„ Fortnightly „ . .	·059	220·07	·047	351·57
Luni-Solar „ „ . .	·014	105·77	·014	295·77
Solar-Annual „ . .	·346	11·46	·346	352·31
„ Semi-Annual „ . .	·141	135·37	·141	97·08

Values of the Tidal Constants, Kurrachee, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Kurrachee; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

A_0=7·114 feet.

S_1	H=R=	·093	M_6	R=	·047	Q_1	R=	·148	T_2	R=	·108
	κ=ζ=	164·11		ζ=	42°·04		ζ=	143°·56		ζ=	105°·63
S_2	H=R=	·945		H=	·050		H=	·132		H=	·108
	κ=ζ=	323°·90		κ=	201°·15		κ=	47°·42		κ=	347°·76
S_4	H=R=	·009	M_8	R=	·008	L_2	R=	·081	$(MS)_4$	R=	041
	κ=ζ=	27°·93		ζ=	290°·77		ζ=	298°·76		ζ=	152°·91
S_6	H=R=	·008		H=	·008		H=	·141		H=	042
	κ=ζ=	287°·99		κ=	262°·92		κ=	268°·23		κ=	325°·96

Short Period Tides—contd.

A_0=7·114 feet.

S_6	H=	R=	·001	O_1	R=	·731	N_2	R=	·581	$(2SM)_2$	R=	·014
	κ=	ζ=	82°·88		ζ=	172°·53		ζ=	76°·40		ζ=	287°·07
					H=	·655		H=	·593		H=	·014
					κ=	46°·32		κ=	279°·51		κ=	114°·04
M_1	R=		·118	K_1	R=	1·411	λ_2	R=	...	$2N_2$	R=	·089
	ζ=		32°·99		ζ=	103°·63		ζ=	...		ζ=	10° 82
	H=		·053		H=	1·317		H=	...		H=	·091
	κ=		26°·18		κ=	45°·74		κ=	...		κ=	244°·01
M_2	R=		2·563	K_2	R=	·331	ν_2	R=	·095	$(M_2N)_4$	R=	·066
	ζ=		120°·61		ζ=	255°·95		ζ=	267°·68		ζ=	61°·57
	H=		2·615		H=	·281		H=	·097		H=	·069
	κ=		293°·64		κ=	319°·58		κ=	225°·47		κ=	77°·72
M_3	R=		·027	P_1	R=	·373	μ_2	R=	·072	$(M_2K_1)_3$	R=	·055
	ζ=		72°·62		ζ=	356°·53		ζ=	287°·14		ζ=	338°·28
	H=		·027		H=	·373		H=	·075		H=	·053
	κ=		332°·17		κ=	47°·58		κ=	273°·21		κ=	93°·42
M_4	R=		·033	J_1	R=	·132	R_2	R=	...	$(2M_2K_1)_3$	R=	·028
	ζ=		1°·46		ζ=	154°·48		ζ=	...		ζ=	339°·89
	H=		·034		H=	·119		H=	...		H=	·027
	κ=		347°·53		κ=	63°·66		κ=	...		κ=	23°·86

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·054	16°·95	·058	346°·87
„ Fortnightly „	·005	188·05	·004	73·51
Luni-Solar „ „	·044	234·84	·045	61·80
Solar-Annual „	·070	2·11	·070	41·05
„ Semi-Annual„	·086	47·37	·086	125·25

Values of the Tidal Constants, Bhávnagar, 1891.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891 observations at Bhávnagar, and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891 observations:—

Short Period Tides.

A_0=22·592 feet.

S_1	H=	R=	·165	M_6	R=	·234	Q_1	R=	·213	T_2	R=	·370
	κ=	ζ=	195°·69		ζ=	197°·12		ζ=	255°·85		ζ=	236°·98
S_2	H=	R=	3·499		H=	·246		H=	·194		H=	·370
	κ=	ζ=	176°·72		κ=	134°·28		κ=	92°·83		κ=	237°·40
S_4	H=	R=	·125	M_3	R=	·015	L_2	R=	·579	$(MS)_4$	R=	·672
	κ=	ζ=	238°·87		ζ=	65°·94		ζ=	247°·28		ζ=	337°·73
S_6	H=	R=	·018		H=	·016		H=	·819		H=	·684
	κ=	ζ=	291°·10		κ=	222°·16		κ=	144°·05		κ=	196°·79
S_8	H=	R=	·002	O_1	R=	1°·77	N_2	R=	2·468	$2SM)_2$	R=	·091
	κ=	ζ=	255°·07		ζ=	45° 21		ζ=	95°·68		ζ=	223°·97
					H=	·980		H=	2·510		H=	·093
					κ=	84°·11		κ=	112°·80		κ=	4°·91
M_1	R=		·184	K_1	R=	2·512	λ_2	R=	...	$2N_2$	R=	·100
	ζ=		117°·22		ζ=	266°·92		ζ=	...		ζ=	291°·27
	H=		·088		H=	2·366		H=	...		H=	·101
	κ=		126°·02		κ=	90°·19		κ=	...		κ=	106°·46
M_2	R=		10·869	K_2	R=	1·029	ν_2	R=	·841	$(M_2N)_4$	R=	·355
	ζ=		274°·89		ζ=	351°·09		ζ=	192°·43		ζ=	240°·82
	H=		11·050		H=	·896		H=	·855		H=	·367
	κ=		133°·94		κ=	177°·07		κ=	114°·39		κ=	116°·99

Short Period Tides—contd.

A_0=22·592 feet.

M_3	R =	·081	P_1	R =	·681	μ_2	R =	·235	$(M_2K_1)_3$	R =	·329
	ζ =	300°·62		ζ =	288°·58		ζ =	191°·73		ζ =	64°·84
	H =	·083		H =	681		H =	·243		H =	·315
	κ =	269°·20		κ =	97°·93		κ =	269°·84		κ =	107°·17
M_4	R =	·880	J_1	R =	·182	R_2	R =	...	$2(M_2K_1)_3$	R =	·146
	ζ =	72°·94		ζ =	108°·58		ζ =	...		ζ =	100°·44
	H =	·919		H =	·166		H =	...		H =	·142
	κ =	151°·05		κ =	123°·66		κ =	...		κ =	355°·28

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·095	180°·85	·101	22°·78
„ Fortnightly „	·096	73·92	·078	35·16
Luni-Solar „ „	·173	281·02	·176	61·97
Solar-Annual „	·268	212·21	·268	132·86
„ Semi-Annual „	·033	170·33	·033	11·63

Values of the Tidal Constants, Bombay (Apollo Bandar), 1891.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891 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 1891 observations:—

Short Period Tides.

A_0=10·156 feet.

S_1	H = R =	·073	M_6	R =	·006	Q_1	R =	·154	T_2	R =	·152
	κ = ζ =	201°·63		ζ =	172°·48		ζ =	221°·86		ζ =	48°·77
S_2	H = R =	1·567		H =	·006		H =	·140		H =	·152
	κ = ζ =	5°·50		κ =	109°·78		κ =	58°·90		κ =	49°·19
S_4	H = R =	·016	M_8	R =	·002	L_2	R =	·101	$(MS)_4$	R =	·152
	κ = ζ =	220°·53		ζ =	183°·81		ζ =	19°·27		ζ =	183°·47
S_6	H = R =	·003		H =	·002		H =	·143		H =	·155
	κ = ζ =	184°·09		κ =	340°·22		κ =	276°·07		κ =	42°·58
S_8	H = P =	·001	O_1	R =	725	N_2	R =	·977	$(2SM)_2$	R =	·045
	κ = ζ =	221°·63		ζ =	8°·27		ζ =	297°·86		ζ =	350°·92
				H =	·660		H =	·993		H =	·046
				κ =	47°·22		κ =	315°·06		κ =	131°·82
M_1	R =	·118	K_1	R =	1·490	λ_2	R =	...	$2N_2$	R =	·138
	ζ =	65°·68		ζ =	222°·42		ζ =	...		ζ =	111°·82
	H =	056		H =	1·403		H =	...		H =	·140
	κ =	74°·50		κ =	45°·69		κ =	.		κ =	287°·10
M_2	R =	3·971	K_2	R =	·469	ν_2	R =	·267	$(M_2N)_4$	R =	·150
	ζ =	112°·46		ζ =	175°·03		ζ =	44°·91		ζ =	63°·38
	H =	4·037		H =	·408		H =	·271		H =	·155
	κ =	331°·50		κ =	1°·00		κ =	326°·94		κ =	299°·68
M_3	R =	·057	P_1	R =	·411	μ_2	R =	·243	$(M_2K_1)_3$	R =	·032
	ζ =	47°·50		ζ =	236°·47		ζ =	222°·96		ζ =	145°·33
	H =	·058		H =	·411		H =	·252		H =	·030
	κ =	16°·16		κ =	45°·81		κ =	301°·17		κ =	187°·70
M_4	R =	·135	J_1	R =	·129	R_2	R =	...	$(2M_2K_1)_3$	R =	·077
	ζ =	262°·19		ζ =	22°·53		ζ =	...		ζ =	194°·97
	H =	·139		H =	·118		H =	...		H =	·075
	κ =	340°·39		κ =	44°·59		κ =	...		κ =	89°·90

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·040	154°·56	·042	356°·47
„ Fortnightly „	·061	80 65	·050	41·84
Luni-Solar „ „	·047	310·98	·048	91·87
Solar-Annual „	·057	31·09	·057	311·74
„ Semi-Annual „	·062	35·41	·062	236·71

VALUES OF THE TIDAL CONSTANTS, BOMBAY (PRINCE'S DOCK), 1891.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891 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 1891 observations :—

Short Period Tides.

$A_0 = 8{\cdot}187$ feet.

S_1	H =	·083	M_6	R =	·014	Q_1	R =	·159	T_2	R =	·153
	κ = ζ =	198°·89		ζ =	233°·22		ζ =	221°·34		ζ =	46°·51
S_2	H =	1·605		H =	·015		H =	·145		H =	·153
	κ = ζ =	3°·80		κ =	170°·53		κ =	58°·39		κ =	46°·93
S_4	H =	·027	M_8	R =	·003	L_2	R =	·130	$(MS)_4$	R =	·137
	κ = ζ =	220°44		ζ =	289°·18		ζ =	15°·03		ζ =	183°·69
S_6	H =	·004		H =	·003		H =	·184		H =	·139
	κ = ζ =	204°·44		κ =	85°·59		κ =	271°·83		κ =	42°·79
S_8	H =	·001	O_1	R =	·714	N_2	R =	·985	$(2SM)_2$	R =	·046
	κ = ζ =	172°·88		ζ =	6°·90		ζ =	296°·99		ζ =	339°·53
				H =	·649		H =	1·001		H =	·047
				κ =	45°·86		κ =	314°·18		κ =	120°·43
M_1	R =	·120	K_1	R =	1·482	λ_2	R =	...	$2N_2$	R =	·144
	ζ =	65°·13		ζ =	221°·01		ζ =	...		ζ =	112°·23
	H =	·057		H =	1·395		H =	...		H =	·147
	κ =	73°·95		κ =	44°·28		κ =	...		κ =	287°·51
M_2	R =	4·039	K_2	R =	·463	υ_2	R =	·267	$(M_2N)_4$	R =	·147
	ζ =	110°·12		ζ =	173°·66		ζ =	44°·16		ζ =	63°·80
	H =	4·106		H =	·403		H =	·272		H =	·152
	κ =	329°·22		κ =	359°·64		κ =	326°·19		κ =	300°·10
M_3	R =	·065	P_1	R =	·403	μ_2	R =	·242	$(M_2K_1)_3$	R =	·028
	ζ =	43°·86		ζ =	234°·71		ζ =	225°·10		ζ =	170°·03
	H =	·067		H =	·403		H =	·250		H =	·027
	κ =	12°·51		κ =	44°·05		κ =	303°·31		κ =	212° 40
M_4	R =	·109	J_1	R =	·125	R_2	R =	...	$(2M_2K_1)_3$	R =	0·70
	ζ =	251°·39		ζ =	24°·51		ζ =	...		ζ =	186°·87
	H =	·113		H =	·114		H =	...		H =	·069
	κ =	329°·60		κ =	46°·56		κ =	...		κ =	81°·80

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·051	159°·19	·054	1°·10
„ Fortnightly „	·070	75·33	·057	36·52
Luni-Solar „ „	·061	284·50	·062	65 40
Solar-Annual „	·105	33·40	·105	314·06
„ Semi-Annual „	·065	1·83	·065	203·13

Values of the Tidal Constants, Cochin, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Cochin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

A_0 = 2·331 feet.

S_1	H =	·024	M_6	R =	·008	Q_1	R =	·069	T_2	R =	·028
	κ = ζ =	189°·26		ζ =	115°·84		ζ =	85°·20		ζ =	26°·38
S_2	H = R =	·265		H =	·008		H =	·063		H =	·028
	κ = ζ =	30°·71		κ =	98°·45		κ =	80°·11		κ =	3°·16
S_4	H = R =	·005	M_8	R =	·006	L_2	R =	·021	$(MS)_4$	R =	·021
	κ = ζ =	192°·76		ζ =	355°·60		ζ =	15°·18		ζ =	151°·89
S_6	H = R =	·007		H =	·007		H =	·031		H =	·021
	κ = ζ =	228°·01		κ =	332°·41		κ =	359°·25		κ =	146°·10
S_8	H = R =	·001	O_1	R =	·338	N_2	R =	·143	$(2SM)_2$	R =	·002
	κ = ζ =	284°·04		ζ =	269°·20		ζ =	103°·22		ζ =	304°·70
				H =	·306		H =	·145		H =	·002
				κ =	59°·46		κ =	302°·08		κ =	310°·49
M_1	R =	·036	K_1	R =	·629	λ_2	R =	...	$2N_2$	R =	·013
	ζ =	353°·45		ζ =	205°·14		ζ =	...		ζ =	231°·77
	H =	·017		H =	·591		H =	...		H =	·013
	κ =	71°·36		κ =	52°·16		κ =	...		κ =	275°·28
M_2	R =	7·15	K_2	R =	·100	υ_2	R =	·047	$(M_2N)_4$	R =	·021
	ζ =	338°·59		ζ =	149°·79		ζ =	198°·87		ζ =	268°·83
	H =	·727		H =	·086		H =	·048		H =	·021
	κ =	332°·79		κ =	23°·26		κ =	344°·51		κ =	101°·89
M_3	R =	·015	P_1	R =	·168	μ_2	R =	·003	$(M_2K_1)_3$	R =	·026
	ζ =	34°·96		ζ =	263°·99		ζ =	113°·43		ζ =	302°·57
	H =	·016		H =	·168		H =	·003		H =	·025
	κ =	206°·26		κ =	49°·70		κ =	101°·83		κ =	143°·79
M_4	R =	·028	J_1	R =	·037	R_2	R =	...	$(2M_2K_1)_3$	R =	·020
	ζ =	95°·58		ζ =	44°·56		ζ =	...		ζ =	325°·43
	H =	·029		H =	0·34		H =	...		H =	·020
	κ =	83°·99		κ =	43°·85		κ =	...		κ =	106°·82

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·029	159°·70	·031	315°·04
„ Fortnighly „	·088	133·26	·071	6·95
Luni-Solar „ „	·024	311·43	·024	317·23
Solar-Annual „	·295	8·66	·295	312·95
„ Semi-Annual „	·273	200·86	·073	29·46

Values of the Tidal Constants, Minicoy, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Minicoy; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

A_0=5·174 feet.

S_1	H = R =	·037	M_6	R =	·004	Q_1	R =	·082	T_2	R =	...
	κ = ζ =	209°·86		ζ =	253°·01		ζ =	288°·97		ζ =	...
S_2	H = R =	·360		H =	.004		H =	·075		H =	...
	κ = ζ =	18°·83		κ =	105°·81		κ =	63°·23		κ =	...

Short Period Tides—contd.

A_0=5·174 feet.

S_4	H =	·003	M_8	R =	·002	L^1	R =	·014	$(MS)_4$	R =	·005
	κ = ζ =	128°·05		ζ =	335°·23		ζ =	246°·70		ζ =	176°·42
S_6	H = R =	·001		H =	·002		H =	·021		H =	·005
	κ = ζ =	170°·54		κ =	138°·95		κ =	18°·49		κ =	127°·36
S_8	H = R =	·000	O_1	R =	·373	N_2	R =	·177	(2SM)	R =	·002
	κ = ζ =	213°·69		ζ =	298°·61		ζ =	335°·35		ζ =	256°·76
				H =	·338		H =	·180		H =	·002
				κ =	58°·49		κ =	300°·67		κ =	305°·83
M_1	R =	·067	K	R =	·738	λ_2	R =	...	$2N_2$	R =	·023
	ζ =	150°·12		ζ =	215°·61		ζ =	...		ζ =	266°·49
	H =	·032		H =	·695		H =	...		H =	·024
	κ =	25°·56		κ =	49°·76		κ =	...		κ =	246°·19
M_2	R =	·865	K_2	R =	·110	ν_2	R =	·057	$(M_2N)_4$	R =	·015
	ζ =	16°·85		ζ =	163°·40		ζ =	67°·37		ζ =	307°·27
	H =	·880		H =	·096		H =	·058		H =	·015
	κ =	327°·78		κ =	11°·14		κ =	316°·76		κ =	223°·52
M_3	R =	·007	P_1	R =	·224	μ_2	R =	·005	$(M_2K_1)_3^{\circ}$	R =	·009
	ζ =	248°·96		ζ =	248°·84		ζ =	16°·93		ζ =	260°·43
	H =	·007		H =	·224		H =	·005		H =	·008
	κ =	175°·36		κ =	47°·35		κ =	278°·79		κ =	45°·51
M_4	R =	·010	J_1	R =	·071	R_2	R =	...	$(2M_2K_1)_3$	R =	·002
	ζ =	116°·04		ζ =	259°·41		ζ =	...		ζ =	140°·19
	H =	·011		H =	·065		H =	...		H =	·002
	κ =	17°·91		κ =	76°·08		κ =	...		κ =	207°·90

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·030	82°·69	·032	68°·31
„ Fortnightly „	·078	119·68	·063	10·86
Luni-Solar „ „	·011	6·49	·011	55·56
Solar-Annual „	·369	63·70	·369	355·19
„ Semi-Annual „	·106	50·93	·106	273·92

Values of the Tidal Constants, Tuticorin, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Tuticorin; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

A_0 = 2·074 feet.

S_1	H = R =	·040	M_6	R =	·015	Q_1	R =	·031	T_2	R =	·025
	κ = ζ =	51°·16		ζ =	41°·92		ζ =	322°·84		ζ =	280°·24
S_2	H = R =	·473		H =	·016		H =	·028		H =	·025
	κ = ζ =	83°·10		κ =	22°·79		κ =	77°·88		κ =	130°·87
S_4	H = R =	·006	M_8	R =	·012	L_2	R =	·024	$(MS)_4$	R =	·013
	κ = ζ =	238°·86		ζ =	197°·86		ζ =	59°·08		ζ =	145°·42
S_6	H = R =	·004		H =	·013		H =	·042		H =	·013
	κ = ζ =	145°·22		κ =	292°·36		κ =	23°·20		κ =	259°·05
S_8	H = R =	·007	O_1	R =	·124	N_2	R =	·082	$(2SM)_2$	R =	·006
	κ = ζ =	222°·17		ζ =	264°·81		ζ =	309°·08		ζ =	58°·27
				H =	·111		H =	·084		H =	·009
				κ =	47°·45		κ =	35°·11		κ =	304°·64
M_1	R =	·009	K_1	R =	·331	λ_2	R =	...	$2N_2$	R =	·010
	ζ =	29°·50		ζ =	53°·27		ζ =	...		ζ =	37°·22
	H =	·004		H =	·308		H =	...		H =	·010
	κ =	354°·88		κ =	27°·04		κ =	...		κ =	95°·65

Short Period Tides—contd.

A_0=2·074 feet.

M_2	R =	·653	K_2	R =	·152	ν_2	R =	0·24	$(M_2N)_4$	R =	·022
	ζ =	289°·09		ζ =	318°·61		ζ =	106°·89		ζ =	242°·32
	H =	·667		H =	·128		H =	·024		H =	·023
	κ =	42°·71		κ =	85°·57		κ =	3° 50		κ =	81°·97
M_3	R =	·019	P_1	R =	·075	μ_2	R =	·027	$(M_2K_1)_3$	R =	·005
	ζ =	349°·86		ζ =	353°·58		ζ =	224°·23		ζ =	305°·27
	H =	·019		H =	·075		H =	·028		H =	·005
	κ =	160°·30		κ =	13°·13		κ =	91°·48		κ =	32°·67
M_4	R =	·025	J_1	R =	·025	R_2	R =	...	$(_2M_2K_1)_3$	R =	·005
	ζ =	285°·09		ζ =	65°·01		ζ =	...		ζ =	339°·44
	H =	·026		H =	·022		H =	...		H =	·005
	κ =	152°·33		κ =	63°·59		κ =	...		κ =	232°·92

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·047	192°·33	·051	219°·93
,, Fortnightly ,, ...	·080	351·49	·063	359·84
Luni-Solar ,, ,, ...	·045	29·72	·046	276·09
Solar-Annual ,, ...	·241	245·71	·241	316·17
,, Semi-Annual ,, ...	·152	274·71	·152	55·62

VALUES OF THE TIDAL CONSTANTS, TRINCOMALEE, 1890-91.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1890-91 observations at Trincomalee; 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 = 1·842 feet.

S_1	H = R =	·018	M_6	R =	·006	Q_1	R =	·012	T_2	R =	..
	κ = ζ =	65°·25		ζ =	326°·31		ζ =	140°·57		ζ =	...
S_2	H = R =	·191		H =	·006		H =	·011		H =	...
	κ = ζ =	269° 31		κ =	108°·71		κ =	177°·27		κ =	...
S_4	H = R =	·007	M_8	R =	·002	L_2	R =	·041	$(MS)_4$	R =	·009
	κ = ζ =	251°·57		ζ =	329°·74		ζ =	181°·55		ζ =	142°·24
S_6	H = R =	·000		H =	·002		H =	·053		H =	.010
	κ = ζ =	45°·00		κ =	159°·61		κ =	308°·76		κ =	189°·70
S_8	H = R =	·001	O_1	R =	·068	N_2	R =	·142	$(2SM)_2$	R =	·010
	κ = ζ =	323°·13		ζ =	28°·66		ζ =	62°·56		ζ =	295°·54
				H =	·062		H =	·144		H =	·010
				κ =	307°·58		κ =	227°·80		κ =	248°·07
M_1	R =	·016	K_1	R =	·223	λ_2	R =	...	$2N_2$	R =	·024
	ζ =	85°·38		ζ =	199°·08		ζ =	...		ζ =	308°·58
	H =	·008		H =	·211		H =	...		H =	0·24
	κ =	4°·92		κ =	330°·86		κ =	...		κ =	231°·60
M_2	R =	·579	K_2	R =	·081	ν_2	R =	·047	$(M_2N)_4$	R =	·007
	ζ =	192°·68		ζ =	166°·28		ζ =	229°·76		ζ =	109°·59
	H =	·587		H =	·072		H =	·048		H =	·007
	κ =	240°·15		κ =	249°·29		κ =	208°·88		κ =	322°·30
M_3	R =	·004	P_1	R =	·074	μ_2	R =	·032	$(M_2K_1)_3$	R =	·008
	ζ =	122°·83		ζ =	122°·64		ζ =	65° 20		ζ =	18°·44
	H =	·004		H =	·074		H =	·033		H =	·008
	κ =	194° 03		κ =	343°·26		κ =	160°·13		κ =	197°·68
M_4	R =	·012	J_1	R =	·022	R_2	R =	...	$(_2M_2K_1)_3$	R =	·005
	ζ =	129°·74		ζ =	268°·44		ζ =	...		ζ =	58°·47
	H =	·013		H =	·020		H =	...		H =	·005
	κ =	224°·67		κ =	279°·21		κ =	...		κ =	21°·62

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·022	88°·50	·023	330°·72
„ Fortnightly „	·067	334·91	·055	14·54
Luni-Solar „ „	·015	283·21	·015	235·75
Solar-Annual „	·291	52·03	·291	281·40
„ Semi-Annual „	·207	34·94	·207	133 69

VALUES OF THE TIDAL CONSTANTS, KIDDERPORE, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Kidderpore ; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from 1891-92 observations :—

Short Period Tides.

A_0=10·618 feet.

S_1 H=R =	·086	M_6 R =	·145	Q_1 R =	·025	T_2 R =	·093
S_1 κ = ζ =	198°·63	M_6 ζ =	114°·80	Q_1 ζ =	353°·02	T_2 ζ =	258°·13
S_2 H=R =	1·541	M_6 H =	·154	Q_1 H =	·022	T_2 H =	·093
S_2 κ = ζ =	99°·47	M_6 κ =	323°·91	Q_1 κ =	356°·69	T_2 κ =	179°·74
S_4 H=R =	·108	M_8 R =	·059	L_2 R =	·171	$(MS)_4$ R =	·692
S_4 κ = ζ =	105°·65	M_8 ζ =	355°·29	L_2 ζ =	31°·00	$(MS)_4$ ζ =	8°·93
S_6 H=R =	·003	M_8 H =	·064	L_2 H =	·279	$(MS)_4$ H =	·706
S_6 κ = ζ =	65°·86	M_8 κ =	274°·10	L_2 κ =	97°·67	$(MS)_4$ κ =	78°·63
S_8 H=R =	·002	O_1 R =	·232	N_2 R =	·626	$(2SM)_4$ R =	·084
S_8 κ = ζ =	246°·04	O_1 ζ =	211°·33	N_2 ζ =	140°·67	$(2SM)_4$ ζ =	85°·32
		O_1 H =	·209	N_2 H =	·638	$(2SM)_4$ H =	·086
		O_1 κ =	21°·55	N_2 κ =	43°·83	$(2SM)_4$ κ =	15°·61
M_1 R =	·023	K_1 R =	·409	λ_2 R =	...	$2N_2$ R =	·040
M_1 ζ =	22°·41	K_1 ζ =	151°·10	λ_2 ζ =	...	$2N_2$ ζ =	316°·85
M_1 H =	·011	K_1 H =	383	λ_2 H =	...	$2N_2$ H =	·041
M_1 κ =	141°·52	K_1 κ =	53°·53	λ_2 κ =	...	$2N_2$ κ =	53°·46
M_2 R =	3·576	K_2 R =	·586	ν_2 R =	·131	(M_2N_2) R =	·115
M_2 ζ =	347° 22	K_2 ζ =	110°·22	ν_2 ζ =	56°·88	(M_2N_2) ζ =	289°·35
M_2 H =	3·645	K_2 H =	502	ν_2 H =	·133	(M_2N_2) H =	·119
M_2 κ =	56°·92	K_2 κ =	94°·51	ν_2 κ =	4°·68	(M_2N_2) κ =	262°·21
M_3 R =	·015	P_1 R =	·151	μ_2 R =	·265	$(M_2K_1)_3$ R =	·146
M_3 ζ =	39°·02	P_1 ζ =	310°·06	μ_2 ζ =	49°·79	$(M_2K_1)_3$ ζ =	66°·27
M_3 H =	·016	P_1 H =	·151	μ_2 H =	·275	$(M_2K_1)_3$ H =	·139
M_3 κ =	323°·58	P_1 κ =	40°·60	μ_2 κ =	189°·20	$(M_2K_1)_3$ κ =	38°·41
M_4 R =	·727	J_1 R =	·25	R_2 R =	...	$(2M^2K_1)_3$ R =	·040
M_4 ζ =	257°·04	J_1 ζ =	282°·86	R_2 ζ =	...	$(2M^2K_1)_3$ ζ =	98°·66
M_4 H =	7·55	J_1 H =	·022	R_2 H =	...	$(2M^2K_1)_3$ H =	·038
M_4 κ =	36°·45	J_1 κ =	348°·89	R_2 κ =	...	$(2M^2K_1)_3$ κ =	335°·63

Long Period Tides.

	R	ζ		κ
Lunar Monthly Tide	0·301	202°·65	0·323	9°·20
„ Fortnightly „	0·257	117·96	0·205	27·23
Luni-Solar „ „	0·883	113·64	0·900	43·94
Solar-Annual „	2·527	153·23	2·527	152·69
„ Semi-Annual „	0·751	341·33	0·751	340·25

Values of the Tidal Constants, Akyab, 1891-92.

The flloowing are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Akyab; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

$A_0 = 7{\cdot}452$ feet.

S_1	H =	·050	M_6	R =	·024	Q_1	R =	·013	T_2	R =	·062
	κ = ζ =	74°·69		ζ =	187°·60		ζ =	320°·14		ζ =	356°·28
S_2	H = R =	1·142		H =	·025		H =	·012		H =	·062
	κ = ζ =	306°·90		κ =	126°·87		κ =	279°·28		κ =	230°·60
S_4	H = R =	·005	M_8	R =	·010	L_2	R =	·068	$(MS)_4$	R =	·015
	κ = ζ =	178°·78		ζ =	227°·05		ζ =	62°·98		ζ =	327°·56
S_6	H = R =	·003		H =	·010		H =	·119		H =	·015
	κ = ζ =	103°·50		κ =	146°·08		κ =	301°·87		κ =	307°·32
S_8	H = R =	·002	O_1	R =	·203	N_2	R =	·498	$(2SM)_2$	R =	·036
	κ = ζ =	59°·93		ζ =	301°·88		ζ =	6°·31		ζ =	180°·81
				H =	·182		H =	·508		H =	·036
				κ =	334°·52		κ =	272°·57		κ =	201°·05
M_1	R =	·006	K_1	R =	·480	λ_2	R =	...	$2N_2$	R =	051
	ζ =	40°·18		ζ =	33°·01		ζ =	...		ζ =	83°·09
	H =	·003		H =	·448		H =	...		H =	·052
	κ =	297°·20		κ =	342°·97		κ =	...		κ =	275°·85
M_2	R =	2·509	K_2	R =	·364	ν_2	R =	·118	$(M_2N)_4$	R =	·108
	ζ =	297°·57		ζ =	225°·97		ζ =	192°·28		ζ =	241°·40
	H =	2·561		H =	·308		H =	·120		H =	·113
	κ =	277° 33		κ =	305°·31		κ =	227°·09		κ =	127°·42
M_3	R =	·013	P_1	R =	·136	μ_2	R =	·018	$(M_2K_1)_3$	R =	·013
	ζ =	69°·82		ζ =	302°·92		ζ =	295°·99		ζ =	316°·58
	H =	·013		H =	·136		H =	·019		H =	·013
	κ =	39°·46		κ =	346°·16		κ =	255°·51		κ =	246°·30
M_4	R =	·014	J_1	R =	·009	R_2	R =	...	$(_2M_2K_1)_3$	R =	·019
	ζ =	335°·52		ζ =	298°·47		ζ =	...		ζ =	42°·61
	H =	·015		H =	·009		H =	...		H =	·019
	κ =	295°·04		κ =	319°·08		κ =	...		κ =	52°·16

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·075	304°·87	·081	18°·37
„ Fortnightly „	·052	165·07	·041	259·55
Luni-Solar „ „	·062	61·28	·063	81·53
Solar-Annual „	·883	84·43	·883	131·19
„ Semi-Annual „	·187	78·91	·187	172·43

Values of the Tidal Constants, Rangoon, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Rangoon; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

$A_0 = 10{\cdot}215$ feet.

S_1	H = R =	·114	M_6	R =	·231	Q_1	R =	·032	T_2	R =	·324
	κ = ζ =	126°·04		ζ =	133°·05		ζ =	324°·42		ζ =	234°·01
S_2	H = R =	2·209		H =	·244		H =	·029		H =	·324
	κ = ζ =	170°·22		κ =	79° 73		κ =	56°·13		κ =	176°·35
S_4	H = R =	·091	M_8	R =	·092	L_2	R =	·416	$(MS)_4$	R =	·376
	κ = ζ =	264°·44		ζ =	276°·32		ζ =	214°·90		ζ =	350°·43
S_6	H = R =	·014		H =	·099		H =	·657		H =	·383
	κ = ζ =	42°·11		κ =	85°·23		κ =	161°·19		κ =	212°·65

Short Period Tides—contd.

A_0=10·215 feet.

S_8	H=	R=	·006	O_1	R=	·308	N_2	R=	1·041	$(2SM)_2$	R=	·200
	κ=	ζ=	93°·07		ζ=	38°·12		ζ=	146°·18		ζ=	270°·17
					H=	·278		H=	1·061		H=	·204
					κ=	21°·72		κ=	116°·51		κ=	47°·95
M_1	R=		·028	K_1	R=	·748	λ_2	R=	...	$2N_2$	R=	·089
	ζ=		98°·28		ζ=	152°·93		ζ=	...		ζ=	106°·28
	H=		·013		H=	·701		H=	...		H=	·091
	κ=		112°·37		κ=	34°·55		κ=	...		κ=	184°·71
M_2	R=		5·971	K_2	R=	·717	ν_2	R=	·216	$(M_2N)_4$	R=	·166
	ζ=		268°·00		ζ=	225°·64		ζ=	170°·79		ζ=	236°·46
	H=		6·081		H=	·617		H=	·220		H=	·172
	κ=		130°·23		κ=	168°·30		κ=	149°·01		κ=	69°·02
M_3	R=		·028	P_1	R=	·163	μ_2	R=	·517	$(M_2K_1)_3$	R=	·104
	ζ=		207°·68		ζ=	307°·74		ζ=	201°·40		ζ=	5°·11
	H=		·029		H=	·162		H=	·537		H=	·099
	κ=		181°·02		κ=	59°·00		κ=	285°·85		κ=	108°·95
M_4	R=		·398	J_1	R=	·009	R_2	R=	...	$(2M_2K_1)_3$	R=	·138
	ζ=		83°·81		ζ=	213°·69		ζ=	...		ζ=	209°·00
	H=		·413		H=	·009		H=	...		H=	·135
	κ=		168°·27		κ=	344°·21		κ=	...		κ=	51°·83

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	0·189	131°·80	0·202	23°·70
„ Fortnightly „	0·181	307·07	0·145	22·09
Luni-Solar „ „	0·446	269 52	0·454	47·29
Solar-Annual „	1·131	155·54	1·131	134·28
„ Semi-Annual „	0·141	310·18	0·141	267·66

VALUES OF THE TIDAL CONSTANTS, MERGUI, 1891-92.

The following are the amplitudes (R) and epochs (ζ) deduced from the 1891-92 observations at Mergui; and also the *mean* values of the amplitudes (H) and of the epochs (κ) for each particular tide evaluated from the 1891-92 observations:—

Short Period Tides.

A_0=12·902 feet.

S_1	H=	R=	·065	M_6	R=	·076	Q_1	R=	·028	T_2	R=	·163
	κ=	ζ=	69°·92		ζ=	312°·35		ζ=	238°·33		ζ=	93°·88
S_2	H=	R=	2·946		H=	·081		H=	·025		H=	·163
	κ=	ζ=	347°·90		κ=	236°·69		κ=	281°·53		κ=	16°·51
S_4	R=	R=	·050	M_8	R=	·012	L_2	R=	·209	$(MS)_4$	R=	·158
	κ=	ζ=	236°·47		ζ=	26°·57		ζ=	227°·64		ζ=	83°·22
S_6	H=	R=	·017		H=	·013		H=	·340		H=	·161
	κ=	ζ=	92°·39		κ=	45°·69		κ=	306°·04		κ=	178°·00
S_9	H=	R=	·002	O_1	R=	·233	N_2	R=	1·000	$(2SM)_2$	R=	·154
	κ=	ζ=	148°·00		ζ=	116°·40		ζ=	6°·01		ζ=	218°·95
					H=	·210		H=	1·019		H=	·157
					κ=	312°·72		κ=	307°·68		κ=	124°·17
M_1	R=		·009	K_1	R=	·557	λ_2	R=	...	$2N_2$	R=	·161
	ζ=		244°·27		ζ=	73°·29		ζ=	...		ζ=	164°·17
	H=		·004		H=	·521		H=	...		H=	·164
	κ=		15°·86		κ=	334°·70		κ=	...		κ=	312°·73
M_2	R=		5·402	K_2	R=	1·028	ν_2	R=	·050	$(M_2N)_4$	R=	·136
	ζ=		213°·60		ζ=	1°·57		ζ=	256°·36		ζ=	206°·41
	H=		5·505		H=	·880		H=	·051		H=	·141
	κ=		308°·38		κ=	343°·82		κ=	240°·88		κ=	242°·86

Short Period Tides—contd.

A_0=12·902 feet.

M_3	R =	·063	P_1	R =	·151	μ_2	R =	·409	$(M_2K_1)_3$	R =	·039
	ζ =	172°·74		ζ =	240°·25		ζ =	160°·09		ζ =	305°·38
	H =	·064		H =	·151		H =	·425		H =	·037
	κ =	134° 91		κ =	331°·81		κ =	349°·65		κ =	301°·57
M_4	R =	·128	J_1	R =	·026	R_2	R =	...	$(2M_2K_1)_3$	R =	·006
	ζ =	302°·55		ζ =	238°·39		ζ =	...		ζ =	299°·25
	H =	·112		H =	·024		H =	...		H =	·006
	κ =	132°·11		κ =	289°·96		κ =	...		κ =	227°·39

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·078	234°·38	·084	27°·49
,, Fortnightly ,, . . .	·054	155·12	·043	37·27
Luni-Solar ,, ,, . . .	·042	143·77	·043	48·99
Solar-Annual ,, . . .	·528	142·47	·528	140·92
,, Semi-Annual ,, . . .	·125	161·35	·125	158·25

VALUES OF THE 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, commencing 24th October 1890:—

Short Period Tides.

A_0=4·606 feet.

S_1	H = R =	·013	M_6	R =	·006	Q_1	R =	·025	T_2	R =	...
	κ = ζ =	51°·34		ζ =	222°·83		ζ =	261°·11		ζ =	...
S_2	H = R =	·974		H =	·007		H =	·023		H =	...
	κ = ζ =	312°·00		κ =	170°·98		κ =	232°·47		κ =	...
S_4	H = R =	·001	M_8	R =	·003	L_2	R =	·082	$(MS)_4$	R =	·011
	κ = ζ =	331°·39		ζ =	269°·00		ζ =	310°·83		ζ =	187°·13
S_6	H = R =	·001		H =	·003		H =	·102		H =	·011
	κ = ζ =	233°·13		κ =	319°·88		κ =	271°·09		κ =	289°·84
S_8	H = R =	·002	O_1	R =	·171	N_2	R =	·409	$(2SM)_2$	R =	·027
	κ = ζ =	43°·15		ζ =	308°·15		ζ =	192°·72		ζ =	237°·88
				H =	·157		H =	·415		H =	·027
				κ =	299°·21		κ =	275°·74		κ =	135°·16
M_1	R =	·013	K_1	R =	·419	γ_2	R =	...	$2N_2$	R =	·051
	ζ =	122°·71		ζ =	211°·68		ζ =	...		ζ =	204°·15
	H =	·007		H =	·397		H =	...		H =	·052
	κ =	248°·67		κ =	326°·60		κ =	...		κ =	267°·46
M_2	R =	1·992	K_2	R =	·335	ν_2	R =	·086	$(M_2N)_4$	R =	·040
	ζ =	174°·32		ζ =	262°·27		ζ =	356°·78		ζ =	105°·41
	H =	2·021		H =	·296		H =	·088		H =	·041
	κ =	277°·04		κ =	311°·59		κ =	223°·89		κ =	291°·15
M_3	R =	·007	P_1	R =	·122	μ_2	R =	·091	$(M_2K_1)_3$	R =	·026
	ζ =	66°·70		ζ =	90°·33		ζ =	85°·56		ζ =	134°·84
	H =	·008		H =	·122		H =	·094		H =	·025
	κ =	40°·77		κ =	327°·74		κ =	290°·99		κ =	352°·48
M_4	R =	·006	J_1	R =	·025	R_2	R =	...	$(2M_2K_1)_3$	R =	·005
	ζ =	260°·22		ζ =	176°·96		ζ =	...		ζ =	140°·96
	H =	·006		H =	·023		H =	...		H =	·005
	κ =	105°·65		κ =	308°·32		κ =	...		κ =	231°·48

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·036	269°·92	·038	289°·62
„ Fortnightly „ . . .	·064	57·63	·053	358·23
Luni-Solar „ „ . . .	·013	214·30	·013	111·59
Solar-Annual „ . . .	·241	278·33	·241	130·92
„ Semi-Annual „ . . .	·136	98·54	·136	163·71

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 1892 (which arrived at my office from London in three instalments, namely, on November 11th, and December 15th, 1891, and January 11th 1892, and were at once distributed), and with the preparation of those for 1893. 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 1891 of every high and low water at 14 stations measured in duplicate from the tidal diagrams, together with tidal observations for the same year taken daily during daylight from a graduated staff at the site of the Moulmein tidal observatory, and similar observations for some months of that year taken at the sites of the Chittagong and Cocanada observatories, kindly supplied with great regularity by the Port Officers.

In order to save Mr. Roberts the labour of the calculations, all the predicted times and heights of high and low water for 1891 at these stations were compared with the above mentioned actual values and the errors tabulated, thus giving him in a convenient form information likely to assist him in improving the predictions. I do not know how far he utilises this information. I have already drawn attention to the excess during the last six years, of the predicted heights of low water over the actual heights, during the month of August, at Moulmein. The principal riverain stations are Kidderpore, Rangoon, and Moulmein, and the tidal observations taken at them are reduced by a special method in separate monthly groups, each group extending from the first to the last year of the observations, there being a January group, a February group and so on, as explained in the preface to the Hooghly River Tide Tables for 1888.

The values obtained from these groups are understood to be modified by Mr. Roberts where necessary by the light of the tables of differences between the actual and predicted high and low water values which are sent to him yearly with that object. In the Tide Tables for 1891, which is the latest volume that can be examined as a whole, the height predictions at Kidderpore were too high at both high and low water during the first half of August, and the last half of October. At Rangoon they were too high at low water in August, September, October and November. At Moulmein they were too high in August and September. For the anticipated height of the tide to be too great especially at low water is not only inconvenient, but may be dangerous; and it is to be hoped that as Mr. Roberts accumulates data he may be able to increase the accuracy of the riverain predictions; though I am afraid we can never hope for extreme accuracy at riverain stations, where the height of the water may be unexpectedly influenced by exceptional seasons, bringing with them an excess or scarcity of rain or snow.

At page xiv of the appendix to the General Report for 1889-90, there is a table of "comparisons between datum as adopted for the tide tables and that adopted for chart soundings." When that table was prepared, an effort that began several years previously was still being made to introduce "Indian spring low-water mark," the scientific datum, at as many tidal stations as possible.

At each station where this had been done, the preface to the tide tables contained a statement that in calculating the heights they were referred to the scientific datum; the difference between this and the datum for chart soundings (unless it happened to be the scientific datum) was given, and if small, it was added that the two might be accepted as practically identical, and at the foot of the tables of high and low water a note was put for the guidance of navigators, stating that the heights were referrible to the datum for chart soundings. This plan, which has had a sufficiently long trial, is not satisfactory; and after consulting qualified persons who largely use the tide tables, I had adopted the datum of sounding in the latest charts as the datum for the Tide Tables for 1893, stating in each preface the difference (where it exists) between this and the scientific datum to enable scientific people to refer the heights to the latter if they feel so inclined. The table of comparisons contained in the General Report for 1889-90 has thus become obsolete, and in place of it I give the following table. A description of the datum of each tidal station entered

in it, including the level of the datum with reference to a well-known bench mark, will be found in the preface for the station in the tide tables.

Tidal Station.	Datum of soundings in latest Charts and for Tide Tables, 1893.
Aden	Low-water equinoctial springs.
Kurrachee	Mean low-water of ordinary spring-tides.
Okha	Approximate mean of lowest ordinary spring-tides.
Port Albert Victor	Low-water of ordinary spring-tides.
Bhávnagar	The level of lowest low-water springs observed by Marine Survey in 1886.
Bombáy—*	
Apollo Bandar	Mean of the lowest ordinary spring-tides.
Mormugáo	Mean low-water of ordinary spring-tides.
Kárwár	Ditto ditto ditto.
Beypore	Lowest low-water spring-tides.
Cochin	Mean low-water of ordinary spring-tides.
Minicoy	8·05 feet below a bench-mark near the *Kacheri*.
Tuticorin	Mean low water of ordinary spring-tides.
Colombo	Ditto ditto ditto.
Galle	Ditto ditto ditto.
Trincomalee	Ditto ditto ditto.
Pámban	Ditto ditto ditto.
Negapatam	10·73 feet below a bench-mark in Marine Office.
Madras	Indian spring low-water mark.
Cocanada	Ditto ditto.
Vizagapatam	Ditto ditto.
False Point	Lowest low-water during the dry season.
Dublat	The zero of Kedgeree gauge.
Diamond Harbour	Mean low-water of ordinary springs at Kidderpore.
Calcutta—	
Kidderpore	Ditto ditto ditto ditto.
Chittagong	Low-water spring-tides of the dry season.
Akyab	Mean low-water of ordinary spring-tides.
Elephant Point	Low-water of spring-tides of the dry season.
Rangoon	Ditto ditto ditto.
Amherst	Low-water ordinary spring-tides.
Moulmein	23·34 feet below a bench-mark in the Port Office.
Mergui	Indian spring low-water mark.
Port Blair	Ditto ditto.

* Bombay, Prince's Dock:—The datum is Prince's Dock sill: this is 14·00 feet lower than the Apollo Bandar datum.

The volumes of Tide Tables for 1893 will contain predictions for 33 tidal stations, the new stations of Trincomalee and Minicoy having been added since the last issue.

The amount realised by the sale of the Tide Tables is much the same as it was last year, and the limited number of presentation copies are distributed in strict accordance with the lists sanctioned by Government.

The usual tabular statements are appended, showing the percentage and amount of the errors in the predicted times and heights of high and low water for the year 1891 at 15 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 1891.

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	677	35	43	13	7	2
Kurrachee	703	18	37	20	20	5
Bhávnagar	688	21	36	13	18	12
Bombay { Apollo Bandar	705	28	48	12	10	2
Bombay { Prince's Dock	700	41	44	8	6	1
Cochin	607	22	35	15	19	9
Tuticorin	686	40	39	8	9	4
Cocanada	463	49	45	4	2	...
Kidderpore	690	26	36	12	18	8
Chittagong	553	30	39	9	15	7
Akyab	704	40	46	8	5	1
Rangoon	679	23	39	12	19	7
Moulmein	361	38	40	8	8	6
Mergui	697	36	45	8	7	4
Port Blair	507	45	44	6	5	...

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 1891.

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	663	34	42	12	8	4
Kurrachee	702	29	38	14	14	5
Bhávnagar	691	20	28	11	21	20
Bombay { Apollo Bandar	705	30	43	10	12	5
Bombay { Prince's Dock	703	27	44	14	11	4
Cochin	695	38	44	9	6	3
Tuticorin	682	42	38	8	9	3
Cocanada	461	50	42	5	2	1
Kidderpore	686	23	35	14	17	11
Chittagong	551	26	26	12	19	17
Akyab	705	44	44	7	4	1
Rangoon	675	31	34	11	13	11
Moulmein	362	36	37	9	9	9
Mergui	702	24	37	14	15	10
Port Blair	504	42	45	7	5	1

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 1891.

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 ce	Per cent.	Per cent.	Per cent.
Aden	677	6·7	92	8	...	...
Kurrachee	703	9·7	85	14	1	...
Bhávnagar	688	31·8	43	24	17	16
Bombay { Apollo Bandar	705	14·5	73	21	5	1
Bombay { Prince's Dock	700	14·6	55	33	10	2
Cochin	697	3·2	91	9	...	...
Tuticorin	686	3·2	88	12	...	...
Cocanada	463	5·2	70	25	5	...
Kidderpore	690	11·7	40	30	16	14
Chittagong	553	13·5	24	20	27	29
Akyab	704	8·4	77	21	2	...
Rangoon	679	16·4	53	30	12	5
Moulmein	361	12·7	43	24	17	16
Mergui	697	18·1	60	29	9	2
Port Blair	507	6·6	93	7	...	...

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 1891.

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	663	6·7	94	6	...	...
Kurrachee	702	9·7	76	19	5	...
Bhávnagar	691	31·8	16	16	16	52
Bombay { Apollo Bandar	705	14·5	69	26	5	
Bombay { Prince's Dock	703	14·6	58	32	9	1
Cochin	695	3·2	89	11	...	...
Tuticorin	682	3·2	86	13	1	...
Cocanada	461	5·2	67	26	6	1
Kidderpore	686	11·7	47	30	14	9
Chittagong	551	13·5	45	30	14	11
Akyab	705	8·4	63	28	8	1
Rangoon	675	16·4	21	25	18	36
Moulmein	362	12·7	37	22	13	28
Mergui	702	18·1	43	24	19	14
Port Blair	504	6·6	93	7	...	...

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 1891.

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.	L. W.	H. W.	L. W.
Open Coast.							
Aden	6·7	10	11	·025	·025	2	2
Kurrachee	9·7	14	12	·026	·026	3	3
Bhávnagar	31·8	16	19	·018	·034	7	13
Bombay { Apollo Bandar	14·5	11	12	·017	·023	3	4
Bombay { Prince's Dock	14·6	9	12	·029	·023	5	4
Cochin	3·2	15	9	·052	·052	2	2
Tuticorin	3·2	10	10	·052	·052	2	2
Cocanada	5·2	7	7	·048	·048	3	3
Akyab	8·4	8	8	·030	·040	3	4
Mergui	18·1	10	15	·018	·028	4	6
Port Blair	6·6	8	8	·025	·025	2	2
General Mean		11	11	·031	·034		
Riverain.							
Kidderpore	11·7	14	15	·050	·043	7	6
Chittagong	13·5	13	17	·062	·043	10	7
Rangoon	16·4	14	13	·025	·056	5	11
Moulmein	12·7	11	12	·046	·066	7	10
General Mean		13	14	·046	·052		

The foregoing statements for the year 1891 may be summarised as follows:—

Percentage of Time predictions within 15 minutes of actuals.

	High water Per cent.	Low water Per cent.
11 Open coast stations	76	75
4 Riverain stations	68	62

Percentage of Height predictions within 8 inches of actuals.

	High water Per cent.	Low water Per cent.
11 Open coast stations	94	87
4 Riverain stations	66	64

Percentage of Height predictions agreeing with actuals within one-tenth of mean range at springs.

	High water Per cent.	Low water Per cent.
11 Open coast stations	97	96
4 Riverain stations	92	88

These figures are very satisfactory, and show a high standard of accuracy in the predictions taken as a whole. A comparison of the average errors of the past three years shows that the predictions for 1891 compare favourably with the exceptionally good predictions obtained in 1889.

Bench Marks.

During the year under report, 48 ordinary embedded bench marks, 425 inscribed or minor bench marks, 46 railway bench marks, 10 P. W. D. bench marks and 12 G. T. Survey stations 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 good condition without exception.

The height of embedded test bench mark at Perambur No. $\frac{2}{12}$ of Spirit Levelled Heights No. 1, Madras Presidency, mentioned at pp. xxxvii and xxxviii of the appendix to last year's General Report, was re-determined by spirit-levelling, and found to be greater by 0·05 feet than it was originally. The description of the restored bench mark was given in my letter No. 103, dated 18th January 1892, and it differs materially from the original description.

Levelling Operations.

The spirit-levelling operations of the last field season consisted of a continuous line of double levelling, which may be divided, for convenience, into the following sections :—

(*a*) Section from Malkhed Railway station along the Nagpur line of the Great Indian Peninsula Railway to Nagpur Railway station.

(*b*) Section from Nagpur Railway station along the Bengal-Nagpur Railway to Bilaspur Railway station.

(*c*) Section from Bilaspur Railway station along the Bengal-Nagpur Railway to Sakti Railway station.

The out-turn amounts to 452 miles of double levelling in the course of which the instrument was set up at 3,387 stations and the heights of 529 permanent bench marks and 12 stations of the Great Trigonometrical Survey were determined. This is a good out-turn and creditable to Mr. Bond, who conducted the operations, especially when the unfortunate circumstances under which he was working, and which are mentioned in the following extract from his report to me on his season's work, are taken into consideration. For the assistance afforded to him and his detachment our thanks are due to the Engineers of the Great Indian Peninsula and Bengal-Nagpur Railways.

The loss the Department has sustained by the death of Sub-Surveyor Narsing Das is regretted not only by all members of this party, but I am sure by many other members of the Department who, during his long service, have had the opportunity of appreciating his many excellencies, not only as a native gentleman of high character but as an able and energetic worker whose devotion to duty, always conspicuous, could not have been better exemplified than in the closing act of his honourable career.

In the Department "Notes" for May 1892 the following paragraph appeared :—

"The Surveyor-General regrets to announce the death, on the 5th April last, at Bilaspur, of Narsing Das, Sub-Surveyor of the Tidal and Levelling Party. Narsing Das joined the Survey Department on 1st May 1864, and rendered valuable service for nearly 27 years, during the greater portion of which he was employed in levelling conjointly with Captain (now Lieutenant-Colonel) Baird, R.E., Lieutenant Trotter, R.E., Captain Carter, R.E., Messrs. Lane, Donnelly, Belcham, Neuville, Rendell, Cusson, and Bond. His zeal and intelligence have been highly commended by the officers under whom he has served, and at the time of his death the question of his promotion to the Junior Division, on the recommendation of his executive officer, Lieutenant-Colonel J. Hill, R.E., was under consideration."

Extract from Report by Mr. J. Bond, *Extra Assistant Superintendent, 3rd grade, on the levelling operations executed by him.—Season 1891-92 :—*

The line of levels completed during the season may be divided into three sections :—

I. From Malkhed to Nagpur.—This section emanated from the embedded bench mark at Malkhed Railway station and was carried along the Nagpur line of the Great Indian Peninsula Railway to Nagpur, closing on an embedded bench mark at the Railway station. The length of this section, exclusive of 16 miles, of branch lines is 98 miles.

II. From Nagpur to Bilaspur.—This section started from the embedded bench mark at Nagpur Railway station, where the previous section closed, and was carried along the Bengal-Nagpur Railway *viâ* Raipur to Bilaspur, closing on the embedded bench mark at the Railway station. The length of this section, exclusive of 27 miles of branch lines, is 257 miles.

III. From Bilaspur to Sakti.—This section emanated from the embedded bench mark at the Railway station, and was carried along the Bengal-Nagpur Railway to Sakti, closing on the embedded bench mark at the Railway station. The length of this section, exclusive of 2 miles of branch lines, is 52 miles.

Branch lines were carried to all the large towns in the vicinity of the main line of levels, and several bench marks have been laid down at Amraoti, Nagpur, Kamptee, Raipur, and Bilaspur, all of which have been inscribed in the usual manner.

The levelling crossed three Principal Series of the Great Trigonometrical Survey, and connected the following stations. Badali H.S., Wirur H S, and Nachangaon H.S., of the Great Arc Series; Gorapur S, Khara H.S., and Sitapur H.S., of the Jabalpur Meridional Series; Lawa H S. common to both these series; and Raipur S., Bodri T.S., and Bilaspur S. of the Bilaspur Meridional Series.

Owing to the large differences of length of the hollow staves N_1, N_2 (determined the previous season from comparison with the 10-foot standard bar), you instructed me to make more frequent comparisons, and at Nagpur these staves were dispensed with and another solid pair, received from the Calcutta office, substituted. Comparisons were taken at the beginning and end of each of the above-mentioned sections, and it will be seen from the following table that the differences of length of both pairs from the 10-foot standard bar are much more accordant.

Results of comparison of staves.

Date of comparison.	Mean difference of length of pairs of staves from 10 feet.	
	Staves B and B^2.	Staves N and N^2.
At Amraoti, 31st October 1891	−·000380′	−·001443′
At Nagpur, 7th December 1891	−·001817′	−·005815′
		Staves B_3 and B_4.
At Nagpur, 13th December 1891	−·001545′	−·000453′
At Dongargarh, 14th February 1892	−·002088′	−·001208′
At Bilaspur, 8th April 1892	−·002490′	−·004118′
At Sakti, 30th April 1892	−·003578′	−·005246′

I append the usual tabular statement of the out-turn of levelling, also the following tables:—

Table A giving the Great Trigonometrical Survey Principal and Secondary Stations connected, and the errors of their heights as determined trigonometrically.

Table B, the Railway bench marks connected on the Bengal-Nagpur Line, with their errors.

Table C, the Public Works Department bench marks connected, and their errors.

The values of the bench marks connected on the Great Indian Peninsula Railway last season were not furnished by the company, and cannot therefore be compared with ours.

Tabular Statement of out-turn of work for the field season 1891-92, by the Levelling Detachment under Mr. J. Bond.

During the month of	Number of Miles Double Levelling.				Total Number of Feet.		Number of stations at which the instrument was set up.	Number of Bench Marks embedded, inscribed and connected.				
	Main Line.		Branch Line.		Rises.	Falls.		Ordinary embedded.	Inscribed.	G. T. Survey Stations.	Railway.	Public Works Department.
	Ms.	Chs.	Ms.	Chs.	ft.	ft.						
November 1891 . .	74	46·54	15	3·30	1,693	1,042	784	8	95	3	6	...
December ,, . .	49	53·04	14	40·90	1,072	692	521	6	61	2	7	9
January 1892 . .	58	6·70	3	73·31	1,529	443	461	8	55	1	7	...
February ,, . .	100	73·00	2	77·91	1,158	1,001	683	12	90	1	11	...
March ,, . .	71	17·70	3	46·50	555	600	504	9	74	2	9	1
April ,, . .	52	28·06	5	29·46	426	539	434	5	50	3	6	...
Totals .	406	65·04	45	31·38	6,433	4,317	3,387	48	425	12	46	10
Total Number of Miles Double Levelling.			452	16	Total of rises and falls.	10,750						

Table A.

List of Great Trigonometrical Survey Principal and Secondary Stations connected by spirit-levelling, Season 1891-92:—

Series.	Name of station.	Height in feet above Mean Sea Level.		Error of height by Triangulation in feet.	Remarks.
		By spirit-levelling.	By Triangulation.		
Great Arc.	Badali H. S. . .	1563·9	1567·5*	+4	Top of closing pillar.
	Wírúr H. S. . .	1190·9	1196·5*	+6	Do.
	Náchangaon H. S. .	1234	1227	—7	Mark stone.
	Láwá H. S. .	1314	1311	—3	Do.
Jabalpur Meridional.	Láwá H. S. .				
	Gordpur S. . .	974	973	—1	Do.
	Khara H. S. . .	2005 9	2003·5*	—2	Top of closing pillar.
	Sítápár H. S. . .	1241·9	1240·5*	—1	Do.
Biláspur ditto	Raijpur S. . .	999	1000	+1	Mark on roof.
	Bodri T. S. . .	947	942	—5	Top of pillar.
	Biláspur S. . .	859	853	—6	Upper mark stone.
	Gathaura T. S. . .	907	901	—6	Ground floor mark.
	Kotgarh S. . .	1008	999	—9	Top of circular pillar.

* Includes height of closing pillar = 3·5 feet.

Table B.

List of Railway Bench Marks on the Bengal-Nagpur Railway connected by the Survey of India Levelling Operations—Season 1891-92.

No.	Bench Marks.	Height above Mean Sea Level in Feet.		Error of Railway Levels in feet.
		By Survey of India Levelling Operations.	By Railway Levels.	
13	Rail at Kamptee Railway Station	938·75	935	—4
23	„ Salwa „	946·95	942	—5
35	„ Tharsa „	946·25	942	—4
44	„ Khat „	923·86	919	—5
81	„ Tirora „	908·38	905	—3
90	„ Gangejhari „	1,021·37	1,023	+2
102	„ Gondia „	1,021·07	1,017	—4
118	„ Amgaon „	1 020·00	1,016	—4
130	„ Salekasa „	1,052·51	1,049	—4
138	„ Darekasa „	1,238·19	1,234	—4
146	„ Bortalao „	1,320·41	1,316	—4
174	„ Nandgaon „	1,009·79	1,007	—3
184	„ Muripar „	1,026·07	1,022	—4
195	„ Drug „	964·83	962	—3
204	„ Bhilai „	998·59	995	—4
212	„ Kumhari „	935·60	931	—5
220	„ Raipur „	957·72	954	—4
229	„ Mandhar „	928·09	924	—4
237	„ Silyari „	910·34	906	—4
247	„ Tilda „	946·52	941	—6
255	„ Hathband „	921·50	918	—4
265	„ Bhatapara „	886·61	883	—4
277	„ Nipania „	847·89	844	—4
288	„ Belha „	876·56	872	—5
298	„ Bilaspur „	882·56	878 882·34	—4 —0
13	Rail at Paraghat Railway Station	873·14	870	—3
20	„ Akaltara „	919·73	917	—3
38	„ Champa „	851·95	848	—4
47	„ Baraduar „	839·31	835	—4
57	„ Sakti „	766·89	762	—5

Table C.

Comparisons of D. P. W. Bench Marks connected by Spirit levelling, Season 1891-92.

Number.	Bench Marks.	Heights above Mean Sea-Level in Feet.		Error of D. P. W Levels in feet
		By Survey of India Levelling Operations.	By D. P. W. Levels.	
3/1	G. T. S. B. ⩚ M. At Nagpur, General Post Office	1,025·13	1,020·56	—4·57
5/1	G. T. S. B. M. At Nagpur, Obelisk near old Residency	1,019·79	1,015·27	—4·52
6/1	G. T. S. B. ⩚ M. No. 48 At Nagpur, Museum	1,006·91	1,002·32	—4·59
7/1	G. T. S.. B. ⩚ M. No. 20 At Nagpur, Protestant Church	1,650·61	1,046·12	—4·49
8/1	G. T. S. B. ⩚ M. No. 16. At Nagpur, District Court	1,019·39	1,014·92	—4·47

Comparisons of D. P. W. Bench Marks connected by Spirit levelling, Season 1891-92—contd.

Number.	Bench marks.	Heights above Mean Sea-level in feet.		Error of D. P. W. Levels in feet.
		By Survey of India Levelling Operations.	By D P. W. Levels.	
$\frac{2}{14}$	G. T. S. B. ⩚ M. 1014·00. At Kamptee, Sadar Bazar	938·27	1,014·00	+57·73
$\frac{8}{14}$	G. T. S. B. ⩚ M. 990·06 At Kamptee, Vegetable Market	914·02	990·06	+76·04
$\frac{7}{14}$	G. T. S. $\frac{\Psi}{o}$ B. M. At Kamptee, Travellers' Bungalow . . .	923·37	...	...
$\frac{11}{222}$	$\frac{098·76}{⩚}$ At Raipur, well in Public Gardens	999·67	998·76	—0·91
	$\frac{870·3}{⩚}$ At Bilaspur, Obelisk, 0·5 foot above Bench mark No. $\frac{3}{300}$.	872·2	870·3	—1·9

UPPER BURMA.

The Bret Country.

Notes on the part of the "Bret" Country, *south-west of* Karenni, *visited in January 1892 by* Captain H. M. Jackson, R.E., *in charge No. 11 Party.*

The portion of the Bret country to which these notes refer lies in the valley of the Tuchaung (*Karen*, Kanpreu or Preu-law) as far south as its eastern bend, towards its junction with the Nam Pawn (Ponchaung). The Brets extend a good deal south of this; but my other work did not allow of further explorations in this direction. A high well-defined range is the recognised boundary between the Bret country and Karenni.

The Brets are very much like other Karens in appearance, customs, habits, religion, dress, and dwellings. Their language is probably an old dialect that has remained unchanged owing to the isolation of the people in a somewhat inaccessible valley, through which there are only two trade routes, and those difficult and little used. The people on the eastern side of the valley have mixed a good deal with the Karenni, and their language has become slightly assimilated to that of their neighbours; those on the western side of the valley, however, speak a dialect which is apparently understood by the Karenni or by the Karens proper from the lower hills, or by the Padaung Karens from the north, or even by Brets from the eastern side of the valley. I had men of all these races with me, so I had good opportunity of judging. In one or two of the western villages, none of these could make themselves understood without great difficulty. I should imagine that the reason is this. The tribe or tribes of which the Brets are the remnant have been gradually driven westwards by the Karenni, to whom they are probably more akin than to the Karen Byu. Thus, those furthest west retain unaltered more of their original language, and this from fundamental difference or want of time has not yet been much affected by the language of the people they have now come into contact with. Possibly the western and eastern Brets may be remnants of different tribes who have come into the valley at different times, but there are no other differences apparent sufficient to support this idea.

In other respects the Brets apparently differ little from other Karens. The men all wear the cane garters peculiar to so many hill tribes from the Nagas southwards. Their burial places would denote a different origin from the Karenni: the latter invariably place a boat-shaped structure over the grave. The Brets place covered conical baskets containing provisions for the last journey: the men all carry spears,—heavy game spears, not the light javelins of the Karenni. There are a few Karenni cheek pieces (*bagas*) in each village and a very few very old muskets. From the scarcity of wild animals I should think that a good deal of hunting is carried on. The dogs, a small short-legged breed, are very clever at "driving" deer. Until lately, feuds between the different villages were apparently common; but the Bret is by no means the ferocious person he has been depicted. He is only a little wild, having comparatively recently passed from the hunting to the agricultural stage; and occasionally, as the country is difficult of cultivation, there being no open valleys, he gets tired of agriculture, or possibly hungry and goes on the

war path. Perhaps, only his neighbours suffer and retaliate, or perhaps, a Shan or Karen bullock caravan falls in his way and has to pay black mail, and so the Bret gets a bad name. It would take very little to keep these people in order. At present they have no real government or social system of any kind. There is generally a so-called head man in a big village; but he has not much authority as a rule. The American Baptist Mission has sent Burmese or Karen "teachers" into many of the Bret villages, and these men seem to have a good deal of influence.

The chief cultivation is rice, mostly in Taung-yas. Judging from the number of store-houses round each village a good deal is grown, but it is difficult to purchase even small quantities without giving notice, as they only husk enough for the daily consumption. Besides rice, maize (Hindi, *jawari;* Burmese, *pyaung-li gauk*) is grown, and a little cotton and tobacco; climbing peas (*pe-byu*) and pumpkins are plentiful. The tobacco is mostly worked by Karennis (from "Pobya") who bring their own elephants, as the Brets do not possess any of these animals. There is a good deal of teak in the valley of the Tu-chaung: I saw many small trees ringed, which would seem to show that the best have been cut; I certainly did not see any of any size.

Cotton is spun and woven into clothes in most of the villages. For iron working, the usual double bamboo bellows forge is used. In such a country, wood-cutting *dahs* and axes are the most important of a man's possessions. In one village, Kahbi, rough pots, etc., are made of a dark clay containing numerous particles of a yellow metallic substance, probably not gold, but I have not had an opportunity yet of having my specimens analysed.

Few domestic animals except pigs and fowls, of which there are plenty, are kept, except at one village, Kreuko, which possesses about 50 head of cattle. With the exception of one small grass *kwin* near Taiku, there is no open country in the valley: it is mostly heavy jungle, except where it has been cleared for cultivation.

The only bullock road through the part of the Bret country visited is that shown on the map; this had not been used for three years, on account of the practice of the villagers of Taiku, Kreuko, Kahbi, etc., of levying black mail and stealing stray bullocks. I had the Yadu branch opened up and improved; and I think that very likely it will become a small trade route in time, as Yadu is capable of any amount of development. The other means of communication are tracks which even the Burman pony cannot traverse. Those not in constant use are thickly overgrown with long grass and bamboos. Dr. Johnson of the American Baptist Mission has had several tracks cut from village to village of his parishioners in the western Bret. South of the part of the country I visited, a bullock trade route crosses from Bawgale in Toungoo to Bawlakhé in Karenni; by means of this I hope to complete the survey of the country next season.

I met with no opposition in going through the country, nor experienced unpleasantness of any kind. This was due in great part, I think, to my being accompanied by the *thugyi* of Yadu, who knows and is known by the northern Brets. I had twelve men of the Karen levy with me, but except to help in keeping together the coolies (these were Brets from Taiku, Padaung and Yadu, and quite the best coolies I have ever had south of the Himalayas), I think there was really little necessity for any escort at all. At only one village did the people run away on our approach; and they were soon persuaded to return by my *cicerone*, the Yadu *thugyi*. I could never quite discover whether this was a little exhibition got up for his own glorification by the latter gentleman, or whether, as he stated, the villagers of Kreuko had bad consciences; I am inclined to think the former, as he seemed so very pleased with himself about it.

HUKONG VALLEY.

Extract from a Report by MR. J. M. KENNEDY, *Sub-Assistant Superintendent, 1st grade, on his Survey Operations with the* MAINGKWAN COLUMN, *Season 1891-92.*

Having received orders to accompany the Maingkwan column, proceeding from Mogaung into the Hukong valley, I arrived at Bhamo, accompanied by Surveyor Faida Ali, on the 25th November 1891, and after spending a few days there in making the necessary arrangements, I left for Mogaung, *viâ* Sinbo, on the 30th, and was engaged during the march in triangulation. On the 8th December, while at Sinbo, when a halt was made to await the arrival of the last detachment of troops for the column, I sent back my police escort to Bhamo. The detachment arrived on the 12th and with it we left on the 15th for Mogaung, where, on the 19th, we joined the Europeans who had preceded us two or three days, and the whole force moved out next day to begin the work of the season.

On the day previous I had, by turning off on the last march into Mogaung, observed at Umantaung hill station, a small steep hill a mile off the road at about 3 miles out of Mogaung. The hill top when I ascended it was so much overgrown with grass and brushwood, which could not be cleared for want of time, that the instrument had to be placed in a very unsteady position high up on one of the small pillars at the corners of the pagoda. This was the last station I was able to observe at, and, except when, later on, I left the column for short excursions around Maingkwan, I had no other opportunity of going 20 yards off the track of the column, where every man was assigned a definite place, which, moving or halting, he was obliged to keep.

From Mogaung the column moved by the road running north-west, 6 or 7 miles east of the Namkong Chaung between a small isolated block of hills and the larger mass of the Shwedaungyi ranges. On the second day's march the whole of the baggage and provision train failed to follow the route taken by the troops, who therefore camped out that night without proper food or shelter.

The column struck the Namkong again on the 23rd at a mile and a half above Kamaing and halted there a day: after three days' more marching, with another halt of four days at Hwélon to get up stores, we reached Laban on the 31st December. Another stay was made at Laban, during which observations for latitude were taken to check the route traverse. From Laban two raids were made on different days on the hill village of Nakum, supposed to be harbouring some murderers. I went out with the first party, traversing 18 miles of ground, to obtain 3 miles of new work. From Laban the sub-surveyor accompanying me had to be sent back, as he was declared by the medical officer with the column to be unfit for field work. Laban, which we were given to understand was a place of some importance, is a mere hamlet of two or three houses; and "old Laban," so marked on former maps, appears to have no existence. A site for a police stockade was cleared close by the village.

Leaving Laban on the 6th January the column marched to Sadusot, a tolerably large village; then by a long march reached the Tinkauk stream, passing over the watershed and out into the Hukong valley; another long march brought us to Palawbum, or Walawbum, called also Ponkaw, a large and thriving village on the west bank of the Nampyet. On the 9th, we marched to Maingkwan; the first three-quarters of the way by a good track, the remainder being, like all the paths immediately around Maingkwan, bad.

Maingkwan, or Meungkham, the golden city, an isolated Shan settlement, is said to have been (at sometime, doubtless rather remote) a town of 7,000 houses; it was, according to local report, a tolerably large place so late as 8 or 10 years ago consisting then of some 150 houses; but, owing chiefly to the continuous raids of the surrounding hill tribes, it has since that time been reduced to an insignificant village of 27 houses. A dreary decayed appearance it now presents, no trace remaining of its former prosperity; the site even, of the old town, if such existed, being undiscoverable.

On the 10th and 11th January, I measured a base-line in the large fields about Maingkwan, and attempted some observations to fix the relative positions of the hills bounding the Hukong valley, but the weather was unfavourable throughout the stay of the column, and nothing very satisfactory in this way could be done. Latitude was observed and verified. On the 12th the amber mines on the small hills, four or five miles south, were visited. The average depth of the shafts is 10 or 12 feet, the deepest being 22 feet; these shafts are cut straight down and are about a foot and a half square—a convenient width to allow the digger to ascend and descend by planting his shoulders against one side of the shaft, and his feet in holes cut in the clay on the opposite side. Independent test-workings were executed by an officer of the Geological Survey, Dr. F. Noetling, who discovered nothing valuable here; this field had probably been long abandoned, and the larger and more profitable workings were afterwards reported to be further south on the same small range of hills near the village of Lalaung.

From Maingkwan, while the Political Officer was receiving deputations from the surrounding villages, I made independent excursions into the country round about, surveying up to the Tanaika river. The river at Mashi, where I first touched it, is about 150 yards wide, the south bank 20 feet high with deep water under, the opposite bank shelving with sands half way out into the bed of the river.

On the 14th January, the N. W. column, under Mr. Needham from Assam, arrived at Maingkwan. No surveyor accompanied this detachment, so that nothing but a line of route traverse had been done, and this on a very large scale. Of this work, for which I am indebted to Mr. Needham, a copy, reduced to the scale of the reconnaissance maps, will be made and submitted with my field sheets.

I accompanied a small detachment of the column on the 16th and 17th to Lalaung, a large village, a day's journey south of Maingkwan; here we were not welcomed with open arms, the head man appearing to be very ill-disposed towards us. We returned next day by a long circuitous march north-east along the Nampyu, falling into our old route at Pan and Sat, and so back to Maingkwan.

On the 20th, another detachment from the main column proceeded to examine the country to the north. Marching back along the Palawbum road to Naungku, we then turned northwards, camping the first day on the Tanaika or Chindwin at Salaw, thence to Makaw on the Tawan, a smaller river than the Tanaika; in two more marches we arrived at 'Ntup'nsa (observed latitude 26° 41'), the most northerly point the column reached. 'Ntup'nsa is a village of some importance, being the chief centre of the rubber trade in the valley, a trade which gives employment to a number of apparently wealthy Chinese whom we found here. We halted on the 24th and left next morning after a display of our small military force for the amusement (combined with instruction) of the chief of the village.

From 'Ntup'nsa, crossing and re-crossing the Nampraw Chaung, we marched to Kum and thence to Ningbyen, passing, at the junction of the Saksai and Taron rivers, the small stockaded village of Tabong, probably the "Dubong" of the old maps. At Ningbyen, which is a village of considerable size, there is a colony of Gurkhas, who have wandered

down here with the expectation of making a speedy fortune by collecting india-rubber; these pioneers of industry are now tied down, settlers per force, being indebted to the Kachins for advances of money and grain supplied them, which advances they are now unable to repay. The men and women are well fed and clad, however, and seem tolerably contented.

From Ningbyen, in company with the Political Officer, I made an excursion to Saraw, a stockaded village in a small rise overlooking a long reach of the Taron river, and giving a good view of the hills to the north. There is a long standing feud between this village and Palawbum, the Palawbum men having attacked and burned Saraw two years ago. We returned to Maingkwan, touching the Tawan river at Taraing, and crossing the Tanaika at Mashi; and, halting here a day or two, again started through Palawbum to 'Nbon, the most easterly village visited in the Hukong valley. The route from 'Ntup'nsa to 'Nbon having been surveyed by a military surveyor detached when we were at the former place, we turned westwards along the Tanaika, and, striking into one of the old routes at Salaw, returned to Maingkwan.

On the 13th February, the column left Maingkwan in two detachments; one accompanied by the military surveyor, Gunga Ram, returning by Laban to Fort O'Donnell, the other party which I accompanied starting in a north and north-westerly direction, following the course of the Chindwin into the Taro valley, which is separated by a single range of low hills from the Hukong valley. The marches between Kantao and Tagum were very trying, there being in most parts only the merest trace of a path, and on the river bank no track whatever. The soft clay bank covered with *kaing* grass, and broken with deep fissures, almost impassable for mules, made the progress of the column, even with the help of an advanced working party, very slow; the baggage at nightfall was here sometimes scattered along two or three miles, and the men who secured either bedding or food were fortunate.

Proceeding out of the Taro valley for three days after leaving Tagum we passed no villages, though small clearings were found in the hills. The troubles of the transport department ended here, for though the ascents and descents were steep, and fodder for the animals was not always procurable at night, we were now on a well-beaten track. At two or three days journey north of the Jade mines the country begins to be populated again, though the few villages passed through, with the exception of Pala, have a poverty-stricken air, occupants of these appearing to be chiefly old men and children; the able-bodied men are at this season at work at the Jade mines. No stay was made at the mines. An account of them has already been given by Captain P. J. Gordon in his report for 1890-91.

The important villages in the Hukong valley are 'Ntup'nsa, the centre of the rubber trade, Ningbyen with its Gurkha settlement, Saraw, Palawbum, and Lalaung on the hills, above which the larger amber mines are said to be. The chief products are india-rubber, jade, amber, ivory, and opium.

TIBET AND WESTERN CHINA.

Report by COLONEL T. H. HOLDICH, R.E., *in charge Simla Drawing Office, on the Route Survey executed by* ATMA RAM, *in company with* CAPTAIN BOWER, *in* TIBET AND WESTERN CHINA, *in 1891-92.*

INTRODUCTION.

Atma Ram, the author of the following notes on his journey from Changthang, eastwards to Ta-Chen-Lu on the confines of China, is a young man of about 24 years of age, who joined the Simla Drawing Office of the Survey of India Department on the 1st November 1890, as writer, and continued in that capacity until April of the following year when he volunteered to accompany Captain H. Bower, in trans-Himalayan explorations of little known regions.

This is what Captain Bower says of him:—

"I have the highest opinion of Atma Ram's powers of physical endurance in marching and camping out at high altitudes, and have nothing but praise for the excellent manner in which he conducted himself throughout the trying times he had in Tibet. He was as willing to lend a hand in loading our baggage animals, as he was untiring in keeping up the excellent record of the traverse survey. Nor was he less conspicuous in his willingness to shoulder a rifle, and I have no doubt that had it been necessary, he would not have flinched, at any critical moment, to have also used the weapon with good effect."

Atma Ram had been taught the use of the prismatic compass in the Forest Training School, at Dehra, where he had been a pupil for a short time; and though his knowledge of surveying was very slender and confined to the use of that one instrument, yet his natural quickness of adaptation and ability enabled him to employ that little knowledge with very good results. He has already shown himself to be a careful, steady and painstaking observer, and he will doubtless prove as resourceful a surveyor with the plane table, in any future explorations he may have the good fortune to undertake, as he is with the compass.

It may, perhaps, be due to the inhospitable region through which he traversed, on his journey in Tibet, that his narrative contains so few incidents of travel, or it may be due to his inexperience, that we have not more ample details of the manners, customs and

ways of the people he came across; but it is probable that had he recorded his notes in his own vernacular, in place of employing the medium of English, he could have given us the result of his observations more fully than his limited knowledge of English permitted.

The experience he has now gained, will, no doubt, serve him well in any future work of this kind, and will justify the expectations which have been formed from this first attempt to survey in such an elevated region as Eastern Tibet; where the frost and cold for lengthened periods are so intense and the marches so laborious and wearisome, that they might well frustrate the successful accomplishment of an unbroken traverse of over 2,000 miles in length, stretching across no less than 24 degrees of longitude.

This, however, was what he accomplished, and the following are his notes on the journey.

Notes on a Journey from LANAK PASS *in* CHANGTHANG *to the* WESTERN FRONTIER OF CHINA, *through* TIBET, *by* ATMA RAM.

We started from Lanak plain (in Changthang), which is surrounded by low hills and where we found the water frozen every where, on the 3rd July 1891, and reached Shum the same afternoon, after crossing the low pass of Lanak and entering a plain in which Shum is located.

On the day following we crossed over another pass, elevated about 18,000 feet above sea level; then crossing several streams we arrived at a place called Tobomarpo, situated in a plain. We next marched along a stream and through a plain to Kalung, situated to the south of a salt lake, a place where the wind always blows strongly. A little snow fell this day. Up to this place we experienced no want of grass, which was growing everywhere, but no fuel could be obtained here, and we were obliged to use *argol*, or the dried droppings of animals, for burning purposes.

Our next march on the 6th, through a sandy tract, took us in a north-easterly direction, to a very beautiful spot known as Papuk, which is situated near the Mangtza Chho lake and surrounded by very fine scenery. We here found a low dry shrub, called *burche*, which we used as fuel. After halting on the 7th at Papuk, we marched on the day following to Khangmar, situated to the south of the Mangtza Chho lake and near a hot spring. We marched on the two succeeding days to Sammar and to Chorimar, the latter situated on the western shore of the Horpa Chho lake. On this last march we noticed that antelope abounded. On the 11th we skirted the shore of the above mentioned lake and camped to the south of it, at an elevation of about 18,020 feet, and then on the 12th after following an easterly bearing for some miles, we altered our direction to the south-east, to a place called Cholong.

Our next march took us over a pass elevated about 18,520 feet above sea level, to Tangnek, a place situated near the north-western shore of the large lake of Charol Chho, where we found fuel very scarce and the wind blowing very high. On the 15th we travelled along the northern shore of the lake and camped at Chamit Charol, where we found plenty of grass. Next day to Khamba Thoksa, where Captain Bower took observations for latitude, and on the day following we made a short march to Khambul, where for the first time on this side of the Lanak Pass, we saw nomad encampments, and engaged men as guides. From Khambul we marched to Rarupka, situated near a small stream, and the next day, after ascending a comparatively easy pass, we encamped at Gakchi, situated at the foot of another pass, which we crossed the day after, the 20th July, and then followed on to Aru, near the western shore of a large lake called Aru Chho, elevated about 17,100 feet above sea level. At all these places water was plentiful and good, but wood for burning was scarce, and we had to resort to *argol* for fuel.

Our next march lay through an extensive grassy plain, on which a great variety of flowering plants seemed to flourish, and where the wild yak and numerous antelope roamed about freely, and we camped at a place called Arurapka, situated at the foot of snow mountains. On the following day, the 22nd, we journeyed due east, leaving the Aru Chho and another smaller lake on either side of the route, to a pass which we ascended, and camped near, for the night. A tarn, containing a little dirty water, supplied our wants in this line, and we found *argol* for burning. A road leads off from this place towards Lhasa.

On the 25th July, we reached a very fine spot, situated in a wide open valley, after having passed *en route* some lakes and a spring of water. During these last three marches we found plenty of water, but fuel was scarce. After a halt at the last camp, owing to a fall of snow, we continued our march in a south-easterly direction, camping in a wide valley on two successive nights, and after crossing a low watershed, we reached a spot at the foot of some hills where, in consequence of our baggage animals having strayed, we stopped till the 3rd August. During these marches fuel and woter never failed us, but we were not a little inconvenienced by repeated falls of snow. Our elevation here was about 17,080 feet above sea level. Several of our baggage animals were lost and we had to do the best we could without them. At this place Captain Bower took observations for latitude. On the 4th August we broke up camp and continuing in a south-easterly direction, we arrived at a spot near a stream which empties itself into a lake to the north-east, having camped mid-way on the previous night. We found the tract we had traversed to be a waterless one, but here we discovered water and a little green grass

to cheer us, and the dry droppings of animals supplied us with fuel for burning. We halted here on the 6th to recover our baggage animals, which had again strayed away. Another long march on the 7th through a grassy valley, brought us to a spot near a stream which empties itself into the lake mentioned above. We were in much want of something to burn at this place and to add to our discomforts, a storm broke over our heads, and deluged our camp. Captain Bower observed for latitude here, which we ascertained to be in elevation about 16,080 feet.

Five marches, varying in length, on a south-easterly bearing, crossing two elevated passes and passing lakes on either side of our route, brought us to a spot in an open valley, where Captain Bower again observed for latitude on the 13th August. On these marches we found water and fuel plentiful, while there was no want of excitement afforded us in the pursuit of game, which abounds in this tract. Yaks, antelope and ducks were seen in large numbers. Traces of men were also noticed.

On the 17th August, after having made four additional marches, through low hills, over two passes, crossing streams and passing a few lakes, we reached a nameless spot in a plain, which we found by observations to be elevated about 16,650 feet; this also was a latitude station. Everywhere on these marches water was plentiful and there was fortunately no want of fuel. Leaving our last camp on the 18th we marched for five days over passes elevated above 17,000 feet, encamped near streams, passed lakes, and on the 22nd we stopped near a small lake where Captain Bower observed for latitude. On this tract we found water everywhere, and fuel was forthcoming in sufficient quantity for our wants. Here we had evidence of men having been before us. The elevation of this camp we found to be about 15,550 feet.

On the 23rd we made a short march, of about 6 miles, to a place near a small stream, where we found sufficient grass for our wants, but fuel was scarce. Here we halted the next day, because we heard that some Champa people were encamped in the neighbourhood, from whom we wanted information, regarding the country, etc. We were not well received by them, however, their jealousy and suspicion having evidently been aroused.

On the 26th we came across a party of Dokpa people who were grazing their cattle, and they obligingly sold us *satu*, salt and sheep. These men wore big hats as a protection from the sun. On the day following, we made a very short march of about 4 miles, to a spot called Sira Nagmo. Two marches more brought us to a place called Zita, situated near a stream, in a plain, after having crossed a pretty considerable stream flowing northwards to a large lake called Chuksi Chho, and said to have a circumference so large, as to occupy a man seven days in walking round. There was no want of grass in this track, but fuel was scarce. The elevation of Zita we found to be about 14,620 feet.

On the 30th August, after crossing two low passes, we arrived at Ratha, a place situated on a small stream which empties itself into a lake to the south. Whilst we were camped here, a party of mounted Dokpas insolently addressed us, forbidding us to leave the spot, till orders were received from higher authority, concerning us. They were soon made aware that their instructions were not going to be complied with. The country we had now traversed, from the Lanak Pass, was treeless, though in places we found a dry bush called *burche*, which we used whenever we could, as fuel, but *argol*, chiefly of the yak and antelope, we found in sufficient quantity to use as fuel. I do not remember seeing any birds throughout this tract, which is known as the Chang. Five marches of varying lengths, from Ratha, over passes, crossing minor streams, through valleys, and skirting lakes, brought us to a spot known as Sitong, where we camped; this was one of Captain Bower's latitude stations. Throughout these five marches, we received decided opposition from the Dokpas, who inhabit these parts, living in tents made of black wool. These men did all in their power, short of physical force, to dissuade us from travelling towards Lhasa, where they sent men to inform the authorities of our approach. Sitong is situated near a stream that flows into the large lake, called Naksung Satu. Several hot sulphur springs exist in this locality, which is elevated about 15,520 feet above the level of the sea. Robbers roam about these parts.

Two more very long and fatiguing marches, skirting the southern shore of the Naksung Satu and Garing Chho lakes, brought us to a place known as Gagalinchin, elevated about 15,560 feet. These two names, Naksung Satu and Garing Chho, are given to the western and eastern halves of one very large salt lake. It is said to be twelve days' march round it. We reached this place, Gagalinchin, on the 7th September, and owing to the determined opposition we received, it was agreed that we should stay here till orders were received from Lhasa. Those orders came shortly and finally stopped the continuation of our march in the direction of Lhasa, so we were obliged to abandon that project, and retracing our steps on the 4th October, we reached Lama-karmo on the 9th, a place situated on the route we had traversed. During our detention at Gagalinchin, we experienced falls of snow on several occasions. Lama-karm, the place we reached on the 9th October, is near the south-west corner of the Chargat Chho lake, from whence we could see snow mountains, lying both to north as well as south. Here we stayed on the 11th and following day, to replenish our stock of provisions.

The next day we marched northwards, along the western shore of the Chargat Chho lake, to Uruni. A curious white rock, called Shamo Atsag Jamo (Shamo's helmet) stands clear out of the water of this lake, near Uruni. I may here explain that Shamo is traditionally said to be one of the ancient warriors of these people.

Our next three marches were in a northerly direction, to Moga Pishor, situated in an

extensive plain, thence to Hormo Sachuk at the foot of a pass, which we crossed, and then to a spot on a small stream which flows into the Chajing Chho lake. In this tract we came across Champa encampments, for grass was growing luxuriantly every where. Pursuing still a northerly bearing, we camped on the 17th, at Taglagapo, passing *en route* two *manephanes*, or piles of stones, having the religious formula of the Tibetans, "om mane padmi om," engraved on them. The next day we crossed a very high snow range at an elevation of about 18,760 feet, and descended to Mugatip, where we camped.

Leaving our last camping ground on the 19th we travelled on to Zokh, passing *en route* a very remarkable rock. We then pushed on through an extensive plain to Potocho, where we camped and halted the next day, owing to our baggage animals having strayed away over night. On the 22nd October we left Potocho and marched to Ten Kum Song, passing some lakes and several caves, which afford shelter to travellers; and then on the day following we ascended a pass, and crossing, descended to Iring-khade, where we camped for the night. The next day we marched through a wide open valley or grassy plain to Khokhung Chhaka, elevated about 15,860 feet above sea level, and almost entirely surrounded by very high snow mountains. Up to this place we had travelled almost due north from Lamakarmo, but now we were to pursue a due easterly bearing.

Our next eight marches were uneventful, and were one and all, in a due easterly direction from Khokhung Chhaka. At first we marched through a grassy plain to Shegar Khung Long, and then crossing a rather elevated pass, about 17,700 feet above sea level, we camped at Shegar Shar Long, leaving a lake on our right hand. We then skirted the Tau Chho lake, and halted for the night at Pading. The following morning we skirted another lake, then ascended a pass, and camped for the night at Kong Thong. Pursuing our journey the next day, we traversed a plain, crossed a pass, and camped for the night at Singi Opo. The following day we camped at Ghagasar, passing *en route* several small streams, which drain into a lake, and then marched to Yagmo and Nazu Zir, where Captain Bower took observations for latitude. In the neighbourhood of Yagmo there exists a rather large salt lake, around which herds of yaks graze, attracted no doubt by the salt licks, which are known to be in the locality. All the surrounding population carry away salt from the mines that exist near Yagmo, which is elevated about 16,110 feet above sea level. Nazu Zir is surrounded by low hills. We never felt any want of grass for our animals throughout this tract of country, and we were fortunate enough to secure sufficient *argol* for burning purposes. It is evident that this has been a well known route, for on the top of the pass near Shegar Khung Long we observed a *manephane*, or pile of stones, with "om mane padmi om" engraved on them.

On the 5th November we marched to Khurlu Mata, situated on a small stream, and on the following day we crossed a pass, and entering a wide valley, we camped on a stream flowing to the east. Many snow peaks were visible on this march. The next day we followed the same stream on which we last camped, passing on either hand, low red coloured hills. During the last three marches we felt no want of grass or *argol*.

Three marches more, after crossing several passes, and hearing of nomad encampments in the neighbourhood of our route, we arrived at a place called Bongro, elevated about 15,380 feet above sea level, and where we learnt that bears were to be found. Grass on these marches is abundant. On the 15th November, after making four marches of varying lengths, we reached a place called Garthe, situated on a stream which flows into the Chonak Chho lake. On these marches we crossed several passes and streams, and came across Dokpa encampments. We halted at Garthe on the 16th in order to purchase, if possible, some yaks for transport purposes.

On the 17th we made a rather long march, and on the 18th we reached Khokink, near which place there were Dokpa encampments. These Dokpas are subjects of China. On the 19th we marched to Data Cho and on the 20th we camped at Pongro, which is surrounded by hills, after passing several *manephanes*, or piles of stones. On the 21st after crossing a pass, we arrived at Atak-Memar, passing *en route*, Kozong and Sharuring, two places which were occupied by Dokpas. On the 22nd we reached Shathama Chichong. It was on this march that we crossed the route taken by A-K., when he travelled from Lhasa to Saitu, during 1879-82. The elevation of Shathama Chichong is about 14,320 feet above sea level.

Six additional marches, some of which were very long, took us to a place called Pongra, where Captain Bower observed for latitude. On these marches we ascended passes, crossed streams, saw many snow peaks around us, and encountered several Dokpa encampments and passed *manephanes;* but besides a fall or two of snow, no particular adventure occurred. We found the elevation of this place to be about 14,920 feet. After making a day's halt at Pongra, we made a long march to a place situated in the midst of hills, from where snow peaks were visible. Here we noticed forests of pine on the hills adjoining our route, as well as several nomad encampments. We learnt also of the existence of bears, jackals and pigeons in this locality.

On the 1st December, we made a short march to a place near Tsuk-Sun-Dong-Gong Gomba, or monastery, where two high officials, called Yong and Lama, respectively, reside. Here we found well built wooden, painted houses, and each house displaying a flag at the end of a long pine pole. Four important roads meet at Tsuk-Sun-Dong-Gong, which contains about 500 houses and is evidently a place of some importance, from all that I could find out, and plays its part in the government of the surrounding country. Two marches more brought us to Nirchumgi sarai, where Captain Bower took observations for latitude.

On the 4th December we marched to Pongmar Thong, situated on the Ircho river, and on the 5th another march took us to Longonpho, after crossing numerous streams, and a pass elevated about 15,000 feet above sea level. After a halt of a day at our last camp, we marched to Yangmando, situated near the Zichu river, passing several encampments. This place is under Chinese rule. Another long march, on the 8th, took us to the large village of Richando, where we saw patches of cultivation. This place is about 13,220 feet above sea, and is situated at the foot of a small hill near the Thomcho river.

On the 9th December we made another long and very trying march to Pata Samdo sarai, near a stream and surrounded by hills. We crossed several passes and streams on this march. Here again Captain Bower took observations, and from here many snow peaks were visible on all sides of our camp. On the 10th we halted at Pata Samdo, and on the day following, we marched to Malanzi, situated at the foot of a red coloured hill, near a stream, crossing the Ma La pass and several streams. Not many encampments existed on this march. On the 12th we journeyed to Vanzomda, near Sari Samdu, situated on a stream which flows into the Sachu river, which latter is bridged. We noticed patches of cultivation, for wheat, barley and vegetables are what the people cultivate in this part of the country. A place called Chanba Gomba lies a little lower down the Sachu river.

Our next march was to Jogor Thong, a latitude station. Several villages were passed *en route*. Here we halted on the 14th, owing to the desertion of our guides. The day following, we reached the large village of Tashi Ling Gomba, containing about 700 houses, and situated near a stream, which empties itself into the Chimchu river. We passed numerous habitations and the tract appears to have a pretty considerable population. The elevation of this place is about 12,820 feet.

On the 16th we made a very long march to Khemo Tinchin, situated on the Komcho river, where we found a large population, in a place containing about 500 houses. Wheat is cultivated in this locality. Our next march was a short one, to Khembo Nar, through a thickly populated tract, and on the following day, we resumed our route to Khembo Chahu. The inhabitants along this march are thievish by custom and impudent in manner. On the 19th we marched to Khemoyok, situated on a stream which flows into the Barazonchu river, and on the day following we reached Maru, the residence of a Lama, situated near a wooden bridge over the Tasichu river, and near a *manephane*, where Captain Bower took observations for latitude. The country on this march was well populated. We had warning given to us that this place was noted for thieves, and that they intended to rob us. In consequence of this warning, we prepared to receive them, but the night passed uneventfully. There are two religious sects amongst this people, one called Pandi and the other Ponbe.

Four more marches, after ascending several passes, crossing numerous streams and passing through pine forests, and a thickly populated country, brought us to Poshi Thong, situated on the Zichu river and in a valley surrounded by pine forests. On the last of these four marches, we passed Rinchi monastery, a place of considerable size and importance. In the forest we passed *en route*, musk deer and pheasants are to be found. After halting one day at Poshi Thong, we made a very long march to Rocham Thang, situated on the Zichu river. On this march we passed some iron mines. The elevation of this place is about 12,500 feet.

Four more marches of varying lengths, brought us to Guru, where we arrived on the 30th December. Several villages were passed, and at some of our halting places, the people asked us to show our passport. The Zichu river, along which our first two marches ran, is bridged in several places. The hills on either side of our route were covered with forests of pine, including both the *longifolia* and *excelsa* species. Several officials approached Captain Bower at Guru, and asked us many questions regarding our intentions, and enquiring if we possessed a passport to travel in these parts. These men tried to intimidate us and attempted to prevent us from journeying onwards to Chiamdo, saying that no Englishman had travelled here before. The elevation of this place we found to be about 11,100 feet.

On the 31st December, we marched to a place called Epwa, situated a few miles beyond the City of Chiamdo, which latter is a centre of great importance. It is densely inhabited and possesses several fine *gombas* or temples. Chiamdo is situated at the junction of the Namchu river and a stream that flows from the west. At Epwa, Captain Bower took observations for latitude, and fixed its elevation at about 11,840 feet. We halted at Epwa on the 1st January 1892, and on the following day made a long march to Pandesar, in which there is a house set aside for the accommodation of Chinese officials travelling between China and Lhasa. Barley and wheat are cultivated at this place. On this march we passed a pine forest. The elevation of Pandesar is about 12,720 feet. Six marches of varying lengths, some long and wearisome, through a well populated tract, brought us to Garing Doba, where Captain Bower took observations for latitude. This place is a part of the country where the people are independent of both China and Tibet. On these marches we ascended several passes and crossed numerous streams, and saw forests of pine on either side of our route. This part of the country is inhabited by Dokpas and Khatis, or a mixed race.

On the 14th January, after making five marches, we reached Monkong Garthok, a place previously visited by explorer A-K., and called by him Garthok or Makham, situated on the Mongothongchu river. On these marches we crossed several passes and met with numerous well populated villages. Pine forests were seen on the hills, on either side of

our route. At certain intervals in this part of the country, there are houses set apart for the accommodation of Chinese officials, when travelling between China and Lhasa. We halted at Monkong Garthok on the 15th January.

We next marched to a place called Phula, situated on the Mongothongchu river, and surrounded by hills covered with dense pine forests. Here we learnt that Prince Henry of Orleans and M. Bonvalot had travelled over this route. We were now at an elevation of about 12,420 feet. On the 17th, we reached Lande (Lhamdun of A-K.), a pretty large place, inhabited by Khatis (a mixed race of Chinese and Tibetans). *En route* we crossed several passes, and skirted many villages and pine forests. Several snow peaks were visible hereabouts. Our next march was to Bon, a place situated at the foot of the Bomba La Pass, from whence eastwards, the country is under the rule of China. Several villages were passed on this march, and the whole tract is thickly populated.

On the 22nd January, we reached Ba or Bathang, situated near the left bank of the Dichu river, after making four marches, first to Khonjika, then crossing the Dichu by ferry boat to Tuana or Dubana, then on to Lah and lastly to Bathang. Bathang possesses a big monastery or *gomba*, surrounded by a wall. The river Bachu, near which we camped, is spanned by a wooden bridge, and on the opposite side of the river, is a village. The population of Bathang is made up chiefly of Khatis, with a sprinkling of Dokpas.

I had an opportunity of witnessing how criminals were kept in confinement here. These poor creatures have instruments like the stocks applied to their necks. The people of the place told us, that about two years ago, two Frenchmen (M. Bonvalot and Prince Henry of Orleans) visited Bathang, and remained in the *sarai* two days. We saw the words "vive la France" written by one of them on the wall of the *sarai*. Horses are used here for ploughing the fields.

On the 25th January, we left Bathang and marched to a small village of 5 or 6 houses called Pongotomo (Pangthamo of A-K.), situated on the Bachu river, and near the foot of the Tag La Pass. A fine forest of pines exists in the locality. *En route* we noticed several snow peaks and passed many hot springs and a few small villages. Our next march was to Tashu, after crossing the snow pass of Tag La. Tashu contains 7 or 8 houses and a few nomad tents, and is a very cold place. We passed on either hand snow ranges and peaks, and also fantastically shaped, whitish hills, covered with forest. Elevation about 13,140 feet.

On the 27th, we marched to Rathi, a small village consisting of about 7 or 8 houses, situated in a valley surrounded by hills. At first our route ran along the Tashuchu river, and then left it, and after ascending the Lathok La Pass, we descended to our camping ground, from which some snow peaks were visible. Fine forests of pine exist on the hills bordering our route, from Bathang to this place; but the people of the country wantonly destroy the trees.

Another march of ordinary length brought us to Namda, (Naida of A-K.), a small village elevated about 12,790 feet, from whence several snow peaks were visible. On this march we noticed only a few nomad tents, but numerous *manephanes*. The people here are very superstitious, and believe they can obtain the salvation of their souls, by marching round the snow ranges that exist in this part of the country.

Three marches more, after crossing several passes and streams, brought us to Lithang monastery, a place of considerable importance and inhabited by Khatis and Dokpas. It is situated on a stream flowing through a valley and is surrounded by hills. As we arrived at Lithang, some men approached us with stones in their hands, evidently bent on mischief; but as a counter move, Captain Bower took up his gun; on seeing which the cowards fled. Lithang possesses a *kotwali* or *kacheri*.

Our next march was to a small village called Horchuka, or Hapchukha, after crossing the Damado La Pass, and passing some places where the inhabitants dig for gold. A crude method of washing the gold is adopted. On the 2nd February, we marched to Thamo Rothang (Tamarathong of A-K.), a very cold place, elevated about 12,980 feet above sea level, and surrounded by forest. *En route* we crossed two passes, and passed some houses and a few nomad encampments. All the way from Lithang the cold was intense. Our next march was to Galuk (Golokthok of A.-K.), a large place and well inhabited. Throughout this march, we observed forests on either side of our route. On the 4th, we marched to Lanipa, a small place, situated at the foot of the Dosa La Pass. We passed a *gomba* or temple *en route*. Forests extend the whole way. Leaving Lanipa, we marched on the day following, to the right bank of the Nagchu river. On the opposite bank (which is reached by a bridge of boats) stands the village of Nagchuka, where A.-K., had observed for latitude. After crossing the Rama La Pass, we made a very great descent to the Nagchu river, and found the place very warm. The whole way from the pass our route ran along a stream, and on either side, the hills were covered with dense forest. We saw, for the first time in our travels, monkeys and squirrels at this place.

Our next march on the 6th, took us to Urong Dongu, a rather large place, and then on the 7th, we reached Mina Galuk (Golokthok of A.-K.) situated near a stream and densely populated. On this march we crossed the Kashi La Pass, from where we saw several snow peaks on all sides of us. Two French missionaries live here, but they were not at home when we arrived. They resided at first at Bathang, but about three years ago they left that place for Mina Galuk. Our next camp was at Amia To, or Amia Gachak (Amya Giachuk of A-K.)—*To* means a house, and *Gachak*, a place. This is a large place and thickly populated. Snow fell during the night. We passed many villages on this march.

On the 9th February, we crossed over the Zila La, or Gi La Pass, and camped at a small place called Chitu. The spot is a beautiful one, and is surrounded by hills covered with forest. On the top of the Gi La Pass, I met a French missionary, travelling to Mina Galuk, and he put me some questions; asking if I spoke English and where I came from. After a little talk, we parted.

On the 10th February, we marched into Ta Chen Lu (A-K's Darchendo), which is known also as Tarsedo, or Gia Tentsi. It is situated in a valley surrounded by very high mountains, and is entirely under the rule of China. It has the reputation of being unhealthy, and we concluded that this was due to the existence of a cemetery on the hill above the city, near which is a spring of water (used by the people for drinking) which flows down to the river. The people keep their houses clean and comfortable, and use chairs and tables, and are, as a rule, civil and obliging. Ta Chen Lu is a large trading city, and is a large mart for tea, in which commodity a brisk trade is carried on. The houses here are almost all built of timber. We halted here, up to the 24th February, and almost every day of our stay we experienced falls of snow.

Notes by COLONEL HOLDICH, R.E., *on the preparation of* CAPTAIN BOWER'S *route maps of exploration in* TIBET AND WESTERN CHINA.

The plotting was first executed on graticule sheets on the ½-inch scale, starting from Lanak Pass, the position of which was taken from the Atlas of India, sheet No. 63A., N. W. Lanak Pass is in Changthang and over a spur from the well known Chang Chenmo range.

The first point of contact with any previous explorer's route was at Ata, on explorer A-K's route from Lhasa northwards; and as it was assumed that the position of that place as fixed by A-K., could not be far from correct (lying as it does, not very distant from Lhasa, which is a fairly well ascertained position, and north by east of it) its longitude was retained.

Captain Bower's position of Atak Memar (A-K's, Ata) is after adjustment of the traverse with his observed latitude of the place, in latitude 31° 58′ 39″ and longitude 92° 23′ 0″ whilst A-K., makes it in latitude 32° 2′ 40″ and longitude 92° 5′ 45″, giving a difference of about 4 miles in latitude and 17 miles in longitude. This must be considered a very fair agreement considering that 1,100 miles of ground, running nearly east had been traversed, and a rate of pacing had to be assumed at 2,200 paces per mile.

Atma Ram's traverse from Lanak Pass to Atak was made to fit in between those two positions and finally adjusted in sections between the camps, fourteen in number, where Captain Bower had observed for latitude.

The next point of contact of Captain Bower's route, after leaving Atak, with any previously well established position, was at Garthok, again on A-K's route, situated not far from, and south-west of, Bathang.

Captain Bower's position of Garthok after adjustment with Atak is in latitude 29°40′28″ and longitude 100°34′20″, whilst A-K. made it in latitude 29°41′7″ and longitude 99°7′50″ showing a difference of about 86 miles in longitude, due evidently, to having assigned too great a value to the length of a pace in the projection of this section of the plot; for in place of employing 2,200 paces to a mile, a scale of about 2,500 paces to the mile would have resulted in a better agreement in the position of Garthok.

The alteration in the length of pace was owing to the change in the character of the country after crossing A-K's route; the rounded hills and open valleys that had been the characteristic formation generally, changing into sharply defined mountain valleys, much cut up by ravines. A good portion of this section was traversed by M. Bonvalot also.

A-K's longitude of Garthok was retained and the traverse between Atak and Garthok was interpolated and finally adjusted in sections between the camps, eight in number, where Captain Bower had observed for latitude.

For the remainder of the route, the positions of Bathang and Darchendo, as deduced by A-K., who agrees closely with Captain Gill's determinations, were retained, and Atma Ram's traverse (which here also proved to be too long) was adjusted to them.

Remarks.

(*a*) Pacings employed in plotting, 2,200 = 1 mile.
(*b*) Length of traverse from Lanak Pass to Yatu = 2,080 miles.
(*c*) The route was traversed by Sub-Surveyor Atma Ram.
(*d*) Captain Bower's latitude observations were reduced at the Trigonometrical Branch Office at Dehra Dun.
(*e*) The heights were deduced from boiling point (hypsometrical) observations and must be considered approximate only.
(*f*) Magnetic variation east + compass error = +4°.
(*g*) All bearings were taken with a prismatic compass.

Drawing Office, Calcutta.

Section I.—Geographical Drawing and Compilation.

Statement showing the work performed during the year 1891-92.

Title.	Number of Sheets.	Scale.	Remarks.
Atlas of India.		Miles per inch.	
Sheets Nos. 12 N. E., 12 S. E., 16 N. E., 16 S. E., 30 S. E., 31 N. E., 36 N. W., 42 S. W., 59 N. W., 87 N. E., 87 S. E., 88 S. E., 102 S. W., 102 S. E., and 131 S. E.	15	4	Additions to names and outline for engraving.
Sheets Nos. 22 S. E., 23 S. E., 25 S. E., 26 N. E., 35 S. W., 36 S. W., 38 S. E., 38 N. W., 40 N. W., 40 S. W., 42 S. E., 49 N. W., 59 S. W., 60 N. E., 60 S. W., 60 S. E., 61 N. W., and 89 S. E.	18	4	Hills brush-shaded for engraving.
Sheets Nos. 22 N. E., 22 S. E., 35 N. E., 35 S. E., 39 N. E., 39 S. E., 53 S. E., 53 S. W., 60 S. W., 61 N. W., 71 N. W., 71 S. W., 71 S. E., 72 N. E., 72 S. E., 72 S. W., 87 S. E., 90 S. E., 90 S. W., 91 S. W., 102 S. W., 105 N. E., 105 S. E., 126 N. W., and 126 S. W.	25	4	Additions to railways, roads, canals, and changes in boundaries.
Sheets Nos. 14, 29, 37, 40, 54, 56, 58, 59, 60, 61, 65, 67, 76, 77, 78, 79, 89, 102, 106, 111, 112, 114, and 116.	23	4	Ditto ditto.
General Maps.			
India (engraved)	6	32	Additions to railways and boundaries.
Do. do. (skeleton)	6	32	Additions to names and outline.
Do. do.	4	64	Additions to railways.
Do. do.	1	96	Corrections to boundaries and railways to March 1892.
Do. do.	1	128	A new compilation; completed.
Do. do.	1	128	Railways to date.
Do. do.	1	256	Ditto.
Do. (lithographed)	6	32	3rd edition; additions to date.
Do. do.	2	32	3rd edition; hills brush-shaded.
Do. do. (railways)	6	32	3rd edition; additions to date.
Do. do. do. (skeleton)	6	32	Additions to date.
India (lithographed) do. (skeleton)	4	48	Corrected to date.
India (lithographed) do. (skeleton)	1	128	Additions to date.
Burma and adjacent countries	2	32	2nd edition, corrected to date.
Do. do.	1	48	Ditto ditto.
Afghanistan	2	24	Additions to railways.
Provincial Maps.			
Burma (Upper)	3	16	A new compilation in progress.
Gujrat	1	16	Additions and corrections to dates.
Bengal, Behar, Orissa, and Chota Nagpur	2	16	A new compilation; completed.
Central India Agency	2	16	Additions to date.
Punjab	4	16	Additions to railways.
Nizam's Dominions	2	16	Corrections to boundaries.
N.-W. Provinces and Oudh	2	16	Additions to date.
Mysore	1	16	Ditto.
Bengal, Behar, Orissa, and Chota Nagpur	2	16	Additions and corrections to date.
Sindh	1	16	
Rajputana Agency	2	16	
Assam	1	16	
Mysore	1	16	
Central Provinces	2	16	

DRAWING OFFICE, CALCUTTA.

SECTION I.

Statement of work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
Divisional Maps.			
Chota Nagpur	8	4	A new compilation, in progress.
Orissa	4	4	Ditto ditto.
Agra	1	4	Additions to railways and corrections to boundaries.
Lucknow	1	1	Ditto ditto.
Allahabad	1	4	Additions to railways.
Meerut	1	4	Additions to railways and corrections to boundaries.
District Maps.			
Shahabad, Sylhet and Kamrup, Dinagepur, Bhagalpur and Purnea, Champaran, Saran, Purnea, Tippera, Lohardaga, Palamau, Bogra, Backergunge	12	4	Additions to roads and corrections to boundaries.
Mymensingh, Nadia, Ulwar State	3	4	Additions to roads and corrections to boundaries.
Standard Maps.			
CENTRAL INDIA AGENCY AND RAJPUTANA—			
Sheets Nos. 408, 421, 449, 474, 482, 483, 429, 450, and 480	9	1	In progress.
Sheets Nos. 396 and 480	2	1	Completed to margin.
Sheets Nos. 135, 136, and 137	3	1	Additions to railways.
Sheets Nos. 238, 239, 269, 270, and 334	5	1	Additions to roads.
BENGAL—			
Sheets Nos. 13, 14, 20, 21, 80, 89, 90, and 91	8	1	Roads inserted.
Sheets Nos. 62, 65, 92, and 95,	4	1	Ditto.
Sheets Nos. 110, 141	2	1	Additions to railways.
MADRAS—			
Sheet No. 151	1	1	Completed to margin.
Sheets Nos. 150, 152	2	1	In progress.
CENTRAL PROVINCES—			
Sheets Nos. 11, 12, 14, 15, 18, 29, 30, and 38	8	1	Additions to roads.
Sheets Nos. 4, 10, 16, 19, and 23	5	1	Additions to roads and railways.
MYSORE—			
Sheets Nos. 57 and 58	2	1	Additions to railways.
HYDERABAD—			
Sheets Nos. 18, 56, 57, 80, 84, 106, 128, 129, 130, 132, 152, 153, 154, 155, 156, 169, 171, 172, 173, 174, 185, 186, 219, and 221	24	1	Roads inserted.

DRAWING OFFICE, CALCUTTA.

SECTION I.—*continued.*

Statement of work.—continued

TITLE.	Number of Sheets.	Scale.	REMARKS.
Standard Maps—(continued).			
BOMBAY SURVEY—			
Sheets Nos. 153, 154, 202, 234, 235, 236, 266, 267, 269, 270, 279, 280, and 297 . . .	13	1	Roads and canals inserted.
UPPER BURMA (NORTH-EAST FRONTIER SERIES)—			
Sheets Nos 15 N. E. (2nd edition), 15 S. E. (4th edition), 23 N. W. (5th edition), 23 S. W. (6th edition)	4	4	Additions to date.
Sheets No. 22 S. W. (2nd edition)	1	4	Completed.
Sheets Nos. 15 (4th edition), 22 (3rd edition), and 23 (2nd edition)	3	8	Ditto.
Supplement to Sheet No. 15 N. E	1	4	Drawn.
UPPER BURMA (SOUTH-EAST FRONTIER SERIES)—			
Sheets Nos. 1 N. W. (2nd edition), 1 S. W. (2nd edition), 1 N. E. (4th edition), 4 N. W. (4th edition), N. E. (3rd edition), 4 S. W. (5th edition), 4 S. E. (3rd edition)	7	4	Additions to date.
Sheets Nos. 1 (4th edition), 3 (3rd edition), 5 (1st edition) . .	3	8	In progress.
Sheets Nos. 2, 4, and 6 . .	3	8	Completed.
Administration Report Maps.			
Palamau	1	12	A new compilation.
Jhansi	1	12	Corrected to date.
North-Western Provinces and Oudh	1	40	Ditto.
Rajputana Agency . .	1	64	Ditto.
Ajmere and Rajputana .	1	8	Ditto.
Assam	1	24	Ditto.
Index Maps.			
For Annual Administration Report	5	Various	Drawn.
For Annual Administration Report	11	Various	Corrected to 30th September 1892.
Miscellaneous.			
Mu Valley State Railway .	1	1	A tracing prepared.
Map of Pachmari and surrounding country	1	2	Prepared for His Excellency the Viceroy of India.
Tirhoot State Railway . .	1	1	A tracing prepared.
North-West Frontier Road from Latamar to Pezu . .	1	1	Ditto ditto.

DRAWING OFFICE, CALCUTTA.

SECTION I.—*continued.*

Statement of work.—continued.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
UPPER BURMA (SOUTH-EAST FRONTIER SERIES)—*contd.*			
Triangulation Charts.			
Ganjam and Orissa Topographical Survey	1	4	A tracing prepared for re-production.
Chin-Lushai Expedition	1	4	Re-drawn; completed.
Work done for other Departments.			
BENGAL—			
Police	4	80	Showing different crimes.
Mortality	4	80	Showing fatal fever, cholera, and small-pox during 1891.
Income Tax	3	80	Showing (1) distribution, (2) proportion of persons assessed, (3) incidence of taxation in 1891-92.
Revenue	6	80	Different maps showing sources of Excise revenue.
Emigration	2	96	Showing districts of emigration and registration.
Revenue	1	16	Showing saliferous districts.
ORISSA DIVISION—			
Revenue	1	16	To illustrate Salt Administration Report.
ASSAM—			
Revenue	1	48	Showing rate of increase and decrease of population.
INDIA—			
Emigration	1	96	Showing registration districts.
"	1	96	Showing the Native districts of Colonial Emigrants.
Maps of Kashmir and parts of Afghanistan, Punjab, and adjacent countries, Persia, East Coast of Arabia, Sind, and Baluchistan and Bombay	6	32	Prepared for Aitchison's Treaties.
Map of Siam	1	32	In progress for ditto.
Postal Map of the Province of Bengal, 1892	12	8	Additions and corrections to date.
Postal Map of the Eastern Bengal Circle	8	4	Drawn and completed.
Map of the Gangetic Alluvium	2	128	Ditto ditto.
Sketch illustrative of the action of Najufgurh	1	...	Drawn for the Director of Records to the Government of India.
Map of India to illustrate the History of the Mutiny in 1857	1	128	
Sheet No. 4, routes in Northern Somali land	1	6	Drawn for Captain Swayne, R.E.
Reduced plan of the routes reconnoitred in Northern Somali lands	1	16	
Road Sketch, Lower to Upper Sheikh	1	4	
Map of 10 miles round Berbera	1	1	
Sketch Map of the Somali country, showing the approximate position of the "Haud"	1	...	
Sheets Nos. 1, 2 and 3, routes in Northern Somali land	1	6	
Sheets No. 1, 2, 3 and 4, routes in Northern Somali land	1	4	
India showing Railways with Stations	2	64	Drawn for the Director-General of Railways.
Maps Coloured.			
Maps on various scales	340	...	For Surveyor-General's Office.
Ditto ditto	83	...	For other department.

DRAWING OFFICE, CALCUTTA.

SECTION I—*continued.*

Statement of work—continued.

Description of work.	Number of Sheets.
Maps examined.	
Atlas sheets	34
General maps	20
Provincial maps	16
Divisional maps	1
District maps	7
Standard maps	35
Administration Report maps	9
Index maps	7
Statistical maps	55
Triangulation charts	1
Miscellaneous maps (departmental)	4
Ditto (extra-departmental)	35
Office copies of various maps, with additions and corrections in territorial boundaries and public works	267
Engraved proofs of atlas sheets in various stages	119
Engraved proofs of general and provincial maps, including index charts	55
Engraved proofs of district maps	27
Litho. proofs of general and provincial maps, including index charts	23
Litho. proofs of district maps transferred from copper-plates	13
Litho. proofs of extra-departmental and statistical maps	29
Photo. proofs of standard maps, large scale plans, and various other maps	455
Colouring of maps for various purposes	178
Tracings of maps for various purposes	22
Projection and examination of graticules and plotting of points	45
TOTAL	1,457

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 geographical names, etc., have been performed by the Examining Section.

DRAWING OFFICE, CALCUTTA.

SECTION II—REVENUE.

Statement showing the work performed during the year 1891-92.

TITLE.	No. of Sheets.	Scale.	REMARKS.
STANDARD MAPS.			
PUNJAB.		Miles per inch.	
District Hissar and Patiala State.			
Sheets Nos. 241 and 256 . .	2	1	Fair maps and proofs examined, corrected and sent to press.
Districts Jullunder, Ludhiana, Hoshiarpur, and Umballa.			
Sheets Nos. 211, 212, 223, 224, 234, 235, 236, 237, 238, 248, 254, 255, 294 and 316 . .	14	1	Proofs examined, press order given.
Sheets Nos. 239 and 240 . .	2	1	Ditto ditto.
District Jhang.			
Sheets Nos. 116, 117, 142, 143 145, 168 and 169 . . .	7	1	Ditto ditto.
District Karnal and Sikh States.			
Sheets Nos. 271, 272, 273 and 274	4	1	Canals, village sites, and names inserted from the survey of 1889-90, and completed to margin for a second edition, and sent to press.
Bahawalpur State.			
Sheets Nos. 18 and 22 . .	2	$\frac{1}{2}$	Fair maps corrected from new material for a second edition.
Indus Riverain Survey.			
Sheets Nos. 5 $\left(\frac{\text{S.E.}}{1,2,3,4}\right)$; 6 $\left(\frac{\text{N.E.}}{1,2,3,4}\right)$; 22 $\left(\frac{\text{N.W.}}{1,2,3,4}\right)$, $\left(\frac{\text{S.E.}}{1,2,3,4}\right)$, $\left(\frac{\text{S.W.}}{4}\right)$; 23 $\left(\frac{\text{N.W.}}{1,2,3,4}\right)$, $\left(\frac{\text{N.E.}}{1,3}\right)$, $\left(\frac{\text{S.W.}}{1,2,3,4}\right)$; 24 $\left(\frac{\text{N.W.}}{1,3}\right)$, and 45 $\left(\frac{\text{N.W.}}{1,3}\right)$.	30	$\frac{1}{4}$	Fair maps examined and corrected.
NORTH-WESTERN PROVINCES AND OUDH.			
District Naini Tal.			
Portion of the late Tarai District.			
Sheet No. 63	1	1	Fair maps examined and sent to press.
Sheets Nos. 64, 65, 81 and 97 .	4	1	Fair maps examined and corrected.
Portion of the late Kumaun District.			
Sheets Nos. 46, 63, 250 and 251 .	4	1	Drawn, examined, and sent to press; proofs under examination.
Sheet No. 64	1	1	Drawn, examined, and held in abeyance for incorporation with recent survey of Rampur State.
Sheets Nos. 46 $\left(\frac{\text{N.E.}}{2,4}\right)$, $\left(\frac{\text{S.E.}}{2}\right)$; 63 $\left(\frac{\text{N.W.}}{1,3,4}\right)$, $\left(\frac{\text{N.E.}}{3}\right)$, $\left(\frac{\text{S.W}}{1,2,3,4}\right)$, $\left(\frac{\text{S.E.}}{1,3,4}\right)$; 64 $\left(\frac{\text{N.E.}}{1,2,3,4}\right)$, $\left(\frac{\text{S.E.}}{2}\right)$, 250 $\left(\frac{\text{S.W.}}{3}\right)$; and 251 $\left(\frac{\text{N.W.}}{1,2,3,4}\right)$, $\left(\frac{\text{S.W.}}{1,2,3,4}\right)$, $\left(\frac{\text{S.E.}}{1,3}\right)$	30	$\frac{1}{4}$	Fair maps examined and sent to press.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of Work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
STANDARD MAPS—*contd.*			
NORTH-WESTERN PROVINCES AND OUDH—*contd.*			
District Bijnor.			
Sheets Nos. 2, 3, 4 and 6 . .	4	1	Fair maps corrected for a second edition.
District Bareilly.			
Sheets Nos. 1, 2, 3 and 4 . .	4	1	Ditto ditto.
Sheets Nos. 81, 82, 97 and 98 .	4	1	Printed sheets corrected for a second edition.
Districts Bahraich and Gonda.			
Sheets Nos. 160 and 161 . .	2	1	Proofs corrected and sent to press.
BENGAL.			
District Balasore.			
Sheets Nos. 2 and 4 (Pargana maps)	2	1	Printed sheets touched up; proofs passed and press order given.
Angul Estate (Orissa).			
Sheet No. 103	1	1	Fair maps and proofs examined and press order given.
Sheets Nos. 104, 105, 132, 133 and 134	5	1	Fair maps examined and proofs sent to press.
District Cuttack.			
Killa Kujang.			
Sheets Nos. 223, 224, 195 and 196	4	½	Fair maps examined and corrected.
District Dacca.			
Main Circuit Maps Nos. 9 and 10	2	1	Printed sheets touched up; proofs passed and press order given.
District Darjeeling.			
Sheets Nos. 269, 270, 271, 292, and 293.	5	½	Fair maps corrected to date for a second edition.
District Hooghly.			
Sheets Nos. 1 to 7 . . .	7	1	Ditto ditto ; proofs passed and press order given.
District Manbhum.			
Main Circuit Maps Nos. 16 and 19.	2	1	Printed sheets touched up for reproduction by photography; proofs passed and press order given.
District Mymensingh.			
Pargana maps Nos. 1, 8, 9 and 20.	4	1	Ditto ditto.
Sheets Nos. 343, 363, and 374 .	3	1	Proofs passed, press order given.
Sheet No. 375	1	1	Proofs examined and sent to press.
District Nadia.			
Pargana maps Nos. 1 to 8 .	8	1	Printed sheets touched up for reproduction by photography; proofs passed and press order given.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of Work.

Title.	Number of Sheets.	Scale.	Remarks.
STANDARD MAPS—*contd.*		Miles per Inch.	
BENGAL—*continued.*			
District Pubna.			
Main Circuit maps Nos. 26 and 27.	1	1	Printed sheets touched up for reproduction by photography; proofs passed and press order given.
District 24-Parganas.			
Sheets Nos. 4, 5, and 6 . .	3	1	Ditto ditto.
District 24-Parganas.			
Dhee Punchanogram.			
Grand Division No. 1.			
Sub-divisions Nos. 1-2, $\frac{4}{1\cdot 2}$, 6-7-8, 15 and $\frac{18}{1, 2, 3}$.	11	99′	Printed sheets touched up for reproduction by photography; corrected to date and proofs examined.
Grand Division No. 2.			
Sub-divisions Nos. 6 and 14 .	2	99′	Ditto ditto.
Grand Division No. 3.			
Sub-divisions Nos. 2 (3, 4, 5, 6), 9, 11, $\frac{12}{1, 2, 3}$, 13, $\frac{15}{1, 2}$, 17, 18, 19, 20, 21, 22, and 23.	17	99′	Ditto ditto.
Grand Division No. 4.			
Sub-divisions Nos. $\frac{A}{1, 2}$, $\frac{B}{1, 2}$, E, F G, $\frac{H}{1, 2}$, and $\frac{I}{1, 2}$.	11	99′	Ditto ditto.
Grand Division No. 5.			
Sub-divisions Nos. $\frac{I}{2}$, $\frac{A}{1}$, $\frac{B. C. E}{1}$	3	99′	Ditto ditto.
Grand Division No. 6.			
Sub-divisions D. E. F. G., $\frac{J}{1, 2}$, K, $\frac{M.}{1, 2,}$ and N.	10	99′	Ditto ditto.
ASSAM.			
Districts Darrang and Kamrup.			
Sheets Nos. 25 and 38 . .	2	1	Completed to margin; proofs examined and press order given.
District Lakhimpur.			
Sheets Nos. 97, 98, 113, 114, 128, 129, 130, 138, 139, 140, 144, 145 and 146.	13	1	Fair maps corrected to date. Proofs examined and sent to press.
CENTRAL PROVINCES.			
District Chanda.			
Sheets Nos. 2 and 6 . .	2	1	Printed sheets touched up for reproduction by photography. Proofs passed, press order given.
BOMBAY.			
Sheets Nos. 179, 185, 244, 331, 352, 353 and 353A.	7	1	Proofs passed with press order.
Sheets Nos. 154, 186, 188, 274, 304 and 330.	6	$\frac{1}{2}$	Fair maps examined and sent to press.
Sheet No. 35 $\left(\frac{N. E.}{1, 2, 3, 4}\right)$.		$\frac{1}{4}$	Fair maps touched up and proofs passed with press order.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of Work.

TITLE.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
STANDARD MAPS—contd.			
BURMA.			
Sheets Nos. 181 and 227	2	1	Proofs passed and press order given.
Sheets Nos. 143, 144, 187, 188, 189, 190, 233, and 284.	8	1/2	Fair maps examined and proofs under examination.
Sheets Nos. 185, 186 and 232	3	1/2	Fair maps corrected to date for a second edition.
DISTRICT MAPS.			
Basti (N.-W. Provinces)	4	1/2	Proofs examined and press order given.
Gorakhpur ,,	4	1/2	Drawing well advanced.
Mirzapur ,,	5	1/2	Ditto in progress.
Garhwal ,,	4	1/2	Ditto ditto.
Raipur (Central Provinces)	6	1/2	Proofs examined and sent to press.
PLANS OF CITIES AND CANTONMENTS.			
City of Calcutta	2	1/6	Printed sheets corrected for a third edition.
Ditto ditto.	1	1/3	Proof passed with press order.
Peshawar Cantonment	4	1/8	Press order given.
Kamptee Cantonment	4	1/8	Proofs passed with press order.
City and Cantonment of Satara	1	1/6	Ditto ditto.
Map of Delhi showing the British position during the siege, 1857.	1	1/4	Drawn; proofs under correction.
Map of Badli Sarai	1	1	Ditto ditto
Rangoon Town	19	1/16	Proofs passed with press order.
City and Cantonment of Dinapur	1	1/8	Ditto ditto.
Lucknow Cantonment	4	1/6	Fair maps corrected to date for a second edition.
Cawnpore ditto	4	1/8	Ditto ditto.
Benares ditto	4	1/8	Ditto ditto.
MISCELLANEOUS.			
Map of country between Aligarh and Meerut, cavalry camp of exercise	1	1	Proofs passed and press order given.
Specimen of Boundary symbols	1	1	Drawn; proof passed and press order given.
Sketch map to illustrate the marches of the Delhi Field Forces, 1857.	1	8	Drawn, examined, proofs under examination.
INDEX MAPS.			
For Annual Administration Report	11	...	Drawn and sent to press.
Ditto ditto	12	...	Corrected to date and sent to press.
PROOFS EXAMINED.			
Photozincographed maps	259	...	
Lithographed maps	12	...	
TRACINGS PREPARED.		...	
Tracings of sheets	61	...	
Ditto village plans	42		
MAPS COLOURED.			
Maps on various scales	168	...	For Surveyor-General's Office.

DRAWING OFFICE, CALCUTTA.

SECTION II.

Statement of Work.

DESCRIPTION OF WORK.	REMARKS.
Computations examined.	
District Hoshangabad, seasons 1887—89 . . .	
District Damoh ,, 1885—87 . . .	
District Jhansi ,, 1888—90 . . .	
Traverse data, etc., supplied.	
District Midnapore along district Balasore . .	For No. 8 Party.
District Puri along Chilka Lake	Ditto.
District Jubbulpore along district Mandla . .	For No. 9 Party.
District Goalpara along Garo Hills	For Deputy Commissioner, Kamrup.
Ditto ditto ditto	For Deputy Commissioner, Garo Hills.
Dakhin Shabazpur Villages	For No. 2 Party.
Village Traverses, supplied, 390 pages . . .	To public officers.
Field books of 5 villages, district Gorakhpur . .	To Sub-Assistant Conservator of Forests.
Area statement of villages in *pargana* Jalamuta .	For Burdwan Detachment.
Rectangular co-ordinates of triangulated stations in district Nimar	For No. 14 Party.
Values and description of level B. M. in and around Elephant Point, Rangoon	For No. 25 Party.
Values and description of level B. M. in district Bassein	To Executive Engineer.
Ditto ditto ditto Basti .	To Collector.
Miscellaneous.	
Calculated spherical co-ordinates of Revenue Survey stations in district Sibsagar, Delhi Cantonment, and part of district Dacca, plotted 1 village on 16-inch scale in district Hoshangabad; prepared a traverse circuit and plotted a group of villages of district Moorshedabad on 4-inch scale; also another group of villages in district Maldah; calculated areas by *parganas* of 2 sheets, Bengal; 17 sheets, Assam, 3 sheets, Punjab; and also areas of cantonments and residencies in Central India Agency. Prepared a statement showing measurement of local beegahs in use in district Sarun; also one of tri-junction *pucka* pillars in the districts of Oudh.	

DRAWING OFFICE, CALCUTTA.

SECTION III.—CADASTRAL.

State of publication of Cadastral Maps on the 30th September 1892.

DISTRICTS.	NUMBER OF SHEETS.							REMARKS.
	MAPS PREPARED			PUBLISHED				
	Up to 30th September 1891.	Added during past 12 months.	Total up to 30th September 1892.	Up to 30th September 1891.	By Surveyor General's Office during past 12 months.	Total to 30th September 1892.	Remaining to be published.	
North-Western Provinces.								
Agra	2,942	...	2,942	2,942	...	2,942	...	
Azamgarh	930	...	930	930	...	930	...	
Ballia	1,601(*a*)	...	1,601(*b*)	1,601	...	1,601	...	
Banda	3,317	...	3,317	3,317	...	3,317	...	
Basti	5,571	...	5,571(*b*)	5,565	6	5,571	...	
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	8,615(*a*)	...	8,615(*b*)	6,603	2,006	8,609	6	
Hamirpur	2,926	...	2,926	2,926	...	2,926	...	
Jaunpur	3,583(*a*)	...	3,583(*b*)	3,583	...	3,583	...	
Jhansi	...	1,149	1,149(*b*)	...	...	...	1,149	
Kumaun (Bhabar)	332(*a*)	...	332(*b*)	...	...	...	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*)	3,794	...	3,794	...	
Rampur State	...	1,349	1,349(*b*)	...	356	356	993	
Tarai	862	...	862(*b*)	409	187	596	266	
TOTAL	46,973	2,498	49,471	44,170	2,555	46,725	2,746	
Burma.								
Akyab	2,785	...	2,785	2,785	...	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	...	
Kyaukse	...	804	804(*b*	...	196	196	608	
Prome	847	...	847	847	...	847	...	
Tharrawaddy	1,363	...	1,363	1,363	...	1,363	392	
Thongwa	2,764	985	3,749(*b*)	2,020	1,337	3,357	...	
TOTAL	17,188	1,789	18,977	16,444	1,533	17,977	1,000	
Bengal.								
Patna and Gya	3,054	...	3,054	3,054	...	3,054	...	
Puri (Khorda Estate)	4,565	...	4,565	4,565	...	4,565	...	
Shahabad	4,924	...	4,924	4,924	...	4,924	...	
Muzuffarpur	1	...	1	1	...	1	...	
TOTAL	12,544	...	12,544	12,544	...	12,544	...	
Assam.								
Darrang	718(*a*)	...	718	704	...	704	14	
Kamrup	1,675(*a*)	310	1,985	1,675	14	1,689	296	
Nowgong	753(*a*)	529	1,282	730	341	1,071	211	
Sibsagar	1,877(*a*)	...	1,877	1,037	454	1,491	386	
Sylhet	61	...	61	16	...	16	45	
TOTAL	5,084	839	5,923	4,162	809	4,971	952	
Central Provinces.								
Raipur	43	...	43	43	...	43	...	
TOTAL	43	...	43	43	...	43	...	
GRAND TOTAL	81,832	5,126	86,958	77,363	4,897	82,260	4,698	

(*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.

Abstract of Work performed during 1891-92.

PROVINCES.	NUMBER OF SHEETS.				REMARKS.
	Examined and rendered suitable for photo-zincography.	Traced and examined for zincography.	Proof sheets examined previous to press order.	Coloured and subsequently examined.	
North-Western Provinces	2,097	364	2,562	2,555	Scale 16 inches = 1 mile.
Burma	1,195	456	1,587	1,533	Ditto ditto.
Bengal	...	...	...	...	Ditto ditto.
Assam	262	552	843	...	Ditto ditto.
TOTAL	3,554	1,372	4,992	4,088	

ENGRAVING OFFICE, CALCUTTA.

Statement showing the Work performed during the year 1891-92.

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	4	15	4,982	92	
Ditto in progress	43	589	75,735	655	
Additions and corrections to published quarter sheets	34	63	10,989	114	
Additions and corrections to published full sheets	24	715	36,021	334	
New plates projected, etc.	1	...	...	...	
General Maps.					
On various scales	24	1,676	112,349	25	
rovincial Maps.					
On scale 1 inch = 16 miles	18	203	28,226	113	
On various scales for Administration Reports	3	...	2,762	...	
District Maps.					
On scale 1 inch = 4 miles	1	...	6,004	...	
On various scales for Administration Reports	31	411	21,287	97	
Index Maps	6	145	8,129	...	
Charts	2	4	1,139	...	
Miscellaneous subjects	17	...	12,904	1	
TOTAL	208	3,821	320,527	1,431	

COPPER PLATE PRINTING.

Impressions taken	18,049
Proofs pulled	492
Transfers pulled	426
TOTAL	18,967

STEEL FACING.

Double elephant plates steel-faced	37
Do. do. steel removed	43
Quarter sheets steel-faced	20
Do. steel removed	14
Miscellaneous plates steel-faced	27
Do. do. steel removed	17
TOTAL	158

PHOTOGRAPHIC AND LITHOGRAPHIC OFFICE, CALCUTTA.

Extract from the Narrative Report of COLONEL J. WATERHOUSE, S.C., *Assistant Surveyor-General, Season 1891-92.*

OUT-TURN.—The out-turn is still steadily increasing, and it is becoming very difficult for the office to meet the heavy demands upon it, especially for colour-printing work.

ORIGINAL SUBJECTS.—The total number of original subjects under reproduction during the year has been 7,532 ; of these 541 have been lithographed, and the remaining 6,905 reproduced by various photographic processes or by zincography. The increase on the whole is 465 subjects more than last year. Of the 541 subjects lithographed, only 63 were departmental, being one more than last year ; 478 were for other departments, or 122 less than last year. Of the 6,905 subjects reproduced by photography, 1,064 were departmental, 4,956 cadastral, and 885 were extra-departmental. Last year the numbers were 1,083 departmental, 4,376 cadastral, and 946 extra-departmental, showing differences of *minus* 19, *plus* 580 and *minus* 61 respectively.

From these figures it would appear that the number of subjects under reproduction has generally been less than last year, except in the case of the cadastral maps. The actual number of sheets of maps, etc., received during the year was 7,858 ; of which 1,071 were departmental, 4,934 cadastral, and 1,853 extra-departmental, and the numbers despatched were 7,490, of which 1,073 were departmental, 4,896 cadastral and 1,521 extra-departmental.

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 577 ; of these 77 were departmental, and the remaining 500 for other departments. Last year 744 subjects were received, of which 101 were departmental and 643 extra-departmental. The section has remained under charge of Mr. H. L. Lepage, the Head Assistant. It is satisfactory to be able to report that in consideration of the increased work and responsibility of this post, the Government have sanctioned an increase to the maximum pay from ₹450 to ₹550.

Although the number of subjects for lithography has not increased, the work in this section has been very largely added to by the preparation of colour-stones, and the draftsmen have been fully occupied throughout the year.

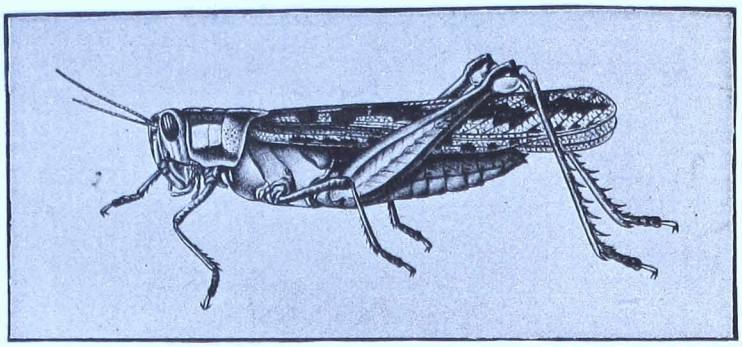
PHOTOGRAPHIC NEGATIVE SECTION.—The total number of negatives taken during the year was 6,153 including 106 negatives and transparencies for use in the heliogravure process. Of these, 1,440 were of departmental, 3,634 of cadastral, and 1,079 of extra-departmental maps, plans and drawings, as against 1,320 departmental, 3,211 cadastral, and 1,163 extra-departmental done during last year, showing a net increase of 459 negatives taken. The section has continued under charge of Mr. H. Haward, and there have been no changes in the processes. Mr. G. W. McKie was discharged on the 31st August for bringing in outside work to be reproduced in the office.

PHOTO-TRANSFER PRINTING SECTION.—The number of photo-transfer prints prepared was 5,729, of which 1,049 were of departmental, 3,648 of cadastral, and 1,032 of extra departmental subjects, as against 1,276 departmental, 3,257 cadastral, and 1,046 extra-departmental, showing a total increase of 150. The apparent falling off in departmental subjects is due to the fact that blue cyanotype prints are now largely used for proofs instead of photo-zincographs. The section has continued under charge of Mr. J. Harrold, and there have been no changes in the processes.

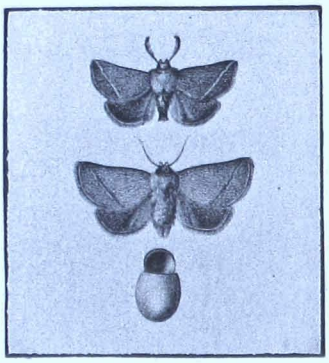
LITHOGRAPHIC AND ZINCOGRAPHIC PRINTING SECTIONS.—The work in these two sections has again very largely increased, and considerable difficulty has been found in getting through it with only one large lithographic machine. The demands for the ruled one-inch cadastral squares and meteorological charts take up a great part of the out-turn of one machine. The second quad-crown machine, referred to in last year's report, was received during the year and is now being put up. As soon as it is in working order, it is hoped that it will enable us to carry out the increasingly large requisitions for printing in colours which are now swamping us with only one large machine to meet them. In the lithographic printing section the number of subjects printed from stone was 541, or 140 less than last year ; of these, 63 were departmental and 478 extra-departmental, against 74 departmental and 607 extra-departmental of last year. The number of pulls was 426,655, or 142,836 more than last year, and of copies 348,153, against 329,027 of last year, the coloured copies being in excess by 18,354 over last year. From this it will be seen that although the number of subjects printed off was much less than last year, the actual work turned out was very considerably more, owing to so much of the work being done in colours.

In the Zinc Printing Section (normal), the number of plates printed was 942, of which 333 were departmental and 609 extra-departmental. The number of pulls was 179,434 (48,104 departmental and 131,330 extra-departmental), and of complete copies 254,285 (53,767 departmental and 200,518 extra-departmental). Last year, the number of plates printed was 1,127 (667 departmental and 460 extra-departmental) ; pulls 276,602 (111,485 departmental and 165,117 extra-departmental) and of complete copies 288,822 (108,724 departmental and 180,098 extra-departmental). This shows a considerable decrease in the number of plates printed of departmental subjects and a large increase in extra-departmental subjects, while the number of copies is 34,573 less. In the Zinc Printing Section (cadastral), 4,966 plates of cadastral maps of the North-Western Provinces, Burma and

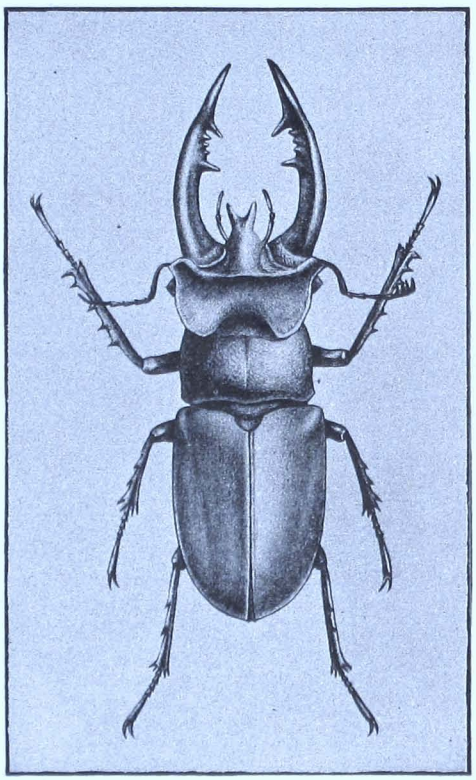
SPECIMENS OF PHOTO-BLOCK PRINTING. BITUMEN-GRAIN PROCESS.



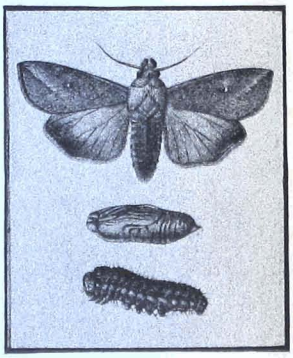
ACRIDIUM AERUGINOSUM: BURM.



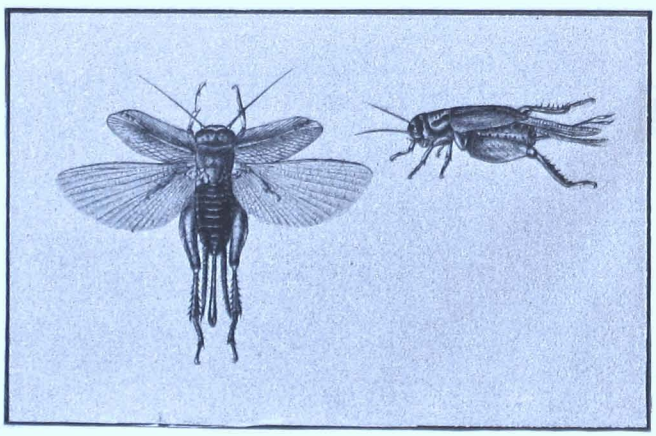
MIRESIA COTESI: SWINHOE.



LUCANUS LUNIFER: HOPE.



LEUCANIA EXTRANEA.



TOKA INSECT.

Reproduced, full scale, from Indian Ink Drawings.

Photo-Blocks. S. I. O., Calcutta, January 1893.

Assam were printed off, the number of pulls being 149,979 and of copies of complete villages 139,819, as against 4,484 plates, 151,557 pulls and 142,519 complete copies of last year.

TYPE PRINTING SECTION.—The printed out-turn in this section again shows a large increase, although the number of items shows a decrease. The number of items set up was 8,615 as compared with 9,098 of last year, the number of pulls being 1,318,597 and of copies 678,968 against 1,074,280 and 581,690 of last year. The printing work has now nearly reached its limit and is in advance of the composing. If the work increases, it will be necessary to set up another steam machine to clear it off. The section has continued under Mr. De Pyvah.

SILVER PRINTING SECTION.—The silver printing shows a large increase, principally on account of silver prints produced for the Secretary of State for India of the photographs to illustrate the late Dr. Forchhammer's reports on the antiquities of Arakan and Pagan, the number of prints being 2,998 against 1,105 of the previous year. The section has also been well employed in producing blue prints for proofs, the number amounting to 2,466 against 2 691 of the previous year.

HELIOGRAVURE SECTION.—This section has remained under charge of Mr. A. W. Turner throughout the year and has made good progress; 50 plates have been prepared by the photo-etching process, and 42, 415 copies printed showing a decrease of 20 in the number of plates and an increase of 8,400 in the number of copies as compared with last year. The decrease in the number of plates prepared is explained by the fact that most of the drawings of insects illustrating Mr. Cotes' papers on Economic Entomology are now reproduced by the block process instead of by heliogravure; 57 blocks were produced during the year, or 22 more than last year.

Photo-etching Process.—No changes have been made in the methods of preparing or etching the engraved plates. For printing, the cold ink noticed in last year's report has been found to answer perfectly and has many advantages over the ordinary method of inking with heat, notably the saving of gas, or other fuel, and the unnecessary heating of the work-rooms, while at the same time the impressions are better, owing to the finer grinding of the colour. We have prepared the inks for ourselves from the formulæ given me at the Ordnance Survey Office, Southampton, last year, but some trial inks obtained from Messrs. Winstone & Co., and Shackell and Edwards gave good results.

The most noteworthy work of the year has been the reproduction of the birch-bark manuscripts discovered in Western Turkestan by Lieutenant Bower. The leaves of the manuscripts had all a more or less yellow tinge, and some of them were very dark and discoloured by age, so that in parts the writing was barely legible. Some of the leaves were reproduced upon plates prepared with the orthochromatic collodio-bromide emulsion described below, and others on gelatine plates rendered orthochromatic by being treated with a tincture containing erythrosin, silver nitrate and ammonium picrate. By this means very successful results have been obtained, as the specimen at page 99 will show.

It may be worth recording here that it has been found that after about 1,000 impressions, plates with delicate shading in the lights may lose much of it and the plate be apparently worn out. This is due to the polishing of the steel-faced surface from the constant rubbing of the hand in printing, but if the steel-facing be removed and renewed, the plate can be printed again in all its original perfection. The D copper-plate printing machine, noticed at page lxvi of the appendix of the last Annual Report, was received and set up. It was found to work more rapidly than the ordinary hand presses, but the very heavy pressure caused by the plates coming suddenly under the cylinder was liable to stop the machine and made it difficult to work Moreover, the stoppage of the printing of the plates for the "*Indian Museum Notes*" from photo-etched plates has greatly decreased the copper-plate printing, and what remains can easily be dealt with by the ordinary staff in the hand-presses. The machine will be valuable should greater pressure of work come on again.

Photo-Block Processes, Bitumen grain method.—This method is an application of the photo-etching process, as ordinarily worked, to the production of a raised printing surface for typographic block printing instead of an incised surface for copper-plate printing. It is worked much in the same manner as described in the Annual Report for 1886-87, but the further experience gained in working these processes has led to the introduction of improvements which bring out the real value of the method for producing delicate blockwork. It is simple and quick. No special negative is required, and the blocks are found to print in the Caxton platen machine without difficulty or special treatment. A great advantage of this process is the rapidity with which the printing can be carried on at the rate of 1,500 to 2,000 a day, instead of about 80 to 100 as with heliogravure plates. Specimens of the results obtained are annexed.

Several photo-blocks were also prepared by means of the ruled glass screens and by the method described in last year's Annual Report, in which pigment tissue is used for forming the image on copper instead of asphalt or bichromated albumen on zinc or copper.

Some attention has been paid to the best method of obtaining the desired results in making negatives by means of these screens, and it has been found that the nature of the grain is affected, first, by the volume of light passing through the lens, and this depends very much upon the subject to be copied, be it a light or dark one; by the aperture of the lens used, and by the light in the studio in which the work is done. Secondly, by the

distance between the screen and the sensitive plate. Consequently each subject requires a certain adjustment of the diaphragms of the lens and of the distance between the screen and the plate which can only be learned by practice.

Nine blocks of figures of soldiers to illustrate the musketry regulations and thirteen to illustrate the "*Indian Museum Notes*," besides other experimental ones, were prepared by this method.

Electrotyping.—The electrotyping work shows a falling off, only 14 plates having been reproduced in this manner against 26 of last year, but they have been larger in size. The out-turn in this section depends entirely upon the wants of the Engraving Office. During the year an attempt was made to adopt vertical depositing troughs instead of horizontal ones, with the object of saving space with the large cells required to deposit double elephant plates, and also to economise time by depositing two plates in one cell instead of one. A trial on the small scale gave excellent results, and a large cell was therefore made up on the same principle; but the result was a complete failure, the deposited copper being very brittle and adherent to the matrix. There was also a great waste of copper by deposition in the inner cell, and it has therefore been thought better to continue working in the old way. These vertical batteries consisted of a central porous cell made with leather sides in which the iron plate and dilute sulphuric acid were placed, while the outer cell contained the solution of sulphate of copper and two depositing plates, one on each side of the central cell.

EXPERIMENTAL AND PERSONAL WORK.—Soon after my return from furlough in November 1891, I had to go again very fully into the question of the reorganisation of the offices and to revise my proposals, which took up most of my spare time till June. In July my health failed, and I was more or less unwell till October. This and the heavier pressure of ordinary office work have prevented my doing very much experimental work or carrying to completion investigations noticed in previous reports. The most important work I have been engaged upon was a trial of an orthochromatic collodio-bromide emulsion process published by Dr. A. Jonas of Vienna, based on Dr. E. Albert's method noticed in last year's report. The process has been found to work very well for half tone work. The plates are almost as sensitive as the slower kinds of gelatine dry plates It is in its present form not so well adapted for line work, but further trials to adopt the process into a dry plate one for general use in copying work in the office were stopped by my ill-health some months ago, and I have not yet been able to resume them. The following is a brief outline of the operations:—

Dr. Jonas' process of preparing the emulsion is based on the silver and ammonia method of preparing the silver bromide gelatine emulsions, but he overcomes the deleterious action which the free ammonia would have on the collodion by neutralising it with acetic acid and thus obtains an emulsion which is exceedingly fine in the grain and creamy.

SOLUTION I.

Ammonium bromide	64 grammes.
Distilled water	80 c. c.
Absolute alcohol	800 „
Thick collodion (4%)	1,500 „
Glacial acetic acid	65 „

The ammonium bromide is first dissolved in the water with heat, then the alcohol, collodion and acetic acid are added in order.

For the collodion I used a mixture of 4 per cent. solutions of Schering's celloidin and of Morson's pyroxyline, both in equal parts of ether and alcohol, the same as ordinarily made up for use in the office, but thicker.

SOLUTION II.

Crystallised nitrate of silver	80 grammes.
Distilled water	50 c. c.

The silver salt is dissolved in the water with heat, and then strong solution of ammonia is added in small portions till the precipitate is redissolved (this takes about 75 c. c.); 800 c. c. of alcohol warmed to 113° are then added. This solution should remain clear and colourless. If it turns brown the alcohol is impure. Both solutions I and II can be prepared in day-light.

Solution II is poured in a thin stream into Solution I, the latter being well shaken meanwhile. This must be done in a dark room with an orange light. Solution II must be kept heated from about 103° to 122° F., otherwise the silver-ammonia salt will crystalise out. It is desirable, therefore, to stand the solution from time to time in a water bath. The mixing of the above quantity of emulsion should take about 10 minutes. The mixed emulsion is well shaken up and tested for acidity. A little of it being poured on a glass slip and wetted with water should show a slightly acid reaction. If alkaline, it is acidified by adding acetic acid drop by drop. It is then well shaken for about a quarter of an hour, and after standing for an hour may either be washed at once by pouring it into five or six times its volume of water, or be kept for one, two, or at most three, days to ripen before washing. This I found to be an advantage in giving greater sensitiveness. The washing

North-East Longitudinal Series, Preliminary Chart, Nos. 1A, 1B, 2, 3, 4, 5 and 6	F.	4	D. E.	7	108	108	14	...	...	525	525	1,314 2	
North-East Trans-frontier, Sheet No. 7 N. W./3	* F.	2	D. E.	1	...	...	...	...	...	77	77	23 0	
North-West Trans-frontier, Himalayan Peaks, Sheets Nos. 1, 2, 5, 6 (in one); 3, 4, 7, 8 (in one); and 9	* F.	16	D. E.	3	18	18	3	...	...	75	75	224 10	
Okha Point and Bet Harbour, Tidal Map	F.	...	1/8 D. E.	1	1	2	1	...	...	4	8	22 0	For Professional Volume.
Punjab Survey, Sheets Nos. 246 (S. E.), 1 and 332 (N. W.)	F. and I.	1/4 and 1/2	D. E.	2	9	7	2	...	...	22	22	147 1	
South-East Coast Series, Final Chart, Nos. 1 and 2	F.	8	D. E. and 1/2 D. E.	2	9	22	6	...	...	549	732	286 5	For Synoptical Volume XXV.
Sector for Star Constants, Diagram	F.	...	1/16 D. E.	1	1	3	1	...	...	11	33	16 8	For office use.
Self-Registering Tide Gauge. Diagram of a portion	F.	...	1/16 D. E.	2	2	...	...	8	...	...	8	21 14	For Professional Volume.
Simla and Kalka Road Survey, Sheets Nos. 2B, 3B, 4B, 5B, 6B, 4C, 5C, 6C, and 7C (Redn. of 6" sheets)	F.	1/8	1/8 D. E.	9	9	8	...	...	15	...	15	71 6	
Singi Meridional Series, Rough Chart, Eastern half, upper portion	* F.	4	1/8 D. E.	1	...	...	...	...	1	...	1	1 3	For office use.
Sketch of Globe traveller, plan	F.	...	1/10 D. E.	1	1	...	...	2	...	...	2	6 5	
Specimen of Hill shading	F.	...	1/16 D. E.	1	...	2	1	...	...	27	54	11 14	For examination of candidates for Junior Division.
Ditto Italic printing	F.	...	1/16 D. E.	1	1	2	1	...	...	54	108	19 10	
Spirit-levelling Operations, No. 6, Bombay Presidency	F.	16	1/8 D. E.	1	1	4	1	...	...	78	310	43 0	For Pamphlets of Spirit-levelled heights.
Sundial, Diagram	F.	...	1/10 D. E.	1	2	2	1	...	...	6	32	24 0	
South-West Quadrilateral of the Great Trigonometrical Survey of India, Diagram	I.	...	1/8 D. E.	1	1	4	1	...	...	...	...	29 1	For Synoptical Volumes.
Trans-frontier Map, Sheet No. 9 (2nd edition)	* F.	16	D. E.	1	...	...	...	...	...	51	51	10 14	
Other maps, for office use, Surveyor-General's Office, etc.	F. and I.	...	...	76	129	482	75	...	24	4,646	2,775	4,494 13	

Copies of Maps of other Departments taken for Departmental use.

Assam, Index to the Forest Survey of Goalpara	F.	4	1/2 D. E.	1	...	...	...	...	...	15	15	3 12	
Ditto, Map of Darugiri Forest Reserve	F.	1/4	1/2 D. E.	1	4	4	1	...	...	15	15	3 5	
Berar, Index Map to the Forest Survey of Melghât taluk (revised)	F.	8	D. E.	1	...	...	...	...	...	15	15	6 6	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 (Lower), Index to the Forest Survey in the east and west Salwein and part of Attaran Division, Section 1	F.	8	D. E.	1	6	12	2	...	...	15	15	6 6	
Burma (Lower), Kon Bilin Forest Reserve	F.	1	1/4 D. E.	1	1	2	...	...	...	15	15	2 9	
Burma (Upper), Map of Nwamadang and Mon West Forest Reserve	F.	2	1/2 D. E.	2	...	...	...	...	...	30	30	12 12	
Burma (Upper), Taungdwin Range, Magwe District, Nos. 1 and 2	F.	1	D. E.	2	...	12	2	...	...	40	40	14 0	
Ganges Garhwal, Naini Tal, and Kumaun Divisions, Map of the Reserved and Protected Forests	F.	4	D. E.	1	...	...	...	...	...	15	15	5 4	
Kumaun and Garhwal Forest Survey, Sheets Nos. LII (revised edition), LIV (2nd edition), and LX (additional piece)	F.	1/4	D. E. and 1/8 D. E.	3	...	7	3	...	...	45	45	14 14	
North-Western Provinces and Oudh, leased Forests in Tiri Garhwal, Nos. 226 S. E./1 and S. W./2	F.	1/4	D. E.	2	...	14	2	...	...	30	30	12 12	
Punjab Forest Survey, Bashahr State, Sheets Nos. 332 N. W./2, N. W./4, S. W./2, S. W./3; 346 S. E./1, S. E./3, (2nd edition); S. W./1, S. W./3, S. W./4, (2nd edition); 347 N. E./1, N. E./2; and 352 S. W./1	F.	1/4	D. E.	12	48	48	8	...	..	180	180	76 8	
Punjab, Map of Pathankot, Kullu, Kalka and Jullunder countries	F.	4	D. E.	2	...	...	...	...	...	50	25	11 2	
Other maps	F.	...	...	7	18	25	5	...	...	132	132	35 14	
TOTAL	...	...	...	219	602	1,172	194	14	72	19,538	20,586	13,538 7	

* Additional pr[illegible]s of previous publications; 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 Dun as a matter of convenience, so that it might be under suitable supervision.

Table of working facts for the year 1891-92.

1891-92.	Number of Days.				Number of Negatives.										Number of working days when Solar Phenomena were	
					Solar Phenomena.								Total.			
	When negatives were taken.	Failures.			Spots and Faculæ.		Spots only.		Faculæ only.		None.				Visible.	Absent.
		From bad weather.	From various causes.	Total.	8″	12″	8″	12″	8″	12″	8″	12″	8″	12″		
October	28	3	...	31	52	...	...	...	...	...	...	...	52	...	28	...
November	30	...	...	30	54	...	...	...	...	...	...	...	54	...	30	...
December	31	...	...	31	57	...	...	...	...	...	...	...	57	...	31	...
January	26	5	...	31	45	...	...	...	...	...	...	...	45	...	26	...
February	23	6	...	29	40	...	...	...	...	...	...	...	40	...	23	...
March	29	2	...	31	51	...	...	...	...	...	...	...	51	...	29	...
April	30	...	...	30	54	...	...	...	...	...	...	...	54	..	30	...
May	29	2	...	31	51	9	...	...	...	...	...	...	51	9	29	...
June	25	5	...	30	45	7	...	...	...	...	...	...	45	7	25	...
July	20	11	...	31	30	3	...	...	...	...	...	...	30	3	20	...
August	15	16	..	31	24	...	...	...	...	...	...	...	24	...	15	...
September	18	12	...	30	31	...	...	...	...	...	...	...	31	...	18	...
TOTAL	304	62	...	366	534	19	...	..	...	...	...	...	534	19	304	...

Eight hundred and ninety silver prints of the 8-inch, and nineteen 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	
1889-90	320	78	45	1888-89	182	
1890-91	303	99	62	1889-90†	212	† Year ending 10th May 1890. Obtained from report to the Board of Visitors.
1891-92	304	100	62	1890-91	Not obtainable.	
MEANS	307	...	58	...	193	

DRAWING SECTION.—The details of the work done in this section are given in the tables which follow:—

Statement showing work performed during the year 1891-92.

Title of Map.	Number of Sheets.	Scale.	Remarks.
		Miles per inch.	
General Maps.			
Nepal Boundary Survey—			
District Darjeeling—			
Sheets Nos. 1, 2, 3 and 4 (Mechi River).	4	1	Corrected and completed. Final press order given.
Map of the Southern Coast of Asia	2	96	For Tidal Volume. In hand.
Standard Maps.			
Baluchistan Maps	2	16	Touched up for photozincography. Final press order given.
Punjab Survey Sheet No. 332, N.W.	4	¼	Corrected and completed for reduction. Final press order given.

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Statement showing work performed during the year 1891-92.

Title of Maps.	Number of Sheets.	Scale.	Remarks.
Standard Maps—contd.		Miles per inch.	
Punjab Survey Maps	4	1/4	Corrected and completed for reproduction. Final press order given.
Gujarat Survey Sheet No. 29 (2nd edition)	4	1/2	For reduction to 1/3 scale. In press.
Gujarat Survey Sheet No. 27, Section 4	1	1/4	Corrected for reprints.
Central Provinces Survey (Hoshangabad and Betul).	21	1/4	Corrected and completed. Final press order given.
Mirzapur Survey Sheet No. 185, N.E.	1	1/2	Ditto ditto.
Plans.			
Dehra Municipality and Cantonments (2nd edition).	12	1/19	In hand.
Index Maps.			
Triangulation Chart of India	2	96	Brought up to date for office use.
Diagram of the S. W. Quadrilateral	1	128	Final press order given.
Nimar Forest Survey	1	16	Corrected and completed. Final press order given.
Miscellaneous Maps.			
Tidal Maps of Beypore, Kurrachee, Aden, Okha Point, and Pamban Pass.	5	Various.	In press.
Cochin, Tuticorin, Point de Galle, Port Blair, Moulmein and Colombo.	6	Various.	In hand.
Tidal Curves—Beypore, Kurrachee, and Aden.	3	...	In press.
Tracings of Mergui base-line towers	2	...	For Colonel Strahan.
Plan and elevation drawings of sun-dial	2	...	Ditto.
Sector for constants of stars	1	...	Final press order given.
Forms.			
Village Field Book	1	...	Final press order given.
Electro-telegraphic Longitude. Computation of *Cc*, *Bb*, *Aa*.	1	...	Ditto ditto.
P. 32, page 3	1	...	Ditto ditto.
Record of chronometer comparisons in Telegraphic Longitudes.	1	...	Ditto ditto.
Charts.			
Triangulation Chart, Madras Longitudinal Series	2	4	For reduction to one-half, for Synoptical Volume. Final press order given.
Triangulation Chart, Madras Meridional and Coasts Series	2	4	Ditto ditto.
Triangulation Chart, South-East Coast Series	2	1	Ditto ditto.
Triangulation Chart, Bombay Longitudinal Series	2	4	Ditto ditto.
Triangulation Chart, Bombay Island	1	1/2	Ditto ditto.
Triangulation Chart, Abu Meridional Series	1	4	Ditto ditto.
Triangulation Chart, Gujarát Longitudinal Series	1	4	For reduction to one-half, for Synoptical Volume. In press.
Triangulation Chart, Singi Meridional Series	1	4	In hand.
Triangulation Chart, Cutch Coast Series	1	4	Ditto.
Triangulation Chart, Khanpisura Meridional Series	2	4	Rough Charts for office use. Final press order given.
Triangulation Chart, North-East Longitudinal Series Nos. 1A, 1B, 2, 3, 4, 5 and 6	7	4	Rough Charts. Final press order given.
Longitude Arcs	9	96	For use of the engravers.
Spirit-levelling Operations No. 6, Bombay Presidency, Season 1890-91	1	8	Corrected and completed for reduction to one-half. Final press order given.
Maps coloured	3,037	Various.	

TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

Maps examined.

	No. of Sheets.
General Maps	4
Original Standard Maps	32
Index Maps	4
Miscellaneous Maps	13
Tracing of Original Maps	4
Charts	25
Photographic proofs of Standard Sheets and other Maps	303
TOTAL	385

N.B.—In addition to the above, many miscellaneous jobs have been performed, such as assisting in Photographic Office, completing Central Provinces Survey, Punjab Survey, and Forest Survey original maps in respect to heading and foot-notes, etc., for press, supplied tracings of margins of sheets to Simla Drawing Office, to Gujarát Party, and to Himalaya Party, examined confidential records, and corrected 152 photo-zincographed sheets of Central Provinces Survey.

Statement of work done for other Departments, etc., during the year 1891-92.

TITLE OF MAPS.	Number of Sheets.	Scale.	REMARKS.
		Miles per inch.	
General Maps.			
Maps showing concentration of Troops in Manipur in April 1891	1	16	Additions and corrections made to map of Assam Province for Quarter Master General in India. Final press order given.
Skeleton Route Map	1	16	Corrected for the Quarter Master General. Final press order given.
Standard Maps.			
Forest Surveys	48	Various	Completed headings, foot-notes, and references. Final press order given for Forest Survey Branch.
Miscellaneous.			
Canal Distributary and Water-Course discharge Chart	1	...	Copied explanation in Persian character. Final press order given.
Maps coloured	160	Various.	

Statement showing the value of work done for other Departments, etc., during the year 1891-92.

DEPARTMENTS, ETC.	Value.	
	R	*a.*
Quarter Master General's Department	9	14
Forest Survey Office	103	0
Deputy Commissioner, Simla	7	13
Major Clibborn, Principal, Thomason College, Roorkee	10	0
TOTAL	130	11

G. I. C. P. O.—No. 16 S. G. 22-4-93.—450

1893.

File No. 111.

Serial No. 2.

GOVERNMENT OF INDIA.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

No. $\frac{8}{111}$.

Dated Simla, the 22nd May 1893.

SUBJECT.

Resolution on the General Report of the Operations of the Survey of India Department for the year 1891-92.

G. C. Press, Simla.—No. 174 R. & A. D.—23-5-93.—670.

Extract from the Proceedings of the Government of India in the Revenue and Agricultural Department,—No. $\frac{8}{111}$. *(Surveys), dated Simla, the 22nd May 1893.*

RESOLUTION.

THE report for the year ending 30th September 1892 is, as usual, well compiled and accompanied by excellent maps and plates.

2. Twenty-one parties and six small detachments were employed on field operations during the year, as shown in the following list :—

	Number of parties.	Number of detachments.
1. Trigonometrical	1	...
2. Topographical	3	2
3. Forest	4	...
4. Cadastral	7	2
5. Traverse	1	1
6. Scientific	3	...
7. Geographical	2	1

Of these, 12 parties and 3 detachments may be held to have been engaged on remunerative operations, *i.e.*, on work connected with the enhancement of land or forest revenue.

3. The trigonometrical operations were, as in the previous year, carried on by one party only. The topographical establishment was somewhat reduced, and the outturn of work has consequently been a little less than in 1890-91. That of the Forest Surveys is, on the other hand, considerably larger than last year, mainly owing to the rapidity of the 4-inch scale operations in Madura and Coimbatore.

4. The establishment engaged on cadastral surveys has been particularly strong during the year under report, and both the outturn of work (6,598 square miles in all) and the reduction which has been effected in its cost are creditable to the Department. The extensive operations in Orissa have been carried out at an expenditure of Rs. 22 less per square mile than last year, and a considerable reduction in the rates has taken place in Upper Burma. In Garhwál the cost has been reduced from Rs. 283 to Rs. 183 per square mile

5. The Government of India notice with satisfaction the efficient manner in which during the year the Survey Department has co-operated with the Provincial Revenue authorities in the conduct of cadastral surveys. As indicated in the Government Resolutions on the survey reports of previous years, the gradual reforms which have been recently introduced, and which require, on the one hand, the more effective utilization of local agency in the construction of field maps, and, on the other, the employment of survey subordinates for the compilation of many of the registers comprised in the record-of-rights, have necessitated intimate and cordial relations between the Survey and Provincial officers. These have now been everywhere established. The amalgamation of the survey and revenue departments has, indeed, during the last year reached its fullest development in the appointment of Lieutenant-Colonel Sandeman as Director of the Bengal Surveys under the administrative orders of the Government of Bengal, and credit is due both to that officer and to Colonel Thuillier for the part which they have taken in the satisfactory arrangements which have been secured for the progress of survey operations in that Province. The instructions in the Resolution of last year on the subject of personal tours have at the same time been zealously carried out in other Provinces by Lieutenant-Colonel C. Strahan, the Deputy Surveyor General directly responsible for the superintendence of revenue

surveys, with the result that none of the difficulties which arose occasionally in previous years through want of a complete understanding between the Revenue and Survey officials have occurred during the year under report.

6. The only survey connected with the development of mining industries has been that of the detachment in Mergui and Maliwun, which has under considerable difficulties proceeded with a topographical survey of the tin and coal bearing regions in that neighbourhood.

7. General measures are under consideration for improving the pay and prospects of the Junior Division of the Survey of India. In the meanwhile, one step has been taken in this direction by securing for survey officers of the Junior Division five posts of the newly-constituted Land-Records Department in Burma.

The designation of officers throughout the Junior Division has been altered, and the Extra-Assistant Superintendents, who are at the head of the Junior Division, now rank as gazetted officers.

8. The work done in the Photographic and Lithographic office continues to show a large increase, especially in the printing sections, and it is found very difficult to comply with the demands for colour printing, even with the aid of steam machinery. The combined outturn in pulls of the lithographic and zincographic presses and machines was in 1878-79, 233,989; in 1888-89, 466,082; and in 1891-92, 756,068: these figures serve to show the increase, due in part to the introduction of steam power, in these sections. During the past year there were issued 1,318,597 impressions from print and 92,415 heliogravure prints. In 1878-79 the impressions were 367,175 only: the heliogravure prints in 1888-89, when this process was started, were 20,307.

The value of the outturn for the last three years, as compared with that for 1881-82, was—

1881-82.	1889-90.	1890-91.	1891-92.
Rs.	Rs.	Rs.	Rs.
1,69,054	2,00,374	2,08,654	2,10,357

The increased work in this office has necessitated the strengthening of the establishment.

The value of the instruments issued by the Mathematical Instrument Office at the same time has risen since last year from Rs. 2,88,337 to Rs. 3,16,373.

9. The Department continues to show good work in all its branches, 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, Inspector General of Forests, Local Governments and Administrations noted on the margin, and to the Foreign, Military, and Public Works Departments.

Madras.
Bombay.
Bengal.
N.-W. P. and Oudh.
Punjab.
Central Provinces.
Burma.
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.