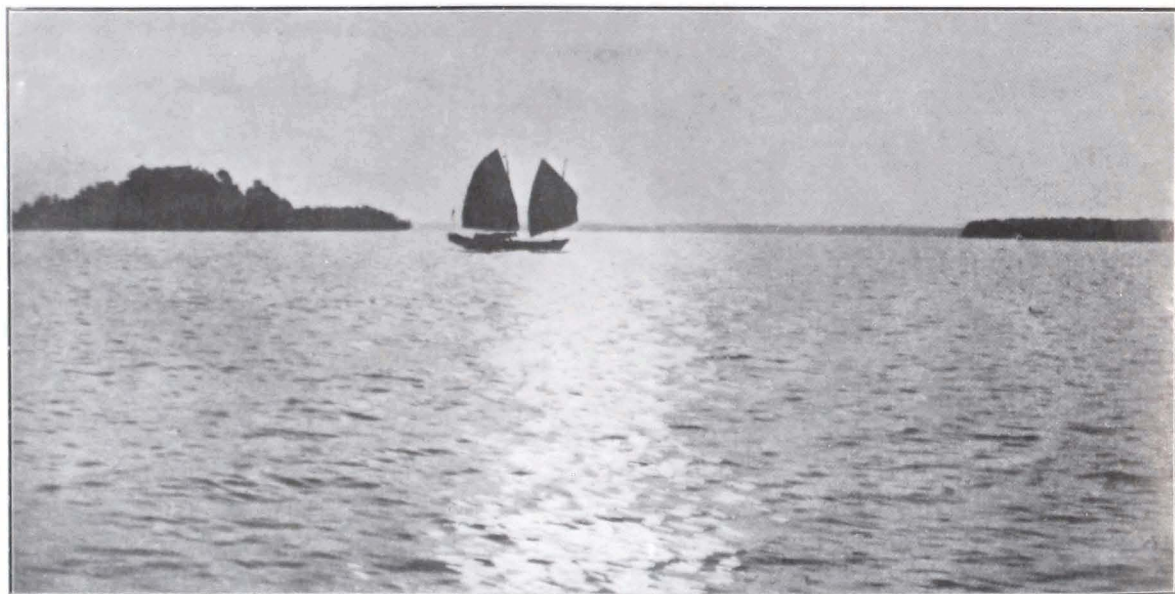


Photograph by Major Wheeler.

MAKALU.



Photograph by Captain Penney.

MERGUI ARCHIPELAGO.

RECORDS

OF THE

SURVEY OF INDIA

Volume XVIII

(Supplementary to General Report 1921-22).

ANNUAL REPORTS OF PARTIES AND OFFICES 1921-22.

PREPARED UNDER THE DIRECTION OF

Colonel C. H. D. RYDER, C. B., C. I. E., D. S. O., R. E.

Surveyor General of India.



DEHRA DUN
PRINTED AT THE OFFICE OF THE TRIGONOMETRICAL SURVEY
1924

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PART I.—TOPOGRAPHICAL SURVEY.

NORTHERN CIRCLE.

(Vide Index Map No. 1).

Summary.—This circle was under the superintendence of Lieut.-Colonel H. Wood, R.E.

During the year Nos. 2, 3, 4 Parties completed 11,528 square miles of detail survey on the $\frac{1}{2}$ -inch, 1-inch, and 2-inch scales, excluding 37 square miles surveyed on half-inch scale in 1920-21 and re-surveyed on one-inch scale in 1921-22 and 9 square miles surveyed on eight-inch scale.

In addition an area of 9,318 square miles was triangulated by Nos. 1, 2 and 4 Parties and 289 square miles was traversed by No. 4 Party for detail survey next year.

The detail survey consisted of:—

492	square miles of half-inch original survey.
294	“ “ of one-inch original survey.
6,345	“ “ of one-inch revision survey.
2,425	“ “ of one-inch re-survey.
1,969	“ “ of two-inch original survey.

No. 22 (Riverain) Party and 23 (Punjab Rectangulation) Party (late Sind Sagar Party) continued special work in the Punjab for the Local Government. The former carried out the usual riverain survey in the Punjab and the latter, rectangulation work in connection with the Sutlej Valley Canal and Colonisation Project.

A detachment designated the Bhopāl Traverse Detachment was formed to carry out traverse work in the Bhopāl State at the request of the Bhopāl Durbar.

No. 20 Party (Cantonment) was re-transferred to this circle from 1st April 1922.

No. 1 PARTY (PUNJAB, PUNJAB STATES AND UNITED PROVINCES).

By C. C. BYRNE.

The head-quarters of the party remained at Mussoorie during the whole year. The

PERSONNEL.

Class I Officers.

- Lt. G.H. Osmaston, M.C., R.E., (on probation),
from 1st May to 11th July 1922.
Lt. G.F. Heaney, R.E., (on probation), from
1st May to 11th July 1922.

Class II Officers.

- Mr. C.C. Byrne, in charge from 18th February
1922.
“ P.A.T. Kenny, O.B.E., in charge up to 17th
February 1922.
“ A.M. Talati, L.C.E., from 1st July to 18th
September 1922.
Major C.H. Fresham.
Mr. R.C. Hanson, to 31st January 1922.
“ A.J.A. Drake, D.C.M., to 30th June 1922.
“ H.F. Hughes, to 14th March 1922.
“ O.D. Jackson.

Upper Subordinate Service.

- Mr. Sher Jang, K.B., from 27th February 1922.
“ Muhammad Husain Khan, K.S., from 16th
January to 1st September 1922.
“ Afraz Gul Khan, K.S., to 31st December
1921.
“ Muhammad Khan.
“ Muhammad Hasan, from 18th April 1922.
“ Jit Singh Rawat.
“ Sijawal Khan.
“ Latif Khan.
“ Mohammad Jamsed, (on probation), from
1st September 1922.
“ Mohammad Abdus Sattar, (on probation),
from 1st September 1922.

Lower Subordinate Service.

30 Surveyors, etc.

health of the party has been fairly good, there were no cases of serious illness and no deaths. Malarial fever and a mild form of Influenza were however prevalent throughout the year, a large percentage of the staff being attacked at various times.

Plane-tabling.—Except for a small area, which remained to be completed at the end of the previous year, no detail survey was done during the year. This area was included in last year's report, but the cost was not taken into account. The cost-rates for the whole area of 8,400 square miles, reported as surveyed last year, on the one-inch, half-inch and quarter-inch scales, are therefore Rs. 11.0 per square mile for original survey, and Rs. 15.2 per square mile for revision survey.

Triangulation.—An area of 2,700 square miles, for detail survey next year, was triangulated by Mr. A.J.A. Drake, D.C.M., assisted by Mr. Jit Singh Rawat. This area lies along the hills in the south-western portion of the Dera Ghāzi Khān district, of the Punjab and the adjacent portion of the Sibi district, of Baluchistān, falling in sheets 39G/11.12.15.16, 39H/9.10.13.14 and parts of 39K/2.3.4.5.

The country is bare and inhospitable, supporting few inhabitants; water is scarce and generally brackish; the altitude ranges from about 300 to 4,500 feet above sea level and, except for a few

camel tracks along the larger streams, there are practically no communications. The main watershed, running roughly south-west to north-east, forms the boundary between the Punjab and Baluchistān.

The main triangulation was done by Mr. Drake; the supplementary work of fixing points in the foot hills and the plains on the east, was done by Mr. Jit Singh Rawat over an area of 1,170 square miles.

In addition to the triangulation there are in the plains a fairly large number of permanently marked village trijunctions, the geographical positions of which were fixed, in the course of previous cadastral surveys, by traverses based on twenty stations of the Principal triangulation (Indus Series). These will provide sufficient points for the revision of the existing one-inch maps covering the Dera Ghāzi Khān, Jāmpur and Rājanpur *Tahsils* of the Dera Ghāzi Khān district. The cost of the triangulation is Rs. 7·8 per square mile.

Recess Duties.—The party, having been in the field during the whole of the previous year, spent the whole of the current year in doing recess work. In the report of the previous year it is mentioned that the greater part of the fair-mapping of that year was done by pupils without adequate supervision; this work, in various stages of completion, has passed into this year's programme and has caused serious delay in the execution of the other work of the party. Nearly all the typing has had to be redone and the examination and correction of these sheets has been a long and very tedious process. It has been found impossible to separate the work of last year from that of the current season with any degree of certainty and consequently it has been necessary, after careful investigation, to make a distribution of the fair-mapping in such a way as to convey a fairly accurate idea of the relative cost. The work to which this report refers covers twenty-nine sheets on the one-inch scale and seven sheets on the half-inch scale, viz :

(i) one-inch sheets:—43P/16, 52C/8.12.16 and 52D/1.2.3.5.6.7.9.10.11.13 to 16, 53A/5.11.12.15.16, 53E/3.7.8.11 and 53F/5.13.14.

The area to be mapped on the above sheets = 7,777 square miles.

(ii) Half-inch sheets:—

52 D/sw. se., 52 H/sw., 53 A/ne., 53 E/nw. ne. se.

The area to be mapped on these sheets = 6,584 square miles.

With the exception of Nos. 52 D/14.15.16 and 53 F/13 all the one-inch sheets were completed and sent for publication during the year. The sheets above mentioned were also completed, except for a few finishing touches; but the final examination and ornamentation of 53 F/13 remains to be done. This sheet will be completed and submitted from the field. The other three sheets will be submitted before the party takes the field, in the first week of October.

As nearly as can be calculated the area fair-mapped during the year, including the four sheets mentioned above, works out to 6,498 square miles; the cost-rate of the mapping on the one and half-inch scale, for publication on the one-inch scale = Rs. 8·1 per square mile; the cost-rate for mapping the complete set of 29 sheets (7,777 square miles) for publication on the one-inch scale = Rs. 11·5 per square mile.

Of the sheets to be published on the half-inch scale, the mapping of Nos. 52 D/sw.se. and 53 E/se. was taken over by No. 3 Drawing Office; the mapping of No. 53 A/ne. was completed and examined, except for the ornamentation and touching up of the limit of cultivation; the drawing of the remaining three sheets was taken in hand and carried on till the end of the year. The sheets were then transferred to No. 3 Drawing Office for completion. It is estimated that the work done is equivalent to the completion of about one sheet and a half, representing an area of 1,500 square miles. The cost-rate of mapping on the three-quarter-inch scale, for publication on the half-inch scale, works out to Rs. 3·8 per square mile.

The heavy arrears with which the party was burdened, the frequent changes of personnel both in the supervising and drawing staffs, the employment of pupils for fair-mapping and the depletion of the supervising staff, are some of the circumstances which have combined to render the task, which the party has had to perform, one of peculiar difficulty. This has been felt at every stage of the work and the fact that 7,998 square miles have been successfully mapped is due to the patient and persevering efforts of those concerned.

Inspections.—The party was inspected weekly by the Superintendent, Northern Circle, throughout the year and by the Surveyor General in April 1922.

No. 2 PARTY (CENTRAL INDIA, DELHI PROVINCE, RAJPUTANA AND UNITED PROVINCES).

By **BT.-LIEUT.-COLONEL S. W. S. HAMILTON, D. S. O., R. E.**

The normal topographical programme of the party was continued.

(a) Original survey on the half-inch scale of sheets 54 J/10.14 (part).

(b) Re-survey on the one-inch scale of sheets 54 I/3.7.12.16, 54 M/3.4 and 54 J/1.5.9.14 (part)

(c) Revision survey on the one-inch scale of sheets 54 E/7(part), 54 I/4.8.11.15, 54 M/7.8 and 54 N/11.12.15.16.

(d) Original survey on the eight-inch scale of the headworks of the Western Jumna Canal.

(e) Triangulation for original survey on the half-inch scale in sheets 54 F/ (less 54 F/1.5 and parts of 9.13) and in sheet 54 J/ (less 54 J/1.5.9.13).

(f) Traversing for original survey on the sixteen-inch and sixty-four-inch scales in the Municipal areas of Allahābād City.

(g) Traversing of the boundaries of demarcated areas of leased land in Imperial Delhi.

(a) The country surveyed on the half-inch and one-inch scales consisted entirely of cultivated plains, for the most part open and easy except in a few places where trees were numerous. There was a great deal of broken ground along the banks of the Jumna and Chambal rivers. Along the tributaries of the Jumna in Jālaun and Cawnpore districts, this broken ground, though not of great height or difficult of negotiation

was much spread out over the country; while that along the Chambal, was from two to three miles in width on either side of the river, forming deep ravines, averaging a hundred and more feet in height, and broken up into pinnacles or flat tops with cliffs on all sides impossible of access. The tracks followed the main streams and were few and far between and mostly only fit for foot traffic. There were no hills in the areas surveyed.

The head-quarters opened in the field at Agra on the 2nd November 1921 and re-opened in recess at Mussoorie on the 4th May 1922. The health of the party was excellent.

Plane-tableing.—As in the previous two field seasons, all first year soldier surveyors and a large number of the pupil surveyors in the circle, numbering 11 and 6 respectively, were attached to No. 2 Party for training. In addition, there were four Class I, one Class II and two Upper Subordinate officers on probation. The country lent itself well for training purposes, though it was not possible to give any real instruction in contouring or in the depiction of hill features. It is hoped that it will prove possible to give such instruction next year when the party will be working in the hilly areas of Gwalior and Eastern Rajputāna.

PERSONNEL.

Class I Officers.

Bt.-Lt.-Col. S. W. S. Hamilton, D. S. O., R. E., in charge to 28th April 1922.

Captain L. H. Jackson, I. A., in charge from 29th April 1922.

Captain W. J. Norman, M. C., R. E. (on probation), Captain T. W. R. Haycraft, R. E. (on probation) to 31st May 1922.

Lieut. G. H. Osmaston, M. C., R. E. (on probation) to 30th April 1922.

Lieut. G. F. Heaney, R. E. (on probation) to 30th April 1922.

Class II Officers.

Mr. J. McCracken, M. B. E.

„ C. O. Picard, to 31st May 1922.

„ Duni Chand Puri.

„ P. K. Ghosh, B. Sc. (on probation).

Upper Subordinate Service.

Mr. Muhammad Husain Khan, K. S., from 22nd October 1921 to 15th January 1922.

„ Muhammad Husain.

„ Imam Din.

„ Afraz Gul Khan, K. S., from 1st January 1922.

„ Jagannath.

„ Narasingh Dass Joshi, B. A.

„ Mohammad Jamsed (on probation).

„ Mohammad Abdus Sattar (on probation).

Lower Subordinate Service.

57 Surveyors, etc.

The party was divided into 5 camps as given in the table below :—

No. of camp.	Name of camp officer.	Camp Headquarters.	No. of surveyors.	No. of officers under instruction. Soldier surveyors and pupils.	Sheets surveyed.	Scale and class of survey.
1	Mr. Md. Husain Khan, K. S., and later Mr. J. McCracken M.B.E.	Akbarpur and Bind	10	1	54 N/11.12.15.16	1-inch revision. ½-inch original and 1-inch re-survey.
			9	2	54 J/10. 14	
2	Mr. C.O. Picard ...	Mainpuri	12	7	54 M/3.4.7.8	1-inch re-survey and 1-inch revision.
3	Mr. Imām Din ...	Shikohābād and Ghiror	6	9	54 I/11.12.15.16 & 54 J/9.	do.
4	1st class surveyor Khushal Khan and later Capt. T.W.R. Haycraft, R.E.	Tündla	7	9	54 I/3.4. 7	do.
5	1st class surveyor Abdul Aziz Khan and later Capt. W. J. Norman, M.C., R.E	Pināhat	6	5	54 I/8 and	1-inch re-survey and 1-inch revision.
					54 J/1. 5.	
	Under O.C. Party ...	...	1		54 E/7	1-inch revision.

In cases where surveyors worked under two different camp officers, they are counted as having been in each camp. Mr. Afraz Gul Khan, K.S., was attached to No. 1 Camp for a short period during the season, for instruction in a camp officer's duties. Mr. D.C. Puri did not have an ordinary camp charge but was employed in teaching and helping the officers and surveyors in charge of Nos. 4 and 5 Camps, none of whom had previously any experience of these duties; in addition he generally supervised the instruction being imparted to their men under training. He was also in charge of the traverse work in Allahābād City and in Imperial Delhi.

1-inch revision survey was carried out by trained and partially trained surveyors, while 1-inch re-survey, which was specially arranged for them in lieu of revision survey, was done by all the officers under instruction and by the first year soldier surveyors and pupils. Later in the season the two junior Class I officers were given an area of original survey on the half-inch scale, the two sheets of which had been specially included in the programme with a view to these officers' instruction.

The one-inch survey was based on old revenue traverse data supplemented by new traverse work carried out the previous season in sheets 54 J/1. 5. 9, while the half-inch survey was based on triangulation, observed and computed in the field earlier in the same year.

For the initial period of instruction, a convenient area of one-inch re-survey, not too difficult, but containing as much variety of detail as possible, was selected for each camp. The graticules, traversed trijunctions, scales, lists, etc. of this area were plotted in recess, on to a half Bristol board, one for each man under training. Each camp officer then devoted from a month to 6 weeks, within the area selected, to the individual training of his men according to their several capabilities; after which, if the officer in charge of the party was satisfied with their progress, the men were given separate and independent plane-table sections. These they had helped to prepare during their collective training, the plotting being done by the men themselves. The officers in charge of Nos. 2, 3 and 4 Camps were each allowed one first

class surveyor to assist them until their men under instruction could work independently and without frequent supervision. This period was found to vary from 6 weeks to 2 months.

In order to give a greater usefulness to the published sheets, the heights along main canals and distributaries have been obtained from the various Executive Engineers concerned and selected values have been inserted on the fair maps in these areas in the plains where no other information was available. A note to this effect has been entered on the plane-table sections. Where possible these were compared in 1920-21 with levelled bench-marks and other traversed heights and were found not to vary more than two or three feet.

The survey of the Headworks of the Western Jumna Canal, undertaken at the request of the Superintending Engineer of the Irrigation Circle, on the eight-inch scale was a small, simple, and straight-forward piece of work which calls for no special remark. It was based on triangulated points from the Himālayan triangulation and was carried out by a surveyor on deputation working directly under the Executive Engineer.

Out-turn and cost-rates are given below :—

Scale.	Class of survey.	Area in square miles.	Cost-rate per square mile.
			Rupees.
½-inch	Original	492	22·1
1-inch	Re-survey	2,425	16·9
1-inch	Revision	2,694	12·8
8-inch	Original	9	121·3

The cost-rate for half-inch original survey is very high due to various reasons; the triangulation being done the same season, the data in consequence were not ready earlier and it proved necessary to move a number of surveyors to small areas, in many cases from long distances, to ensure that the survey was completed in the season, thus causing extra expense. Also this survey has to bear the charges of pay of the two junior Class I officers under instruction during the period, as well as the pay of senior surveyors, sufficiently trained to complete the work efficiently and well. The cost-rate for one-inch re-survey has also been adversely affected by the charges of pay of officers under instruction.

Triangulation.—In its course of progress the party has now reached Gwalior State in Central India and the Indian States of Eastern Rājputāna, and the country triangulated was of a different nature to the heavily cultivated plains of the United Provinces. The country covered by sheet 54 F and the south-west portion of 54 J consisted for the most part of small ranges of hills varying in height from 900 to 1,400 feet, outcrops from the Vindhya Range to the south. These were mostly covered with long grass and dense jungle, and often proved difficult to negotiate. Communications were poor and habitations sparse, but on the whole the country was easy to triangulate, though necessitating extensive clearing and requiring many stations. The central and south-east portions of 54 J, though not heavily cultivated, nevertheless, owing to their flatness, to numerous trees round villages, and to the absence of hills, also necessitated a very large number of stations and required a careful and intelligent reconnaissance. The work was based on the Great Arc Meridional and on the Budhon Series, which run parallel through the area from north to south, and on the old Gwalior and Central India Topo. Triangulation. A large number of the upper markstones of the G. T. series, and in many cases the lower markstones also, were found missing, and a special report on this matter has been submitted to the Superintendent of the Trigonometrical Survey. The triangulation of sheet 54 F (less F/1.5) was done by Mr. P. K. Ghosh, B.Sc., Extra Assistant Superintendent, who completed an area of 3,500 square miles, and that in 54 J by Mr. Jagannath, Sub-Assistant Superintendent, who completed an area of 3,060 square miles.

The triangulation of sheets 54 J/10.14 was completed in the field. Its survey on the half-inch scale, completed during the same season for the instruction of officers under training, is referred to under plane-tabling above. The total out-turn was 6,560 square miles and the cost-rate per square mile was Rs. 2·0.

Traversing.—The traverse of Allahābād City and its Municipal areas for detail survey on the sixteen-inch and sixty-four-inch scales, commenced in 1920-21 for the Allahābād Improvement Trust, was continued in December 1921 and completed in February 1922. The work was in charge of Mr. Duni Chand Puri, Extra Assistant Superintendent, with two traversers and two computers, computation being carried out *pari passu* with the traverse. Twenty-one plot charts of the work in the sixty-four-inch area, which were urgently required for detail survey, were completed in the field. (*See also Part III—Special Reports*).

On the completion of work in Allahābād, the traversers and computers were transferred to Imperial Delhi to undertake the traverse of the boundaries of demarcated areas in the New City, which have been, or are to be, leased in perpetuity to the holders. The traversers were started on work by Lieut.-Col. S. W. S. Hamilton, D.S.O., R.E., a main line being run across the area of the Imperial City from north to south via Kutab Road, Prithvi Raj Road, Hardinge Avenue, Lytton Road and Lanch Kumar Road, joining up Pillars Nos. 607 and 201 of the boundary traverse of Imperial Delhi executed by No. 18 Party in 1915-16, the various sub-traverses required to connect up the area demarcated being taken off this main line. The work and the number of stations required entailed considerably more labour than was originally expected, but by keeping the traversers out until the end of April all the work asked for was completed.

No traverse work for topographical survey was undertaken.

Cost-rates are given in the table below :—

Scale of detail survey	Place	Area in acres	No. of traverse stations	Linear miles chaining	Cost-rate per linear mile Rs.
16-inch ...	Allahābād	31·91	514	78	18·0
64-inch ...	do.	(sq. miles). 1,324·8	623	35	79·7
12-inch (boundary traverse) ...	Delhi ...	941·2	1,188	57	58·8

The cost-rates given include computation of the work.

Recess Duties.—For the purpose of fair-mapping the party was divided into four sections as given in the table below :—

No. of section.	Name of Section officer.	No. of draftsmen.	No. of sheets.	Scale of fair-drawing.
1	Mr. J. Mc Craken, M. B. E.	7	54 N/11.12.15.16, J/14, 54J/NE.	1½-inch and ¾-inch
2	Captain W.J. Norman, M. C., R. E.	5	54 M/3.4.7.8	1½-inch
3	Mr. Imam Din	6	54 I/11.12.15.16, J/9, 54E/NE.	1½-inch and ¾-inch
4	Mr. D. C. Puri	5	54J/1.5 & I/3.4.7.8	1½-inch

Fifteen one-inch sheets have been submitted in September 1922 and the remaining one-inch and half-inch sheets will be submitted before the party leaves for the field. No. 2 Party will thus have no arrears of fair-mapping. The outline of 3 sheets, viz., 54 J/9,14 and 54 I/16 has been drawn on contract overtime system adopted in this party last recess. An estimate is made of the number of hours required and the draftsman, who must have first class qualifications, is then given the sheet to draw entirely out of office hours, being paid his overtime on completion, with the proviso, however, that any corrections must be carried out by him as overtime without payment. The amount expended on overtime payments during recess will total Rs. 414.

The cost-rates of fair-mapping are given below :—

Scale of fair-mapping.	Area in square miles.	Cost-rate per square mile. Rupees.
1½-inch for 1-inch sheets	5,004	6·7
¾-inch for ½-inch sheets	1,749	3·0

A section was also maintained under Mr. Afraz Gul Khan, K. S., for the training of soldier surveyors and pupils. Four soldier surveyors reverted to their units during recess. Captain T. W. R. Haycraft, R. E. (on probation) and Mr. C. O. Picard were transferred to No. 3 Party and No. 3 Drawing Office respectively from 1st June 1922, and Lieutenants G. H. Osmaston, M. C., R. E. and G. F. Heaney, R. E. (both on probation), were transferred to No. 1 Party from 1st May 1922.

(b) A section composed of one triangulator, 2 traversers and 2 computers, under Mr. P. K. Ghosh, B. Sc., has been employed throughout the recess on the computation of last season's triangulation for original survey on the half-inch scale, the preparation of traverse plot charts from the old traverse records of Agra district for re-survey on the one-inch scale, and the preparation of traverse plot charts of 1920-21 traverse for original survey on the half-inch scale, required for next season. The computation of the traverse of Allahābād City has also been completed, and 9 plot charts for detail survey on the sixty-four-inch scale and 44 plot charts for detail survey on the sixteen-inch scale have been drawn and sent to the Chief Engineer, Allahābād Improvement Trust. A schedule, together with an index plot chart, of the boundaries of demarcated areas traversed in the New City of Imperial Delhi has been prepared in book form in recess, and supplied for record to the Chief Engineer, P. W. D., Delhi. Other miscellaneous work has consisted in keeping the party records, etc., up to date, preparation of Bristol boards for training of next year's pupils, preparation of Index maps, field progress charts, triangulation charts, and extraction of data for the continuation of the survey of the Western Jumna Canal on the scale of 1/4,000.

Miscellaneous.—There were no marked physiographical changes in the area that came under survey during the year.

Inspections.—The party was inspected once by the Surveyor-General and on numerous occasions by the Superintendent, Northern Circle.

No. 3 PARTY (UNITED PROVINCES).

BY MAJOR C. G. LEWIS, R. E.

During the year under report the survey of the Garhwāl and Kumaun hills on the two-inch scale was continued, the area required by the Forest Department being nearly completed. The field head-quarters were moved from Bareilly to Almorā, where the party office opened on 7th November. Nos. 1 and 2 Camps took the field earlier than the remainder of the party in order to complete the survey of the higher ground in their areas before the arrival of the snow. They reached their respective head-quarters at the end of October.

The area surveyed consisted of high hills, densely wooded on the northern slopes, and deep valleys, the lower slopes being terraced for cultivation.

The three camps completed their work by the 24th February, 20th March and 9th April respectively.

38 Surveyors, etc.

The health of the party was very good. The 17 surveyors of Nos. 1 and 2 Camps

PERSONNEL.

Class I Officers.

Captain L. H. Jackson, I. A., in charge up to 28th April 1922.
Major C. G. Lewis, R. E., in charge from 29th April 1922.
Captain T. W. R. Haycraft, R. E. (on probation), from 1st June 1922.

Class II Officers.

Captain J. H. Williams, up to 11th May 1922.
Mr. E. B. West, up to 16th July 1922.
.. L. Willinms, M. B. E.
.. J. H. Johnson.
.. A. J. A. Drake, D. C. M., from 1st July 1922

Lower Subordinate Service.

reported a total of only 4 days of sickness during the season. No. 3 Camp averaged 1 day's sickness in 2 months. Surveyor Adalat Khan died on 25th October while on leave and surveyor Farman Ali was killed on 30th January by an accidental fall on a dangerous hill side.

Plane-tabling.—The programme comprised survey in 19 two-inch sheets distributed in three camps as follows :—

No. 1 Camp, under Mr. West, (head-quarters, Gwaldam) sheets 53 N/4s(part). 8 s(part). 12 s. 16 s.

No. 2 Camp, under Mr. L. Williams, (head-quarters, Sandeh and later Thal) sheets 62 B/1 s. 8 s. 12 s and 62 C/1 N & s. 5 N & s (part). 9 N (part). 9 s (part).

No. 3 Camp, under Captain J. H. Williams, (head-quarters, Pithoragarh), sheets 62 C/2 N & s. 3 N. 6 N(part). 6 s(part). 7 N(part).

The Nepāl boundary following the Kālī river formed the eastern limit of the work though a considerable area in Nepāl was surveyed by "sketching" from the British side.

In sheets 53 N/16 s and 62 B/4 s. 8 s some of the reserved forests extend beyond the north margin of the sheet. As there are no reserves in the area to the north, these forests were completely surveyed, the over-lapping portions being mapped as outriggers.

The country surveyed by Nos. 1 and 2 Camps consisted of very high ground, the hills in sheets 62 B/s. 12 rising to 19,000 feet and the average height of valleys being 6,000 to 7,000 feet. Work was completed in the higher ground by the 15th January, when heavy falls of snow occurred which would have made further work in that area impossible. The highest fixing made by a plane-table was at 14,950 feet, while several were made at over 14,000 feet.

In the high ground the hills were mostly devoid of trees, except on the northern slopes. The high level reserved forests which are little exploited, have no compartment boundaries and their external boundaries were as a rule easy to locate; these factors combined to simplify the work of the plane-tablers. In the remaining area chiefly surveyed by No. 3 Camp, the hills were for the most part densely wooded and boundary pillars were difficult to find; in the vicinity of Pithoragarh the country was in addition extremely intricate.

Communications were bad throughout the area, especially in the higher ground; only cooly transport could be employed.

The survey of the Kumaun hills on the two-inch scale was undertaken in 1915 in the interests of the Forest Department and for three seasons prior to the year under review, owing to the fact that the greater portion of the area surveyed consisted of reserved forests, the whole area was surveyed on the two-inch scale to avoid inconvenient changes of scale. This policy was pursued during the current year although the reserved area was only 540 square miles out of a total area surveyed of 1,969 square miles.

Discrepancies between boundaries, as demarcated on the ground and as notified were as a rule reconciled in the field by reference to the Forest officials, but in the higher reserves it was found that many boundary pillars had been erected in positions differing widely from those described in the notifications, being sometimes located far outside the reserve to which they belonged. In these cases the boundary as notified has been correctly shown on the fair maps.

The cost-rate of plane-tabling on the two-inch scale was Rs. 51·6 per square mile. This figure should be taken in conjunction with that for the average number of fixings per square mile, viz., 6·2. As the bulk of the area lay in high, sparsely inhabited hills only a small proportion of which consisted of reserved forests, surveyors were instructed in the case of non-reserved areas, to relax the standard of detail required by the scale and to carry out plane-tabling as for the one-inch scale. The cost-rate is thus not representative of rigorous 2-inch survey. The fact that it is as high as the previous season is due to the very high cost of transport and to the total absence of local supplies.

As it was impossible to purchase supplies of any sort in the area under survey, arrangements were made beforehand with Army head-quarters to draw rations for the party on payment from the 1/3 Q.A.O. Gurkha Rifles at Almorā. The cost of rations was recovered monthly from those to whom they were issued and was refunded in cash to the Officer Commanding 1/3 Gurkha Rifles.

Each camp officer entertained from 50 to 80 permanent Nepālese coolies. These were used for moving camp officers' and Surveyors' camps and for the distribution of rations from camp head-quarters to surveyors. For the conveyance of rations from Almorā to the head-quarters of the three camps, 1½ troops (144 mules) of the 23rd Pack Mule Cadre, complete with personnel, equipment etc., were hired at a cost of Rs. 16 per mule per mensem. In August arrangements for the supply of dumps of grass at pre-arranged camps were made with the Forest Department. The mule cadre supplied their own rations for men and animals, which had to be carried with them on convoy work. This meant that for a trip of 5 marches to camp head-quarters and back (viz. 9 days) only 70 mules were available for the party rations, the remainder being required for the rations and kit of the mule cadre.

A time-table of marches for the mule convoys was drawn up by the Officer in charge, by which each camp was rationed on an average every five weeks. This time-table was strictly adhered to by the convoys. The routes were in a very bad state of repair, which resulted in accidents to mules on several occasions, though only one animal was killed during the season. No local transport could have operated continuously on these roads under such conditions. The cost of this transport was high, but was well repaid by the gain in time and efficiency, which enabled the survey of the high ground to be completed before the coming of snow.

Triangulation.—The programme included the triangulation of sheets 53 N/1. 2. 3. 6. 7 but it was found impossible to attempt this work owing to the difficulties of supply and transport in Garhwā district, and it was abandoned.

No traversing was carried out.

Recess Duties.—The fair-mapping including 16 sheets of arrears which remained over from last year, was distributed in three sections—

No. 1, under Mr. West and later Mr. Drake.

Current 2-inch sheets 53 N/4 S. 8 S. 12 S. 16 S.

Arrears 2-inch sheets 53 J/16 N, N/4 N. O/16 N, 62 C/3 S.

Arrears 1-inch sheet 53 O/16.

No. 2, under Mr. L. Williams.

Current 2-inch sheets 62 B/4 S. 8 S. 12 S, 62 C/1 N & S. 5 N & S. 9 N & S.

Arrears 2-inch sheets 53 O/15 N & S, 62 C/4 N. 8 N.

Arrears 1-inch sheets 62 C/4 S.

No. 3, under Mr. Johnson.

Current 2-inch sheets 62 C/2 N & S. 3 N. 6 N & S. 7 N.

Arrears 2-inch sheets 53 O/11 N & S 14 N & S.

Arrears 1-inch sheets 53 O/12.

Captain Haycraft assisted in the examination of sheets for No. 3 section.

Considerable use was again made of overtime, 4 outline sheets and 3 contour sheets were drawn on contract and all typing in overtime was done as "piece-work," special rates being worked out for the various items such as village names, spaced names, heights and contour values.

The cost-rate of 2-inch fair-mapping for 2-inch sheets was about Rs. 25.0 per square mile. Owing to the arrears it is impossible to estimate accurately the area of mapping actually completed.

Eight arrears sheets have been submitted for publication and it is anticipated that the remainder will be submitted by the close of recess. The current sheets are well advanced; they will be completed by a small party drawing section during the cold weather and should all be submitted before the commencement of next recess.

Inspections.—The party was inspected once in recess by the Surveyor General and was visited weekly by the Superintendent, Northern Circle, throughout the recess season.

No. 4 PARTY (UNITED PROVINCES).

By M. C. PETERS.

This party which had been in abeyance since 1917 took the field in full strength and completed the detail survey on the one-inch scale of sheets 63 M/3.7.8.11.12.15.16 and 63 N/9.10.11.12.13.14.15.16. The party also completed the triangulation of the hilly tract in sheet 63 M/15 and the traversing of the cultivated plains in Nepāl lying in sheets 63 M/3.7.11.15.

PERSONNEL.

Class I Officer.

Mr. M. C. Peters, in charge to 13th March and from 25th March 1922.

Class II Officers.

Mr. G. A. Norman, M.B.E., from 10th December 1921 to 13th March 1922 and from 25th March 1922, in charge from 14th to 24th March 1922.

Mr. F. C. Saint, to 30th April 1922.

.. Moqimuddin, from 1st June 1922.

Upper Subordinate Service.

Mr. Chuni Lal Kapur.

.. Lakshmi Dutt Joshi.

.. Vidya Dhar Chopra.

.. Laltan Khan, I. D. S. M., to 10th April 1922.

.. Mohabat Lal Kohli (on probation), from 17th October 1921 to 15th September 1922.

.. Narayana Chandra Ray (on probation), from 20th May 1922.

.. Dalip Singh Gandhi (on probation), from 29th May 1922.

Lower Subordinate Service

36 Surveyors, etc.

wooded. The detail survey of the hilly area in sheet 63 M/15 and of the plains of Nepāl was based on points fixed respectively by triangulation and traversing during the current season. The survey of the remaining area except sheets 63 N/9.10 was carried out on blue prints of existing one-inch sheets, the plane-table traverses being based on the positions of trijunction pillars as shewn on the blue prints.

The work was divided into four camps as follows :—

No. 1 Camp, under Mr. F. C. Saint with 11 surveyors completed the revision survey on the one-inch scale of sheets 63 M/8.12.16 and 63 N/13.14. Mr. Chopra was placed in this camp but proceeded on medical leave very shortly after the field season commenced. Towards the end of the season the camp was strengthened by 4 surveyors transferred from the Training Camp.

No. 2 Camp.—Mr. G. A. Norman, M. B. E., took over charge of this camp on the 18th December 1921 from Mr. Lakshmi Dutt Joshi who proceeded on medical leave, and executed the revision survey on the one-inch scale of sheets 63 N/11.12.15.16. The camp originally consisted of 9 surveyors, but during the last month of the field season, was strengthened by 3 pupils from the Training Camp who had completed their allotted work in that camp.

No. 3 Camp, under Mr. Chuni Lal Kapur with 8 surveyors completed the one-inch original survey in Nepāl and the one-inch revision survey of the remaining area in sheets 63 M/3.7.11.15. One surveyor from the Training Camp was transferred to this camp towards the close of the field season.

No. 4 Camp formed a training camp round Pipraich under Mr. Laltan Khan, I. D. S. M. One Upper Subordinate officer and 13 pupils were instructed in plane-tabling and together completed the one-inch survey of sheets 63 N/9.10. The survey was based on the plotted positions of village trijunction pillars whose coordinate values were obtained from Revenue traverse records. The area has been treated as revision survey. Eight of the pupils on completing their allotted areas were transferred towards the close of the season to other camps.

The out-turns and cost-rates are as follows :—

One inch original survey 294 square miles at Rs. 8.2 per square mile.

One inch revision „ 3691 „ „ at Rs. 13.8 „ „

The cost-rate for the original survey is less than that of the revision survey owing to the nature of the country in Nepāl being less intricate than the United Provinces and to the fact that the most experienced surveyors were employed on the work.

The reserved forest areas are densely wooded; the remainder of the country consists of well cultivated plains dotted over with lakes, marshes and numerous groves of mango trees and intersected by several rivers the principal of which are the Gogrā, Gandak and Rāptī.

The field season opened on the 7th November 1921 and closed on the 15th March 1922. The field head-quarters was at Gorakhpur.

The health of the party was on the whole very good, but there were a few cases of malarial fever among the men working in the Nepāl area.

Plane-tabling.—The nature of most of the country surveyed is flat and highly cultivated with some hilly ground in the north-eastern corner. The reserved forest areas are densely

Triangulation.—The nature of the country is undulating and hilly and covered with dense forest growth. It was intended that the triangulation should emanate from the base Chanda T.S.—Balua T.S., geodetic stations of the North-East Longitudinal Series, but owing to heavy tree growth having sprung up between these tower stations since they were built, after a good deal of tree-felling had been done, to save time, it was considered expedient to abandon the line and start the triangulation from the base Balua T.S.—Barar h.s., the latter of which is a minor station. Mr. M. L. Kohli triangulated an area of 58 square miles in sheet 63 M/15 to fix sufficient points and heights for the detail survey.

The cost-rate including computations is Rs. 18·9 per square mile.

Traversing.—A total length of 133 linear miles of traversing with heights, representing an area of 289 square miles, was run by 2 traversers in the highly cultivated plains of Nepāl comprised in sheets 63 M/3.7.11.15 to supply data for the original survey.

The cost-rate including computations is Rs. 15 per square mile.

Recess Duties.—These comprised the fair-mapping on the scale of one and a half inch to a mile for publication on the scale of one inch to a mile of fifteen sheets surveyed during the year, and the final computations of triangulation and the plotting of village trijunction pillars for 2 one-inch sheets from Revenue traverse records for instructional purposes for next field season. The work and personnel was divided equally into three sections as follows:—

No. 1 Section, under Mr. G. A. Norman, M. B. E., was allotted the fair-mapping of sheets 63 N/11.12.14.15.16.

No. 2 Section was placed in charge of Mr. Moqimuddin who was responsible for the completion of the fair-mapping of sheets 63 M/8.12 and 63 N/9.10.13.

No. 3 Section, under Mr. C. L. Kapur carried out the fair-mapping of sheets 63 M/3.7.11.15.16.

An area of 3,671 square miles at a cost-rate of Rs. 7·4 per square mile was fair-mapped.

Sheets 63 M/3.7.11 and 63 N/9.10 were submitted for publication before 30th September 1922 and the remaining sheets 63 M/8.12.15.16 and 63 N/11.12.13.14.15.16 will be completed before the party takes the field.

The final computations of triangulation were completed by Mr. C. L. Kapur assisted by a computer.

Miscellaneous.—Owing to the non-co-operation movement, which had made itself felt in some parts of the area under survey, it was often difficult to obtain carts and those secured had to be paid for at any fancy price the owner chose to name. This movement culminated in the holocaust at the police station at Chauri Chaura, 12 miles from Gorakhpur on the 4th February 1922.

At the request of the United Provinces Government and with the concurrence of the Benares State Durbar, Mr. M. C. Petters was placed on deputation from the 14th to the 24th March 1922 to examine and report on the disputed boundary between Benares State and United Provinces lying along the Ganges river. The dispute, which dates back to 1848, is due to the lateral movements of the river and reaches an acute stage whenever sufficient silt has been deposited by floods on the sand banks to make them cultivable. The main point in dispute was whether the southern boundary of Benares State in the area concerned was a fixed line or whether it should vary according to the movements of the Ganges river. After examining all old maps forwarded by the parties on both sides and previous rulings on the subject, a survey on the eight-inch scale was prepared and it was decided that the southern boundary of Benares State followed a fixed line. The area is sandy and subject to annual inundation; the depth of water and a strong current during the rainy season will not allow boundary marks to remain. Three guide pillars were accordingly built in a straight line from which it will always be possible to relay the boundary line marked on the original survey with the aid of a plane-table and magnetic compass. In the event of one of the guide pillars being destroyed, the boundary can still be laid down with precision.

There were no arrears of fair-mapping from previous seasons.

The beds of the Gandak and Gográ rivers have altered their courses appreciably to the west and south since the last survey in the early eighties.

Inspections.—The party was inspected by the Surveyor General on the 20th April 1922; it was also inspected once during the field season and weekly during the recess season by the Superintendent, Northern Circle.

No. 20 PARTY (CANTONMENT).

BY C. E. C. FRENCH.

During the year the party continued survey operations in the Southern Circle, and on the 1st April 1922, came under the administrative control of the Superintendent, Northern Circle. A temporary suspension of the field operations was considered necessary as the field work showed signs of outstripping the pace of the drawing; the party was therefore collected at Dehra Dūn during the hot weather months to deal with the mapping.

The health of the party has been good throughout the year.

PERSONNEL.

Class I Officer.

Captain J. K. Douglas, R. E., in charge to 16th October 1921.

Class II Officers.

Mr. J. H. S. Wilson, up to 31st January 1922.
 „ C. E. C. French, in charge from 17th October 1921.
 „ F. W. Smith, from 13th February 1922.

Upper Subordinate Service.

Mr. Dharmu, to 30th June 1922.
 „ J. M. Mukerji.

Lower Subordinate Service.

28 Surveyors, etc.

Plane-tabling.—The cantonments of Deolāli and Ahmadābād were surveyed on the sixteen-inch scale, with their bāzārs on the sixty-four-inch. The remaining sixteen-inch areas in the Civil and Military Station of Bangalore and remnants of the bāzār areas on the scale of fifty feet to one inch were also completed, the aggregate areas on these scales being 5,525·0 acres on the sixteen-inch, 106·36 on the sixty-four-inch and 65·63 on the fifty feet scale respectively.

An area of 40·21 square miles at Deolāli was surveyed on the six-inch scale for the purpose of illustrating future military developments.

The accuracy of the field work has been tested by a chain-line of 60·60 linear miles and 206 *in situ* fixings.

Traversing.—31·94 linear miles were done by Mr. Dharmu and surveyor Arthur Francis; 96 stations being fixed, the average number of stations per mile being 3·01 and the cost-rate Rs. 237·66 per mile.

Levelling.—The proximity of standard bench-marks in these cantonments offered a good opportunity of testing the accuracy of the existing heights, previously obtained by triangulation and traverse; these proved very satisfactorily and in no case were alterations of more than a foot found necessary.

Messrs. Dharmu, Mukerji and one surveyor completed 96·83 linear miles of levelling in these cantonments at a cost of Rs. 18·90 per mile.

Recess Duties.—The fair drawings of Pallāvaram, St. Thomas's Mount, Poonamallee, Velichi and West Hill comprising 39 sheets have been submitted for publication; the remainder comprise Secunderābād, Cannanore, Madras Military Lands, Bangalore, Deolāli and Ahmadābād in 96 sheets, the mapping of which is well in hand.

Inspections.—The party was inspected by the Superintendent, Southern Circle at Deolāli on the 29th January 1922 and by the Superintendent, Northern Circle at Dehra Dūn on the 24th July 1922.

No. 22 (RIVERAIN) PARTY (PUNJAB).

BY DHANI RAM VERMA, RAI SAHIB.

The programme of the party consisted in traversing the riverain estates along the

PERSONNEL.

Class I Officer.

Mr. H. H. B. Hanby, in charge from 10th February to 31st August 1922.

Class II Officer.

Mr. Dhani Ram Verma, R. S., in charge up to 9th February 1922 and again from 1st September 1922, and attached in the intervening period.

Upper Subordinate Service.

Mr. Jamna Prasad, R. S.
 „ Ram Narayan Hastie.
 „ Gulab Singh, up to 4th November 1921.
 1 Supervisor.

Lower Subordinate Service.

33 Traversers, etc. and 22 purely temporary traversers etc.

Indus, Chenāb and Panjnad rivers in Muzaffargarh district for cadastral survey by the Settlement Department and survey of Lahore "Nazul" land in continuation of last year's work.

The field season opened on the 1st October 1921 and closed on the 25th March 1922.

Special survey of Khaur oil fields in Attock district was undertaken in recess. It lasted from the 17th April to 27th July 1922.

The head-quarters of the party remained at Lahore throughout the year.

The health of the party was, on the whole, good. Several men working on the Indus suffered from malarial fever in the early part of the season.

Mr. Gulab Singh and traverser Itrat Husain were compelled to take leave from the 5th November 1921 and 6th January 1922 respectively. Three khalāsīs died of malaria.

The detail traversing on the Indus in Alipur *tahsīl* was carried out under Mr. Jamna Prasad, R.S., and in Muzaffargarh *tahsīl* under Mr. Gulab Singh and subsequently under traverser Roda Ram and on the Chenāb and the Panjnad in Alipur *tahsīl* under Mr. Ram Narayan Hastir. The base lines on the Panjnad were laid out under Mr. Ram Narayan Hastir. At the request of the Settlement Officer, Muzaffargarh, the missing pillars of old base lines along the Indus in Alipur and Muzaffargarh *tahsīls* were relaid under Mr. Jamna Prasad, R.S., and traverser Roda Ram respectively. The traversing and topography of the Khaur special survey was carried out by Mr. Ram Narayan Hastir himself as no surveyor was available. The Lahore "Nazul" land survey was done directly under the officer in charge of the party.

During the field season the computing and *masāvi* sections at the head-quarters were supervised by computer Badlu Ram and draftsman Makbul Husain respectively.

The party continued the work of traversing and laying down base lines. 2,269 linear and 413 square miles of minor traverse in the Indus, Chenāb and Panjnad riverain tracts in Muzaffargarh district were executed, 10,284 theodolite stations in 84 villages were fixed. 213 corners of 71 squares in 246 square miles were demarcated with permanent mark-stones on both banks of the Panjnad river in Muzaffargarh district and Bahāwalpur State, to serve as bases for future survey and demarcation of boundaries and fields in the bed of the river. 27 missing stones of 9 old base lines along the Indus river in Muzaffargarh district were re-laid at the request of the Settlement Officer, Muzaffargarh. 1,154 plotted and 453 boundary *masāvis* (settlement mapping sheets) on the scale of 1/2,640, and 28 four-inch sheets were traced and supplied in time to the Settlement Officer, Muzaffargarh. Besides these, 564 boundary *masāvis* were partly compiled on the scale of one inch = 220 feet for the next season's work; and 257 miscellaneous traces were prepared, all the traverse stations marked during the field season were plotted on 28 four-inch sheets. 1,668 pages of field books and 351 of set-up forming 8 volumes of field books and 5 volumes of set-up of the riverain work of the year were completed.

The minor traverse was based on the main circuits run in the previous seasons. The average daily out-turn per man was 6 stations and 1.32 linear miles. This low average is due partly to heavy line clearing along the rivers and partly to the inexperience of traversers newly entertained.

The average daily out-turn of laying out base-lines per man was 3 corners.

There was general scarcity of labour especially in the Indus riverain tract extending down to the confluence of the Indus and Panjnad rivers and much jungle clearing had to be done by khalāsīs.

The following tables give full details of the riverain work completed during the year:—

FIELD WORK.

NAMES OF RIVERS AND DISTRICTS AND SCALES.	MAIN-CIRCUIT.				MINOR TRAVERSE FOR DETAIL SURVEY.					BASE-LINES.			REMARKS.
	Straight length in miles.	Number of square miles.	Number of linear miles.	Number of theodolite stations.	Straight length in miles.	Number of square miles.	Number of linear miles.	Number of theodolite stations.	Number of villages.	Number of corners.	Number of squares.	Area in square miles.	
<i>Chenāb River.</i> Districts Muzaffargarh and Multan. Scale 1/2,040.	28	76	335	1,420	10	21*	7	...	* Re-embedded
<i>Indus River.</i> Districts Muzaffargarh and Dera Ghāzi Khān. Scale 1/2,040.	46	221	1,220	5,490	43	6*	2	...	* Do.
<i>Panjnad River.</i> Districts Muzaffargarh and Bahāwalpur State. Scale 1/2,640.	36	110	708	3,365	22	213	71	240	
Total	110	413	2,269	10,284	84	240	80	246	

OFFICE WORK DONE FOR THE CADASTRAL SURVEYS OF RIVERAIN ESTATES.

Name of river.	Name of district.	Scale of <i>masāvis</i> .	Number of plotted <i>masāvis</i> showing traversed points.	Number of compiled <i>masāvis</i> showing riverain boundaries.	Number of sheets traced for the use of settlement officers on scale 4 inches = 1 mile.	Number of 4-inch sheets on which new work was plotted.
Chenāb ...	Muzaffargarh ...	1/2,640	208	66	4	7
Panjnad ...	„ ...	1/2,640	368	165	8	10
Indus ...	„ ...	1/2,640	578	222	16	17
	Total ...	...	1,154	453	28	34

Besides these 257 miscellaneous traces were prepared and 564 boundary *masāvis* were partly compiled in advance for the next season's work.

Lahore Nazul land survey.—The survey, on the scale of 1 inch = 40 feet, undertaken towards the end of the previous recess at the request of the Deputy Commissioner, Lahore in connection with the Lahore city extension scheme was continued till the 10th November 1921. The area surveyed till the end of September 1921 was 33·5 acres and the area of the remaining portion mostly consisting of the adjoining congested part of the city surveyed subsequently was 16·0 acres, making the total out-turn of 49·5 acres. The cost-rate for the area surveyed in the year under report comes to Rs. 29·4 per acre and that for the whole area to Rs. 14·5 per acre.

Khaur special survey.—This was undertaken, in continuation of the last year's work, for the Attock oil company at their request through the Deputy Commissioner, Attock district. The work consisted in surveying on the eight-inch scale, with contours at 10 feet vertical intervals, the adjoining productive area to the south of the eastern extension and re-demarcating the boundaries of the eastern and southern extensions dealt with last year. The topography was based on supplementary theodolite traversing. In all, 125 theodolite stations were laid down and 19·07 linear miles were traversed and 6 intersected points with heights were fixed for detail survey and boundary demarcation. The work was commenced in April and finished in July 1922. An area of 0·15 square mile was surveyed. The last year's survey of the central portion, area 4 square miles, was corrected at the request of the company, to show new works that had been completed subsequently.

Cost-rates are as given below :—

Traversing per linear mile	...	...	Rs. 92·7
Original survey per square mile	...	...	„ 366·7
Supplementary survey per square mile	...	...	„ 172·5

177 pages of field books forming 2 volumes and 29 pages of set-up forming 1 volume were completed. 4 miscellaneous traces were prepared and all the traverse stations marked and intersected points were plotted on the three 8-inch plot sheets of the last year's work.

Nature of the country.—The area dealt with by the party was of varied character. The riverain area under water action was broken and full of swamps and partly under cultivation and partly densely wooded. The Lahore "*Nazul*" land was a plain waste land covered with low grass and road avenues with the adjoining congested part of the city. The Khaur mining area was characterised by low bare rocky hills and open undulating ground partly cultivated and partly covered with scrub jungle.

The average errors were as follows :—

(a) Base lines :—

0·69 foot per corner of a riverain base-line as compared with its theoretical value.

	Angular error per station in seconds.	Linear error in links per 10 chains.
(b) Minor traverses		
Indus River ...	6·30	0·67
Chenāb River ...	7·55	0·59
Panjnad River ...	7·28	0·66
Khaur mining area ...	3·81	0·66

Recess Duties—(a). The computing and plotting section consisting of, on the average, 17 draftsmen, etc., was under the supervision of Mr. Jamna Prasad, R.S., and subsequently under draftsman Makbul Husain. The section partly compiled 564 boundary *masāris* and completed preliminary work on 1,565 village *masāvis* in advance for the next season's work. Besides this it made miscellaneous traces and prepared rough field traverse charts for the use of the traversers in the next field season.

(b) The computing section consisting of on the average 12 computers, etc., was under the supervision of computer Badlu Ram. The section completed all traverse computations appertaining to the work of the year and its records detailed in the previous paragraphs. Besides this 5,804 pages of field books forming 19 volumes and 1,456 of set-up forming 14 volumes of the riverain traverse of the Rājanpur *tahsil* (Dera Ghāzi Khān) executed in seasons 1915-19 were completed, leaving no work in arrears.

(c) The triangulation and traverse chart section consisting of on the average 10 computers and draftsmen was formed from the 21st July 1922 and put under the supervision of Mr. Jamna Prasad, R.S. The section compiled data of the old Lower Bāri Doāb work for incorporation in the manuscript charts for the degree sheets 43/L and 44/B.C.E.F.G undertaken last year. It is intended to complete them in the ensuing field season.

The total expenditure of the party from the 1st October 1921 to the 30th September 1922 was Rs. 1,07,121, as detailed below:—

(a) Riverain survey	...	...	...	Rs. 1,02,661
(b) Lahore town traverse, additional debit	...	...	...	1,477
(c) Lahore "Nazul" land survey	...	...	...	470
(d) Khaur special survey	...	...	...	2,513

Inspections.—The Superintendent, Northern Circle, inspected the party in the field on the 11th December and at its head-quarters at Lahore from the 19th to the 21st December 1921.

NO. 23 (PUNJAB RECTANGULATION) PARTY (LATE SIND-SĀGAR PARTY) (PUNJAB).

BY MAJOR R. FOSTER, I. A.

The party was employed on rectangular demarcation in connection with the Punjab Government Sutlej Valley Canal and Colonisation Project consisting of:—

PERSONNEL.		
<i>Class I Officer.</i>		(a) Traversing for the location of the corners of 2,400-acre rectangles in parts of sheets 39 O/2.3.5.6.7.10.11.13.14, 44 C/1.2, 44 F/8.11.12.15.16, and 44 G/1.2.5.6.
Major R. Foster, I. A., in charge.		(b) Location of the corners of 2,400-acre rectangles from the traversed points, base lines, and village trijunctions in parts of sheets 39 O/2.3.5.6.7.10.11.13.14, 44 B/8.11.12.15.16, 44 C/1.5.9.13, 44 F/ 2.3.4.7.8, and 44 G/1.2.5.6.
<i>Class II Officers.</i>		(c) Subdemarcation of 2,400-acre rectangles into 25-acre rectangles in the area falling in sheets 44 B/4.8 and 44 C/1.5 and into 100-acre rectangles in the area falling in sheets 39 O/5.6.7.10.13.14, 44 B/8.11.12.15.16, 44 C/1.5.9.13 and 44 F/2.3.4.
Mr. J. C. C. Lears, up to 15th September 1922.		
„ C. O. Picard, from 1st September 1922.		
„ D. N. Banerjee.		
<i>Upper Subordinate Service.</i>		
Mr. Lakshmi Dutt Joshi, from 19th July 1922.		
„ Amrit Ram.		
2 Supervisors.		
<i>Lower Subordinate Service.</i>		
17 Surveyors, etc.		
76 Purely Temporary Traversers.		

The locale of operations was the tract between the old bed of the Beās and the Sutlej rivers in the Multān and Montgomery districts of the Punjab. Except for a cultivated strip along the latter, the country is a flat plain covered with scrub jungle, thick only in those parts which are reserved as Government "Rakhs". The Bahāwalpur and Minchinābād *tahsils* of Bahāwalpur State are well cultivated in the north, and consist of a dry plain covered with scrub in the south.

The head-quarters of the party closed at Mussoorie on 10th October 1921, and opened in the field at Multān Cantonment on 20th October 1921; the party closed its field season on 8th May 1922, and re-opened in Mussoorie on 17th May 1922. At the commencement of the field season the party was divided into 4 camps; from 1st December 1921 into 5 camps, and from 21st February 1922 into 6 camps.

The health of the party was fair. The number of khalāsīs was large, and, partly through the failure of the blanket contractor, partly through the ignorance of the khalāsīs in not reporting sick, a large number fell ill with pneumonia, and, during the season 8 khalāsīs died, chiefly from this cause. One khalāsī died from the effect of a wound accidentally inflicted by a traverser with a shotgun.

Traversing.—The nature of the country traversed varied from waterless tracts covered with scrub jungle to fairly thickly cultivated plains.

Traversing to fix corners of 2,400-acre rectangles was carried out by No. 4 Camp, consisting of 8 traversers under Mr. Amrit Ram. Lines were run for the purpose of laying down temporary marks near the 2,400-acre corners, and connected, in the area falling in the Multān district, to previous triangulation carried out by this party and riverain base lines laid down by No. 22 Party and in Bahāwalpur State to the Sutlej Meridional Series. 1,643·2 linear miles were traversed, 3,112 stations observed at and 43 azimuths were observed. The cost-rate amounted to Rs. 26·9 per linear mile.

Rectangulation.—The nature of the country rectangulated is the same as in the area mentioned above.

The work consisted of (1) location on the ground of main corners of 2,400-acre rectangles by means of traverse base-lines and village trijunctions, previously laid down, and the temporary stations fixed by traverse (2) location on the ground of 25-acre and 100-acre corners on the long sides of 2,400-acre rectangles by means of theodolite, short and long chains (3) subdemarcation of 2,400-acre rectangles into 25-acre and 100-acre rectangles. All corners were marked by flat topped stone pillars, 6 inches square and 30 inches long, embedded up to 21 inches in the ground.

In the previous year the party carried out subdemarcation to 25-acre rectangles, but this year it was decided, to enable this party to complete the whole area of the project in 3 field seasons, that subdemarcation to 100-acre rectangles only should be carried out. This was done except for an area of 157·1 square miles in which the 25-acre corners on the long side of 2,400-acre rectangles had been laid out the previous year, which was subdemarcated to 25-acre rectangles.

50 per cent of the work was tested by 5,137·7 linear miles partalled.

No. 4 Camp, under Mr. Amrit Ram, besides carrying out traversing, located 443 main corners of 2,400-acre rectangles.

No. 1 Camp, under Mr. J. C. C. Lears, with 10 traversers laid out 203 main corners of 2,400-acre rectangles and 1,619 100-acre corners on the long side of 2,400-acre rectangles.

No. 2 Camp, under Mr. Gurditta Ram, Assistant Engineer, P. W. D., attached, with from 22 to 32 traversers laid out 1,128 25-acre corners and 2,835 100-acre corners on the interior sides and No. 3 Camp under Mr. Girdhari Lal Bhola, Assistant Engineer, P. W. D., attached, with from 19 to 30 traversers laid out 1,305 25-acre corners and 2,632 100-acre corners on the interior side.

No. 5 Camp was formed of 13 to 17 traversers under Mr. D. N. Banerjee on 1st December 1921, after that officer had completed the training of the new traversers and the two Assistant Engineers. It carried out demarcation of long sides of 2,400-acre rectangles and laid out 2,732 100-acre corners.

No. 6 Camp was formed of 7 traversers under Mr. M. H. Punwani, Supervisor, on 21st February 1922, after that officer had completed his training, and carried out demarcation of long sides of 2,400-acre rectangles, laying out 549 100-acre corners.

The out-turn of the party for the season is as follows :—

646 main corners of 2,400-acre rectangles, 10,367 100-acre corners and 2,433 25-acre corners located 9,159 100-acre rectangles, and 4,020 25-acre rectangles laid out, comprising a total of 1,588·2 square miles.

The cost-rate of rectangulation is Rs. 181·2 per square mile or Re. 0·28 per acre.

Recess Duties.—The strength of the party was considerably reduced in recess, all the purely temporary staff being sent on leave.

No. 1 Section, under Mr. J. C. C. Lears, assisted by Mr. Indar Singh Supervisor, and 5 surveyors etc., and No. 2 Section, under Mr. D. N. Banerjee, assisted by Mr. M. H. Punwani Supervisor, and 5 traversers, took up the compilation of *masāvis* and drawing of index maps.

No. 3 Section, under Mr. Amrit Ram, with 5 computers, completed the computation of the current season's traverse, and plotted the traverse stations on to *masāvis* in preparation for the next season.

Inspections.—The Superintendent, Northern Circle, inspected the party in the field from 12th to 18th December 1921 and frequently in recess. The Surveyor General of India accompanied by the Superintendent, Northern Circle, inspected the party in recess in April 1922.

THE BHOPĀL TRAVERSE DETACHMENT.

BY MAYA DAS PURI, RAI SAHIB.

The detachment was formed on the 18th October 1921 to traverse village boundaries for the cadastral survey of the Bhopāl State, on the sixteen-inch scale. As the Government of India's

PERSONNEL.

Class II Officer.

Mr. Maya Das Puri, R. S., in charge.

Upper Subordinate Service.

Mr. Nabidad Khan, from the 1st November 1921.

Lower Subordinate Service.

5 Traversers, Computers, etc. and 11 purely temporary traversers etc.

sanction for the formation of the detachment was not received till late in the season, the first two months were spent in making preliminary arrangements.

The office at Mussoorie was closed on the 11th November 1921 and opened on the 21st November 1921 at Bhopāl where it remained till the close of the season. The field operations were closed on the 31st May 1922.

During the field the traversers employed on main circuits, as well as the computing section were supervised by the Officer in charge; and the new traversers under training divided into two camps under Mr. Nabidad Khan, Sub-Assistant Superintendent, and Harkishan Das, traverser. In recess the computing section was directly under the Officer in charge, while the plotting section was supervised by Mr. Nabidad Khan.

The Bhopāl *Durbār* desired that local men should be employed on the work, as far as possible, and intimated that *khalāsis* could be obtained at cheap rates. For this reason only a few trained lower subordinates were transferred to the detachment, while all the other hands were to be locally entertained and trained. *Khalāsis* however proved to be unobtainable locally, and eventually had to be imported from outside the State, on account of which there was a delay of nearly a month.

On the 30th November 1921 at the request of the Revenue Minister, Bhopāl, the proposed locale of operations was changed and the Durāhā *tahsīl* of the northern district was decided on as the area in which work should be commenced. Owing to this change in programme, the orders regarding the demarcation of village boundaries and to afford assistance to the detachment were late in arriving and considerable trouble was, at first, experienced in obtaining local labour and conveyance and in tracing out village boundaries on the ground.

Where the boundaries were not traceable, points were thrown about 25 chains apart on both sides of the alignment pointed out by villagers. In large villages, sub-circuits were run in the interior about half a mile apart to aid in the detail survey, and for the same reason two or three dressed stones were embedded along the boundaries of each village to serve as permanent marks.

In all, 936 linear miles of main and sub-circuits were executed, and 3,987 theodolite stations laid out in 327 square miles along the boundaries and interior of 165 villages; and 235 dressed stones embedded on the theodolite stations.

355 sheets (size of a sheet being 20 inches × 28 inches) were plotted on the sixteen-inch scale, 24 four-inch sheets were traced, and the areas of 169 polygons were computed by universal theorem and planimeter. These were supplied to the State authorities during the year. Besides this, several miscellaneous traces were prepared, and all the work done during the year, was plotted on the four-inch scale.

The work was entirely based on Great Trigonometrical values. Main circuits were run between G.T. stations over favourable ground with a 330-foot crinoline tape and a 6-inch theodolite; and were connected with Manūābhar H.S., Tuna H.S., Singpur H.S., Mahādeo H.S., Rāntek H.S., Kushandi H.S., Barli H.S., Pānbiār H.S. and Talāi Tonk H.S. In sub-circuits along village boundaries generally, 5" theodolites and two chains 66 and 100 feet long were used.

The nature of ground under survey was undulating, hilly, interspersed with rocky knolls, partly covered with dense jungle and partly well cultivated.

As no medical aid was available in the area under survey, there being no dispensary in the *tahsil*, all patients had to be brought to Bhopāl for treatment. Several men fell sick specially at the end of the field season due to heat and malaria but all recovered.

The average errors of the work are:—

				Angular error per station in seconds.	Linear error in links per 10 chains.
(a)	Main circuits	...	...	4·0	0·27
(b)	Minor traverses	...	...	9·67	0·74

The total expenditure of the detachment including contribution towards pension from the 18th October 1921 to the 30th September 1922 was Rs. 59,046.

Inspections.—The detachment was inspected by the Superintendent, Northern Circle, on the 27th and 28th July 1922.

SOUTHERN CIRCLE.

(Vide Index Map No. 1).

Summary.—This circle was under the superintendence of Colonel H. H. Turner, R. E., up to 17th April 1922, and again from 30th May 1922 to 9th August 1922, under Lieut.-Colonel C.P. Gunter, O.B.E., R.E., from 18th April 1922 to 29th May 1922 and again from 10th August 1922. It comprised Nos. 5, 6, 7 and 8 Parties, No. 4 Drawing Office, Record Section and the Training Section.

During the year Nos. 5, 6, 7 and 8 Parties completed 21,961 square miles of detail survey and 9,869 square miles of triangulation. During recess the fair-mapping of the area surveyed was taken up and will be completed before the parties proceed to the field.

The detail survey consisted of:—

7,916	square miles of half-inch original survey.
365	” ” ” half-inch supplementary survey.
6,906	” ” ” one-inch original survey.
3,336	” ” ” one-inch revision survey.
2,763	” ” ” one-inch supplementary survey.
278	” ” ” one-inch original forest survey.
333	” ” ” two-inch original forest survey.
14	” ” ” four-inch original forest survey.

No. 20 Party (Cantonment) on completion of its programme in the Southern Command was placed under the administrative control of the Superintendent, Northern Circle from the 1st April 1922.

The Mysore - South Kanara Boundary demarcation was continued but not completed.

The Training Section, composed of Upper Subordinate probationers and pupil surveyors, worked throughout the year.

A survey course for Artillery officers was completed in September.

The following work was completed by the Photo-Zinco Section of No. 4 Drawing Office:—

Reproductions	...	...	212
Enlargements	...	...	195
Reductions	...	...	221
Vandyke plates prepared	...	...	183
Prints pulled	...	...	7,057

The Record Section submitted for publication 6 triangulation pamphlets and completed data for 8 triangulation pamphlets for record in the circle office.

Nos. 5, 6, 7 and 8 Parties and the Training Section were inspected once in the field and on several occasions during recess by the Superintendent, Southern Circle.

No. 5 PARTY (CENTRAL INDIA, CENTRAL PROVINCES AND GWALIOR).

BY MAJOR F. B. SCOTT, I. A.

This party completed the detail survey on the $\frac{1}{2}$ -inch scale of sheets 46 N/NE and

PERSONNEL.
Class I Officers.
Major F. B. Scott, I. A., in charge from 4th February 1922.
Captain G. Lennox, I. A., in charge to 3rd February 1922.

Class II Officers.
Mr. J. H. S. Wilson from 1st February 1922.
” F. C. Pileher.
” F. W. Smith to 11th February 1922.
” J. A. Calvert to 11th January 1922.
” Mahammad Najamuddin, B.A. (on probation)

Upper Subordinate Service.
Mr. P. S. Vengusvami to 17th September 1922.
” D. R. Vohra from 1st January 1922.
” J. A. Cabral.
” M. R. Sharma (on probation).

Lower Subordinate Service.
37 Surveyors, etc.

46 N/SE, less 46 N/16 and isolated portions of Indore State forests, on the 1-inch scale of sheets 55 B/3.7.8.11.12.15.16 and 55 F/3.4.8 and isolated portions of Indore State forests in sheets 46 N/NESE, and on the 4-inch scale of small blocks of reserved forests in sheets 55 B/15, 55 F/4.7.8.11 and 55 J/2.

The country consists of well cultivated wooded plains and intricate jungle-clad hills.

The field season opened on the 20th October 1921 and closed on the 1st April 1922. The field head-quarters was at Khandwā.

The health of the party was not very good, a number of surveyors suffering from fever.

Plane-tableing.—The area surveyed on the $\frac{1}{2}$ -inch scale comprises the Mālwa plateau, open

cultivated country, in the north, the Vindhya Range, consisting of intricate jungle-clad hills, in the centre, and the Narmadā valley, well cultivated and wooded, in the south.

The area surveyed on the 1-inch scale consists of the valley of the Narmadā river, densely wooded and broken ground, and cultivated and wooded plains to the south of the river.

The work was divided into three camps as under :—

No. I Camp.—Under Mr. F. C. Pilcher, with one Upper Subordinate officer and eleven surveyors carried out original survey on the $\frac{1}{2}$ -inch scale of sheets 46 N/NE. and 46 N/SE. less sheet 46 N/16 and original survey on the 1-inch scale of 278 square miles of Indore State forests in these sheets.

No. II Camp.—Under Mr. F. W. Smith till the 11th February 1922 and then under Mr. J. H. S. Wilson, with twelve surveyors carried out original and supplementary survey on the 1-inch scale of sheets 55 B/15.16 and 55 F/3.4.8, and original survey on the 4-inch scale of small blocks of reserved forest in sheets 55 B/15, 55 F/4.7.8.11 and 55 J/2.

No. III Camp.—Under Mr. P. S. Vengusvami till the 22nd February 1922 and then under Mr. Najamuddin, with one Upper Subordinate officer and eleven surveyors carried out original and supplementary survey on the 1-inch scale of sheets 55 B/3.7.8.11.12.

The original survey calls for no special note. The 1-inch supplementary survey was carried out by transferring photographic reductions of 4-inch forest surveys to the plane-table sections and checking the detail on the ground.

Triangulation.—Subsidiary triangulation was carried out by surveyor Nur Muhammad in sheets 46 N/NW.SW., 55 B/NW. and 55 B/NE. less 55 B/13, and by Mr. Vengusvami in sheets 55 B/13, 55 F/NW. and 55 F/NE. (north half), for survey on the $\frac{1}{2}$ -inch scale except for isolated portions of Indore State forest on the 1-inch scale. The country triangulated consists of open undulating cultivated plains in the north, intricate jungle-clad hills of the Vindhya Range in the centre and the valley of the Narmadā river in the south.

Recess Duties.—(a) The fair-mapping and typing was divided into three sections as under :—

No. I Section.—Under Mr. J. H. S. Wilson drew 1-inch sheets 55 B/8.12.15.16 and 55 F/3.4.8.

No. II Section.—Under Mr. F. C. Pilcher drew $\frac{1}{2}$ -inch sheets 46 N/NE.SE. and 1-inch sheets 55 B/3.7 and 290.11 square miles of Indore State forests on the 1-inch scale.

Typing and Training Section.—Captain G. Lennox was in charge of the typing of the party and the training of young surveyors.

There will be no arrears of fair-mapping by the end of recess.

The fair-mapping of sheet 55 B/11 was not undertaken as large errors were found and a part of the area will have to be re-surveyed.

(b) All computations have been completed, with the exception of the synopsis of sheet 55 N.

The party was inspected both in the field and recess by the Superintendent, Southern Circle.

No. 6 PARTY (HYDERĀBĀD).

BY CAPTAIN J. K. DOUGLAS, R. E.

This party completed the detail survey on the $\frac{1}{2}$ -inch scale of sheets 56 D/NE., 56 H/NW. SW. NE. SE. and 56 L/NW. This area included 365 square miles of reserved forests previously surveyed on the 2-inch scale. $\frac{1}{2}$ -inch reductions were used and found correct.

PERSONNEL.

Class I Officers.

Lieut.-Colonel C. P. Gunter, O. B. E., R. E., in charge from 3rd October 1921 to 17th April 1922 and from 30th May to 9th August 1922.

Captain J. K. Douglas, R. E. (on probation), from 17th October 1921 to 19th March 1922 and from 1st May 1922; in charge from 1st May to 29th May 1922 and from 10th August 1922.

The field season opened on the 28th October 1921 and closed on the 4th April 1922. The field head-quarters were at Secunderābād.

The health of the party was good on the whole, 2 menials died of cholera.

Class II Officers.

- Mr. H. B. Simons to 17th October 1921; in charge from 1st to 2nd October 1921.
 „ E. A. Meyer, from 10th January 1922 and in charge from 18th April to 30th April 1922.
 „ J. C. St. C. Pollett, from 17th October 1921.
 „ E. N. Natesan, B.A.

Upper Subordinate Service.

- Mr. K. G. Mandanna.
 „ D. R. Vohra, from 14th October to 30th December 1921.
 „ T. S. Narayana, B.A. (on probation), from 22nd May 1922.

Lower Subordinate Service.

26 Surveyors, etc.

with 9 surveyors completed the $\frac{1}{2}$ -inch original survey of sheets 56 H/SE. SW.

No. 3 Camp, under Mr. E. N. Natesan, B.A., with 8 surveyors completed the $\frac{1}{2}$ -inch original survey of sheets 56 H/NE. and 56 L/NW.

The total area surveyed was 6,635 square miles which includes 365 square miles of supplementary survey in which $\frac{1}{2}$ -inch reductions from 2-inch forest maps previously executed were used. The reductions were tested by various *in situ* fixings and found correct.

The whole of the area surveyed is in Hyderabad State.

Triangulation.—The work consisted solely of supplementary triangulation in the Amrabad, Devarkonda and Mirialguda Forest areas, in the Mahabnagar and Nalgonda districts.

The country consists mainly of thickly wooded hills. Mr. Mandanna completed 690 square miles of supplementary triangulation. The whole of the area concerned is in Hyderabad State.

Traversing.—No traversing was carried out.

Recess Duties.—The fair-mapping was divided as follows:—

No. 1 Section, under Mr. Meyer, $\frac{1}{2}$ -inch sheets 56 D/NE. and 56 H/NW.

No. 2 Section, under Mr. Pollett, $\frac{1}{2}$ -inch sheets 56 H/SW. and 56 H/SE.

No. 3 Section, under Mr. Natesan, $\frac{1}{2}$ -inch sheets 56 H/NE. and 56 L/NW., and 1-inch sheets 57 G/10, 14 surveyed by the Training Section.

All the above sheets have been submitted for publication.

The computations of the supplementary triangulation were completed during recess. The arrears of computations consist of sheets 56 O/1,2,5,6,9,10, which will be taken up as soon as sheets 56 O/13,14 have been triangulated.

Triangulation charts of 56 D and H have been taken in hand.

No. 7 PARTY (MADRAS).

By MAJOR J. D. CAMPBELL, D. S. O., R. E.

This party completed the detail survey on the 1-inch and 2-inch scales of sheets 57 I/1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16 and 57 J/1,5, and of the areas falling in the Madras Presidency in sheets 56 L/8,12,16 and 56 P/4,8,14 not previously surveyed on the 2-inch scale, also certain reserved forests falling partly or wholly in sheets 57 E/14,15 and 57 J/2,6 on the 2-inch scale.

The nature of the country generally comprised cultivated open expanses of level or undulating land, rocky scrub covered hills and the forest clad ranges of the Nallamalais and Erramalas.

The office of the party opened at Kurnool, the field head-quarters, on the 1st November 1921. The office was closed at Kurnool on the 4th April 1922 and opened at Nandyal on the 6th April 1922 and finally closed at Nandyal on the 17th April 1922 and reopened at Bangalore on the 24th April 1922. There was practically no rain during the field season.

PERSONNEL.

Class I Officers.

- Major J. D. Campbell, D.S.O., R.E., in charge.
 Captain G. W. Gemmell, I.A. (on probation), from 15th January 1922.
 Lieutenant G. Bomford, R. E. (on probation), from 15th January to 2nd August 1922.

Class II Officers.

- Mr. F. H. Grant.
 „ A. F. Murphy.
 „ N. S. Harihara Iyer.
 „ T. O. Threlfall (on probation).

Upper Subordinate Service.

- Mr. K. Narayanaswami Chetti.
 „ Shih Lal, B. S.
 „ Shadi Lal Dube.
 „ K. B. Muthanna (on probation).

Lower Subordinate Service.

39 Surveyors, etc.

The health of the party was fair only, the forest tracts of the Nallamalais and Erramalas being notoriously feverish.

There was an average absence of about two surveyors from this cause during the field season.

Plane-tabling.—The country surveyed is partly flat or slightly undulating, open and cultivated, the cultivation being mainly dry. The minor hills are rocky and bare with a little scrub. The reserved forests in the higher ranges are covered with bamboo and other jungle of varying density.

The survey presented no difficulties, chaining having seldom to be resorted to. Work was done on blue prints on mounted straw boards of both Madras Revenue work and 4-inch Forest surveys. In the case of the latter, 1-inch reductions were printed in blue and detail required on that scale inked up. Contours were accepted to a greater extent than hitherto and were inked up on the blue print reductions. Information was obtained from the Forest Department as to where new work was to be expected and the 4-inch maps were accepted except (a) where additions or alterations were ascertained to have been made since the 4-inch survey (b) where contouring was known to be doubtful owing to its not agreeing with the heights, on the 4-inch maps (c) Heights destined to appear on the fair sheets were checked and revised.

The work was divided into five camps as follows:—

No. 1 Camp.—Under Mr. F.H. Grant, head-quarters Atmakūr, with 6 surveyors, completed sheets 56 L/8.12.16, 56 P/4.8.14 and 57 I/9.13. The work in this camp was mainly supplementary, (* to Madras—Hyderābād boundary only).

No. 2 Camp.—Under Mr. A.F. Murphy, head-quarters Nandyāl, with 8 surveyors, completed 1-inch survey in sheets 57 I/2.3.4.6.7.8 and some 2-inch work in 57 I/3.4.

No. 3 Camp.—Under Mr. K. Narayanasvami Chetti, head-quarters Giddalūr with 7 surveyors, completed sheets 57 I/10.11.12.14.15.16 and some 2-inch work in 57 I/12.15.16. The work of this camp was mainly supplementary.

No. 4 Camp.—Under R. S. Shib Lal, head-quarters, Kurnool, with one surveyor and 6 pupils, completed sheets 57 I/1.5, 57 J/1.5 and some 2-inch work in 57 J/2.6. This camp was strengthened towards the close of the field season when surveyors were available from other camps.

No. 5 Camp.—Under Mr. T. O. Threlfall, head-quarters Betamcherla with 7 surveyors completed 2-inch survey in sheets 57 I/2.3.6.7 with some areas falling in 57 E/14.15.

Two Class I officers, Captain Gemmell, I. A., and Lieutenant Bomford, R. E. joined the party in January 1922 and carried out plane-tabling in Camp IV area during the remainder of the field season.

Triangulation.—There were three triangulators as follows:—

Mr. N. S. Harihara Iyer who triangulated 1,827 square miles in sheets 57 J/ 11.12.15.16, and 57 K/9.13.14.15.16. Mr. Shadi Lal Dube 2,018 square miles in sheets 57 J/3.4.7.8 and 57 K/ 1.2.5.6 and surveyor Ultifat Husain who commenced in January 1922 and triangulated 617 square miles in 57 K/7.10.11.12. The country triangulated is much like that surveyed except that rocky scrub covered hills are much more numerous and extensive.

Recess Duties.—(a) The fair-mapping was divided into four sections as follows:—

No. 1 Section.—Under Mr. Grant, and afterwards Mr. Claudius, sheets 56 L/8.12.16, 56 P/4.8.14 and 57 I/9.13.

No. 2 Section.—Under Mr. Murphy, sheets 57 I/3.4.6.7.8.10.

No. 3 Section.—Under Mr. Narayanasvami Chetti, sheets 57 I/11.12.14.15.16.

No. 4 Section.—Under Mr. Shib Lal, R. S., sheets 57 I/1.2.5 and 57 J/1.5.

(b) Computations have been brought practically up to date by a section of varying strength under Lient. Bomford, R. E., and afterwards Captain Gemmell, I. A.

(c) *Preparations for the field.*—These have differed slightly from previous years in that instead of, as hitherto, obtaining blue print reductions of 4-inch forest work and inking up the necessary detail preparatory to re-photography, black prints have been obtained after thickening up the 250 contours on the original 4-inch maps. Where this could not be done owing, as is frequently the case, to the contours not agreeing with the heights, the 250 contour has been left unemphasized and the areas will be recontoured on the ground. The black print reductions have been mounted, together with prints of the old Mysore 1-inch maps, on the Madras Revenue Survey sheets and the whole photographed to obtain blue prints for plane-tables. This system is satisfactory and has saved immense labour in inking up blue reductions.

No. 8 PARTY (BOMBAY AND MADRAS).

BY LIEUT.-COLONEL M. O'C. TANDY, D.S.O., O B.E., R.E.

The party completed the survey of 4,555 square miles on the 1-inch scale in sheets 58 F/11.12.15.16, 47 F/9.10.11.12.13.14.15.16, 47 J/3.4.7.8.

PERSONNEL.

Class I Officers.

Lieut.-Colonel M. O'C. Tandy, D. S. O., O. B. E., R. E., in charge, except while on leave from 23rd March to 30th April 1922.
 Captain J. K. Douglas, R. E. (on probation), in charge from 23rd March to 30th April 1922.

Class II Officers.

Mr. M. Mahadeva Mudaliar, M. A.
 " B. T. Wyatt.
 " M. S. Ganesa Aiyar.

Upper Subordinate Service.

Mr. H. Narasimhamurti Rao.
 " Shaikh Muhammad Salik.
 " Abdul Ghafur.
 " Janam Raj Chibbar (on probation).

Lower Subordinate Service.

42 Surveyors, etc.

Field work was divided in 4 camps. carried out on blue prints of the Madras Revenue Surveys and supplementary survey on blue prints of one-inch reductions of the old 4-inch forest maps of the Survey of India. In the Bombay area revision survey was carried out on blue prints of the departmental maps surveyed about 40 years ago.

Field work was divided in 4 camps.

No. 1 Camp.—Under Mr. M. Mahadeva Mudaliar, assisted by Mr. Abdul Ghafur with 11 surveyors completed 970 square miles of original survey and 199 square miles of supplementary survey in sheets 58 F/11.12.15.16, the supplementary triangulation in 58 F/15 being done by Mr. Abdul Ghafur.

No. 2 Camp.—Under Mr. B. T. Wyatt with Mr. Janam Raj Chibbar and at first 10 and later on 7 surveyors completed 1,126 square miles of revision survey in sheets 47 F/9.10.13.14, this area including Poona City and Cantonment and Kirkee.

No. 3 Camp.—Under Mr. M. S. Ganesa Aiyar, assisted by Mr. H. Narasimhamurti Rao with at first 13 and later on 12 surveyors completed 1,412 square miles of revision survey in sheets 47 F/15 and 47 J/3.4.7.8.

No. 4 Camp.—Under Mr. Shaikh Muhammad Salik took the field with 5 surveyors and was subsequently strengthened by the transfer of 3 surveyors from camps Nos. 2 and 3: this camp completed the revision survey of 847 square miles in sheets 47 F/ 11. 12. 16.

Supplementary triangulation to provide a few extra heights in 48 F/15 was carried out during the first month of the field season.

Recess Duties.—The fair-mapping was divided into 3 sections:—

No. 1 Section.—Under Mr. M. Mahadeva Mudaliar (on leave from 1st June 1922 to 31st August 1922) and assisted by Mr. Abdul Ghafur, sheets 58 F/11. 12. 15. 16.

No. 2 Section.—Under Mr. B. T. Wyatt assisted by Mr. Shaikh Muhammad Salik (on leave from 2nd August 1922 to 30th September 1922), sheets 47 F/9. 10. 11. 12. 13. 14.

No. 3 Section.—Under Mr. M. S. Ganesa Aiyar assisted for the first month of recess by Mr. H. Narasimhamurti Rao, sheets 47 F/15.16 and 47 J/3.4.7.8. Mr. Narasimhamurti Rao was employed during the last 4 months of recess in charge of a section revising the heights and projecting and plotting plane-tables for the coming season's work.

All fair drawing will be completed before the party takes the field but the final examination of some of the sheets will have to be completed at field head-quarters.

TRAINING SECTION.

By S.S. McA'F. FIELDING.

Of the 20 pupil surveyors, 3 had been recruited the previous season but had been retained in No. 4 Drawing Office, the remaining 17 had been recruited between January and March 1921, and had received some training in drawing in No. 4 Drawing Office.

PERSONNEL.

Class II Officers.

Mr. S.S. McA'F. Fielding, in charge.
 „ V.W. Morton, up to 12th February 1922.

Upper Subordinate Probationers, 2nd year.

Mr. Suresh Chandra Chatterjee, B. Sc.
 „ Abani Kumar Sen Gupta.
 „ Dalip Singh Gandhi.
 „ Narayana Chandra Ray.
 „ T.S. Narayanan, B.A.

Upper Subordinate Probationers, 1st year.

Mr. Abdul Ghani Qureshi.
 „ Bhudeb Batabyal.
 „ I.K. Ponnappa.
 „ Nilratan Chowdhury.
 „ P. Rajamanikkam.
 „ Satyendra Chandra Chakrabarti.
 „ Kiran Chandra Sen Gupta.
 „ Abdul Jabbar.
 „ Narendra Nath Ganguli.

Lower Subordinate Service.

3 1st Class Surveyors.
 20 Pupil Surveyors.

and one 1st class surveyor, to receive some preliminary training and to allow them time for preparation.

The area selected for survey was sheet 57 K/3 for pupil surveyors and Upper Subordinate probationers 2nd year, and 57 K/4 for the new class of Upper Subordinates, with head-quarters at Kolār town.

Sheet 57 K/3 was a suitable sheet for instruction on the whole though it was found that the eastern portion was too low lying and heavily wooded, with trigonometrical points scarce. The western portion is fairly open, undulating and contains groups of hills suitable for instruction in sketching and contouring.

Communications (main roads and a light railway running through the sheet) were excellent and every assistance was given when required by the local authorities. The whole of sheet 57 K/3 was completed.

Six pupil surveyors were discharged or allowed to resign as they were found unsuitable.

In addition to 57 K/3, the portions left unsurveyed in the previous season in K/4 were completed by two Upper Subordinates (2nd year) on the one-inch scale.

The average out-turn for the season was as follows :—

Upper Subordinate probationers 2nd year (1½-inch)	32	square miles.
„ „ „ „ (1-inch)	32	„
Pupil surveyors 1½-inch	24	„

The camp of the 1st year class of Upper Subordinate probationers remained at Kolār in 57 K/4 throughout the season. They were given preliminary instruction in plane-tableing, the use of a theodolite (reading rounds of angles temporary and permanent adjustments etc.) and were then put through a course of triangulation. The area triangulated was approximately 37 square miles with 5 stations based on a G. T. base. Four men (working in pairs) triangulated at one time, the remainder being employed on plane-tableing. On completion of the triangulation all were put on to plane-tableing over an area of about 30 square miles consisting of plains and hills in the neighbourhood of head-quarters. During the season 4 probationers were allowed to resign their appointments, being considered unsuitable.

In February Mr. Morton was transferred from the section, and the head-quarters of the section was transferred from Srinivāspur to Kolār.

The field season closed at the end of April and the section returned to recess quarters in Bangalore. The health of all members throughout the season had been fairly good. One menial died from natural causes. There was a good deal of fever of a mild type among the menials in the months of March and April but all were successfully treated in the local hospital. A case of small-pox in a pupils squad, in April delayed the return to recess quarters of some pupils for about 10 days.

Immediately on return to recess quarters, the five Upper Subordinates of the 2nd year, were transferred to various circles.

Two more pupil surveyors were discharged, which reduced the strength of the section to

5 Upper Subordinates,
12 Pupil Surveyors.

The Upper Subordinates continued and completed their instruction in theodolite traversing, (with subtense work) levelling, drawing and computations. They also completed the survey of a portion of the military grass farm area on the scale of 16 inches = 1 mile and fixed ranges for artillery purposes by means of triangulation and traverse. Five pupils were attached to No. 4 Drawing Office for instruction in drawing owing to want of accommodation with the section. The remaining 7 practised fair-drawing with the mathematical and swivel pens.

All the Upper Subordinate probationers and pupil surveyors were drafted to various circles and parties on completion of their course in October 1922.

The Training Section will be closed down at the end of this season as no new probationers or pupils have been recruited.

EASTERN CIRCLE.

(*Vide* Index Map No. 1).

Summary.—This circle was under the superintendence of Colonel W. M. Coldstream throughout the survey year. It comprised Nos. 9, 10, 11 and 12 Topographical Parties, No. 21 Forest Party and No. 5 Drawing Office, exclusive of survey units of Local Governments under the administrative charge of the Superintendent.

During the year the 5 field parties completed 11,480 square miles of detail survey on the half-inch, one-inch, two-inch and four-inch scales, the triangulation of 5,076 square miles and the traversing of 2,077 square miles. The maps of the areas surveyed have been drawn in 55 sheets.

The detail survey consisted of :—

4,051	square miles	of	half-inch	original	survey
3,624	"	"	"	"	one-inch original survey
3,267	"	"	"	"	one-inch supplementary survey
518	"	"	"	"	two-inch original survey
20	"	"	"	"	four-inch original survey.

The Officer in charge of No. 9 Party, in addition to the work of his party, was allotted the preparation of a draft for a new chapter of the Handbook of Topography to replace the existing chapter IV (Traversing). This work, which had been begun the previous year, has been done in consultation with other officers of the Department. The draft has been submitted to the Surveyor General and is now at press.

In the summer months a detachment, consisting of one military officer and one Sub-Assistant Superintendent, accompanied the Political Officer of Sikkim on a mission to Bumtang to confer the insignia of the G. C. I. E. on His Highness the Mahārāja of Bhutān. It returned with the Political Officer through a portion of southern Tibet having obtained 6,500 square miles of geographical survey on the scale of four miles to the inch.

No. 9 PARTY (BENGAL, BIHĀR AND ORISSA).

BY BT.-LT.-COLONEL R. H. PHILLIMORE, D. S. O., R. E.

The party completed the one-inch survey of sheets 79 B/3.4.7, south of Calcutta, which had been left incomplete last season.

PERSONNEL.

Class I Officers.

Bt.-Lt.-Colonel R. H. Phillimore, D. S. O., R. E.,
in charge.
Captain R. S. P. MacIvor, I. A., (on probation),
from January 20th, 1922.
Lieut. H. A. Bazley, R. E., (on probation), from
January 14th, 1922.

Class II Officers.

Mr. E. J. Biggie.
Mr. Amar Krishna Mitra.
Lieut. C. S. McLunes.
Captain J. O'C. Fitzpatrick, from November 1st,
1921.
Mr. Bānpendra Nath Saha, M. Sc., (on probation).

Upper Subordinate Service.

Mr. Jagdeesh Prasad Vastav, to 27th March 1922.
Mr. Gopal Lal Mitra.
Mr. Sasadhar Mukerjee.
Mr. Rohini Kumar Talapatra, B. A., (on probation).

Lower Subordinate Service.

37 Surveyors, etc.

It also surveyed the following sheets in Bihār on one-inch scale :—72 L/11.12.13.14.15.16 and 72 P/1.2.5.6.7, besides completing sheets 72 L/9.10 which had been left incomplete in previous seasons.

42 square miles of forest were surveyed on two-inch scale in sheets 72 P/5.7.

Sheets 72 C/14 and G/2 were traversed for detail survey next season, and triangulation was carried out in south of sheet 73 G.

Field head-quarters were opened at Bhāgalpur on November 25th, 1921 and closed on May 2nd, 1922.

Actual plane-tabling commenced in Bihār on November 17th, and the last man closed work in Bengal on May 8th, 1922.

43 officers and surveyors plane-tabled 3,771 square miles compared with 3,000 square miles by 42 plane-tablers last season.

The work in Bihār was divided into three camps as under :—

No. 1 Camp (5 trained surveyors, 1 instructor, 2 officers and 4 pupils under training) was under Mr. E. J. Biggie, and surveyed sheets 72 L/9.10.13.14.

No. 2 Camp (8 trained surveyors, 1 instructor and 1 officer and 5 pupils under training) was under Mr. A. K. Mitra, and surveyed sheets 72 P/1.2.5.6.7.

No. 3 Camp (4 trained surveyors, 1 instructor and 1 officer and 8 pupils under instruction) was under Capt. Fitzpatrick, and surveyed sheets 72 L/11.12.15.16.

Very few of the surveyors here shewn as trained had done much contouring or hill survey before, and camp officers and instructors had to give a great deal of help all round.

The country is generally undulating between 300 and 900 feet above the sea, well covered with villages, scattered trees, broken ground and other detail. There are many isolated hills, generally rocky and covered with scrub jungle, the highest of which, Phuljuri in sheet 72 L/16, rises to 2,312 feet.

These hills are prominent land-marks and plane-table fixings were generally easy to obtain; the ground did not however lend itself to rapid survey as there was a great deal of detail, and owing to the gentle undulations distant view and sketching were impossible.

In sheets 72 P/5.6.7 the Rājmahāl Hills rise to form a prominent range which runs somewhat east of north from Dumkā towards the Ganges river at Sāhibganj.

This range is rocky and now mostly bare or covered with low scrub; most of the forest having been cleared in the course of cultivation by the aboriginal inhabitants, the Paharias. The higher peaks rise to over 1,800 feet above the sea.

Communications throughout the district were very good; the main line of the East Indian Railway running through sheets 72 L/10.11.12 with branch lines to Gīridih and Deogarh. There are several popular and growing health resorts along this line from Karmātaur to Simultala, whilst Deogarh is rapidly becoming an important residential town, being a great place of pilgrimage for worshippers at the Baidyanāth temples.

First class metalled roads radiate from Dumkā, the head-quarters town of the Santāl Parganas district, to Bhāgalpur, Deogarh, Rāmpur Hāt and Sūri.

The branch railway line from Bhāgalpur to Mandār Hill in sheet 72 P/1 was dismantled during the war, and has not yet been relaid.

The climate is good, being dry and bracing, but it gets very hot in April. There was very little sickness in these camps, though Mr. Biggie was in bad health most of the field season.

Supplementary survey on the 1-inch scale was carried out over this area on blue prints of the preliminary editions. These were compiled by the Imperial Standard Mapping Section of the Bengal Drawing Office from Cadastral Surveys of 1901-08. The detail of these sheets was found very accurate and most helpful but in the more hilly area such detail was scanty.

The out-turn for the 17 trained surveyors averaged 24.9 sq. miles for a month of 24 working days.

The out-turn for 21 officers and pupils under training averaged 15.1 sq. miles.

The quality of the final survey was good, though some of the pupils and younger men had to be taken over their ground several times. The survey of steeper hill details in sheets 72 P/6. 7 was not as good as it might have been. There were no cases of misconduct, but three pupils were discharged at the close of the field season as they were below standard.

42 square miles of rocky hills covered with *sāl* forest were surveyed on the 2-inch scale for the Forest Department. The forests are not very valuable and rigorous survey of petty detail was not insisted on. The average out-turn for the two trained surveyors on this work was 9 sq. miles a month.

An unusually large number of khalāsis absconded during the season, mostly *Hos* recruited from Singhbhūm; and mostly from the squads of surveyors working within reach of the railway. Out of 191 men in Camps I and III 28 absconded.

The cost-rate of detailed survey worked out at Rs. 50.7 a mile as compared with Rs. 55.6 a mile in Sundarbans area last season. This rate is still very high as more than half the plane-tablers were under instruction.

The work in Bengal was allotted to *Camp No. IV* under the charge of Mr. J. P. Vastav who had 4 trained surveyors and one pupil under him for completion of 462 square miles left in sheets 79 B/3.7. Work lay to the south of Calcutta on both banks of the Hooghly river.

The area was absolutely flat and densely populated and survey progressed very slowly

but was of very good quality; the four trained surveyors averaged 18·8 sq. miles for a month of 24 working days.

Mr. Gopal Lal Mitra relieved Mr. Vastav of charge of this camp on March 25th.

Triangulation.—The whole of sheet 73 G was allotted to

Lt. C. S. McInnes.

Mr. B. N. Saha.

Surveyor Narayan Singh.

Neither of the two latter had done any triangulation before, and Lieut. McInnes had never done any minor triangulation.

No triangulation had been done by No. 9 Party since season 1913-14, so there are no trained khalāsis or heliotroppers in the party.

Lieut. McInnes left Jājpur Road Railway Station on November 12th 1921, and marched up to Keonjhar, reconnoitring on his way, to meet Mr. Saha and surveyor Narayan Singh who marched down from Chakradharpur Railway Station through Chaibāsa.

Mr. Saha fell ill before reaching his ground and had to take leave. He returned later and commenced work on February 14th, having lost the best part of the season.

Lieut. McInnes and Narayan Singh both found progress very slow owing to lack of communications and the nature of the country, which was heavily wooded and without prominent features. Their areas were therefore cut down to half, and even then they did not commence observations till the last week of February.

There was the usual heavy smoke haze right through March and April, with hardly any relief from thunderstorms.

Lieut. McInnes just managed to complete the triangulation of the four sheets forming south-east quarter of 73 G by the end of April, whilst surveyor Narayan Singh did not quite complete sheets 73 G/10.14.

Surveyor Hari Dutta was brought down to assist in February after completing his traverse work. He and Mr. Saha managed to complete reconnaissance of the four sheets forming the south-west quarter of 73 G, and they both observed a few triangles without completing any one sheet.

All of these triangulators and many of the khalāsis suffered a good deal from malaria.

Next season the triangulators will be able to start observations in November over the area now reconnoitred, and there should be no difficulty in completing the triangulation of the sheet.

The quality of Lieut. McInnes's work was good. His triangular errors averaged 10 seconds for 38 triangles; he fixed 30 stations and 106 points in his four sheets, connecting to three G. T. stations and one G. T. mark.

Traversing.—Surveyor Hari Dutta spent three months, November 8th to February 6th, traversing sheets 72 C/11 and G/2 in the neighbourhood of Patna. These two sheets were cadastrally surveyed on the 16-inch scale in various seasons between 1892 and 1910.

Hari Dutta based his traverse on six G. T. intersected points, and connected with 14 trijunction pillars of the cadastral traverse. He ran 226 linear miles with average error 1 in 500, or 10 feet to a linear mile. He fixed 227 intersected points by observation and 230 points by offset. He reports that about 100 square miles in these two sheets are very congested city and suburban areas; whilst the remainder are open and very easy for survey.

The preliminary editions on one-inch scale in Patna district are accurate and up to date, for such detail as they shew; but in the other districts the old map is not very reliable. Surveyor Hari Dutta was the only member of the party to report interference by non-cooperators. He met with some opposition near Sonpur in Sāran district, but was assisted by the more educated of the inhabitants, and did not have to suspend work.

Recess Duties.—When the party took the field in November 1921 it left a drawing section behind in Shillong under Mr. G. L. Mitra to complete sheets 72 L/6 and 79 B/5.8.10.11.12.16 and 79 C/5.9. The section contained 7 draftsmen from No. 5 Drawing Office and one surveyor who rejoined the party in the field in January.

The last of these sheets to be submitted for publication was 79 B/5 in June 1922. This sheet covers the very congested area along the Hooghly river north of Calcutta.

The party opened fair-mapping in recess on May 12th, with one arrears' sheet and 16 new sheets. Of these 10 sheets were still uncompleted on November 1st, 1922. Seven draftsmen were attached from No. 5 Drawing Office for the greater part of recess.

Much time was saved at the beginning of recess by locating an officer from the party in the office of the Superintendent, Map Publication at Calcutta for three weeks.

This officer handed field sections into the Superintendent, Map Publication's office, took over the enlargements from Photo-Litho. Office, pasted up the combined prints, and handed them in again to Photo-Litho. Office for production of the drawing blue prints. The time taken by the journey of the enlargements to Shillong, and return of the paste-up print to Calcutta was saved by this arrangement, and the effect is shewn in that the average period between handing in field sections to Calcutta and receipt of drawing blue prints in Shillong averaged 21 days in 1922, 41 days in 1921, and 39 days in 1920.

Lieut. Bazley, R.E. who was in Calcutta from April 27th to May 16th was able to assist No. 12 Party in the same way.

Fair-mapping was supervised by the following officers:—

No. I Section, under Mr. E.J. Biggie, with sheets 72 L/9.10.13.14.

No. II Section, under Mr. A.K. Mitra, relieved in September by Lieut. C.S. McInnes, with sheets 72 P/1.2.5.6.7.

No. III Section, under Captain J. O'C. Fitzpatrick, with sheets 72 L/11.12.15.16.

No. IV Section, under Mr. G. L. Mitra, relieved in August by Captain R.S.P. MacIvor, with sheets 79 B/3.4.7.

Computations.—Triangulation.—The triangulation of sheets 73 G/11.12.15.16 was computed by Lieut. C.S. McInnes and Mr. B.N. Saha with one surveyor.

Traverse.—Lieut. Bazley, R.E. held charge of traverse computing section which completed computations of traverse in sheets 72 C/11 and G/2.

The section also assembled all the traverse computations of sheets 79 A,B and C and 72 P into record volumes by degree sheets.

Lists of intersected and offset points were prepared and bound into the volumes, and diagrams were prepared for each degree sheet shewing the traverse lines, and the errors found in them.

The average errors worked out as under:—

	Main Circuits.		All lines including Main Circuits.		Worst line.	
	Linear miles.	Average Closing Errors.	Linear miles.	Average Closing Errors.	Linear miles.	Error passed.
79 A.	958	$\frac{1}{1553}$	1740	$\frac{1}{1427}$	10	$\frac{1}{282}$
B.	928	$\frac{1}{1120}$	1672	$\frac{1}{973}$	2.5	$\frac{1}{73}$
C.	...	not	yet	worked out	...	...
72 P.	...	"	"	"	...	...

Lieut. Bazley also supervised work of plotting section which commenced in August to prepare plane-table sections for the field.

No. 10 PARTY (UPPER BURMA).

BY CAPTAIN O. SLATER, M. C., R. E.

The party continued the detail survey of the Hukawng and the Nāgā territory adjoining it on the west. Sheets 92 B/NE, NW, SE were completed and parts of sheets 83 N/NE., 92 A/sw, SE were surveyed.

PERSONNEL.

Class I Officers.

Lient.-Colonel E. T. Rich, C. I. E., R. E., in charge from 24th October 1921 to 11th June 1922.
 Captain O. Slater, M. C., R. E. (on probation), in charge from 12th June 1922.

Class II Officers.

Mr. W. G. Jarbo, in charge till 23rd October 1921.
 „ S. F. Norman, from 11th August 1922.
 „ O. J. H. Hart, from 23rd December 1921 to 31st May 1922.
 „ F. J. Grice, from 1st November to 30th December 1921.
 „ H. H. Creed.

Upper Subordinate Service.

Mr. Hayat Muhammad, K. S.
 „ Dharendra Nath Saha.
 „ Ram Prasad, R. S.
 Maung Pe, A. T. M.

Lower Subordinate Service.

26 Surveyors, etc.

7 surveyors, completed an area of 2,221 square miles on the half-inch scale in sheets 83 N/NE., 92 A/sw, SE and 92 B/NW.

No. 2 Camp.—Under Mr. H. H. Creed with 6 surveyors completed an area of 947 square miles on the half-inch scale in sheets 92 B/NE, NW, SE.

The total out-turn was 3,168 square miles of original half-inch survey, the cost-rate being Rs. 33·5 per square mile.

Triangulation.—Mr. Ram Prasad, R. S., was to have triangulated in parts of sheets 83 N and 83 O but, owing to the hostility of the Nāgā tribes, had to turn back and was afterwards employed on plane-tabling.

Recess Duties.—The fair-mapping of the party was in the charge of Mr. W. G. Jarbo till Mr. S. F. Norman was posted to the party, after which it was divided into two sections.

No 1 Section, under Mr. W. G. Jarbo, with Mr. D. N. Saha and 7 surveyors and 4 draftsmen, completed the fair-mapping of 2,608 square miles in sheets 83 N/NE., 92 A/sw, SE and 92 B/NE.

No. 2 Section, under Mr. S. F. Norman, with Maung Pe, A. T. M., and 3 surveyors and 3 draftsmen completed 1,705·5 square miles in sheets 92 B/NW, SE.

All the above sheets will be submitted for publication before the party takes the field. The unsurveyed portions of sheets 83 N/NE., 92 A/sw, SE have been compiled from old surveys and reconnaissance surveys. The remaining 637·7 square miles in sheets 92 F/sw, SW and 92 I/sw, SE were completed during October 1921 and these sheets were submitted for publication before the party left for the field.

Maungyo Drawing Office.—During the field season a drawing office was formed to deal with the arrears fair-mapping of Nos. 10 and 11 Parties. This was in the charge of Mr. O. J. H. Hart. The area completed was 5,630·6 square miles in sheets 92 B/NE., 92 J/NW, SE, NE., 95 J/SE., 95 K/NE. and 95 F/NE.

The total out-turn of fair-mapping of the party was 10,582·1 square miles, all on the half-inch scale, the cost-rate being Rs. 4·0 per square mile.

Inspections.—The party was inspected by the Surveyor General and the Superintendent, Eastern Circle during the recess.

No. 11 PARTY (LOWER BURMA).

By J. O. GREIFF.

The field programme of the party was as follows:—

PERSONNEL.

Class I Officers.

Mr. J. O. Greiff, in charge from 1st July 1922.
 Captain T. M. M. Penney, R. E. (on probation), in
 charge to 30th June 1922.

Class II Officers.

Mr. O. J. H. Hart, from 1st June 1922.
 „ G. E. L. Cooper, from 19th October 1921.
 „ A. V. Dickson

Upper Subordinate Service.

Mr. P. C. Sen Gupta, B. Sc.
 „ Khan Muhammad,
 „ A. K. Sen Gupta (on probation), from 25th
 May 1922.

Lower Subordinate Service.

24 Surveyors, etc.

Mergui district, the most southern strip of the mainland of Burma extending from the village of Karathuri in the north to Victoria Point in the south, Sullivan or Lampi island in the Mergui Archipelago, and numerous small islands dotted along the west coast. This strip of country consists of the southern portion of the western range of mountains which stretch across the district from north to south. A few miles below the village of Karathuri, this main range is joined by a cross spur to the eastern barrier that forms the divide between Burma and Siam. At the bend of this cross spur is thrown out the high continuation ridge which trends due south, and terminates in the high promontory of Victoria Point. Here, as throughout the length of the district, continues the characteristic meridional direction of the main ranges, and consequently of the main drainage system. Practically the whole of this southern strip of country is filled by numerous offshoots and subsidiary spurs of the main ridge. From the water edge to the tops of these ridges and spurs there is almost uninterrupted forest.

This area is drained by the Lenya and the Pakehan rivers, which have their source in the cross spur connecting the two main ranges. The former flows for some 60 miles, due north, through a fairly broad valley, when it suddenly alters its course, and forcing its way through a rocky gorge flows due west into the Bay.

The Pakehan river flows due south, and throughout its course forms the international boundary between Burma and Siam, for this most southerly strip of country. For the first part of its course it is a mere mountain torrent, but fed by many affluents, it broadens out, till at Victoria Point it forms an estuary two-and-a-half miles wide. In the low ground, along its right bank, stretches for some distance a plain richly cultivated and well inhabited.

The coast line and the banks of tidal rivers are almost invariably bordered by mangrove swamps, varying from narrow strips to great depths, which form powerful barriers against the sea. They are intersected by numerous canals through which the tide enters and recedes, inundating large areas at high water, as the coast here is little raised above sea level. From these swamps stretch out to sea numerous mud and sand banks rendering the coast unapproachable by vessels of large draught, except in a few places. Most of the larger *channys* (streams or creeks) are navigable for considerable distances at high water, by small launches and country boats.

The western shores of the mainland swarm with game of all sorts; elephant, tiger, rhino and bison are plentiful.

The low lying area and the bamboo forests are the haunt of the sandfly and tick, which make the surveyors' life a burden. If he beats a retreat from these into the valleys he is beset by countless leeches. The undergrowth is a tangled mass of cane, creeper, and scrub.

In the valleys the mist lies heavy each morning till late, considerably hindering the commencement of the day's work.

(i) The completion of the survey of the mainland of the Mergui district and of Sullivan or Lampi island, on the one-inch scale.

(ii) The survey on the 2-inch scale of the reserved forests of Kyaikkamaw and Extension, Kyônkhawun, and Tagundaing, in the Amherst district.

The field season opened at Mergui on the 15th November 1921, the head-quarters of the party arriving on the 23rd. An advance party sent ahead to make the necessary initial arrangements opened at Mergui on the 1st November. The field season closed at Mergui on the 5th June 1922.

The health of the party was good; one khulāsi died of fever in Mergui.

The country surveyed comprised, in the

The country between Maliwun and Victoria Point consists of undulating plains and hills covered with grass and dotted with trees, sometimes in clumps or groves, and here and there in small forest areas.

From Victoria Point to Maliwun there is a good unmetalled road maintained by the P. W. D. From Maliwun it becomes a mule-track as far as Marang, and thence to Karathuri a foot-path. Along the west coast is another track to Maliwun. There are also good paths from Hangapru to the Lenya valley, and along this valley, over the Khao Den pass, to Siam. These communications, with the addition of several elephant-tracks along spurs and ridges, made it possible to start work without the delay, experienced in previous years, in cutting miles of paths.

The principal place of importance in the season's work is Victoria Point, the last British out-post on the east coast. It is the head-quarters of the sub-divisional officer, its position and proximity to Siam investing it with a certain political importance. During the Great War a wireless station and Censor were established here. This southern strip of territory is also rich in tin ore, the chief centre being Maliwun; the ore at present is being extracted chiefly by Chinese.

Lampi or Sullivan island about 50 miles due west of Karathuri, is a high ridge of hills in the form of a horse shoe densely wooded, the outer rim of the shoe being steep and precipitous. Several smaller islands along the west coast were also surveyed. The Archipelago is without doubt one of the great attractions of the district, and well worth a visit. It stretches along the whole of the western coast a vast collection of abrupt islands, of every shape and size with hardly a trace of life. They have been well described as "a cluster of islands and inlets with bays and coves, headlands and highlands, capes and promontories, high bluffs and low shores, rocks and sands, fountains, streams and cascades, mountain, plain and precipice, unsurpassed anywhere for their wild, fantastic and picturesque beauty".

**Distribution.*—The field work was divided up into four camps:—

No. 1 Camp.—Mr. Cooper in charge, to begin with five and later seven surveyors, head-quarters at Hangapru, surveyed an area of 1,071 square miles in sheets 96 I/8. 12. 16, 96 J/5.6.9.10.13 and 96 N/1. The party hospital was in this camp.

No. 2 Camp.—Mr. Dickson in charge, with five surveyors, of whom one was later transferred to No. 1 Camp, head-quarters at Marang, surveyed an area of 568 square miles in sheets 96 J/9.10.11.12.14. 15.

No. 3 Camp.—Mr. P.C. Sen Gupta in charge, with seven pupils, surveyed an area of 170 square miles of reserved forests in the Amherst district, on the two-inch scale in sheets 95 E/13 and 94 H/16. One pupil was withdrawn early in the season as unfit for field work.

No. 4 Camp.—Mr. Khan Muhammad in charge, with two surveyors, surveyed 350·88 square miles in sheets 96 J/1.2.3.5.6.7.11.12 and 96 K/9.

Mr. Khan Muhammad and surveyor Faiz Ali, under the officer in charge of the party, surveyed near the close of the season, 35 square miles in sheet 95 L/8.

Triangulation.—There was no triangulation or traversing done in the season.

The cost-rates are as follows:—

Original one-inch	...	Rs. 69·72 per square mile.
Original two-inch	...	Rs. 133·63 do.

The cost-rate for the one-inch is much lower than the previous year, due to a higher average out-turn per surveyor. The outstanding feature of the field season was the remarkably fine weather experienced compared with previous seasons. Wet days there were, but comparatively few. Communications were easier, the greatest width of country across being about 25 miles with Victoria Point as apex of the triangle. The mean average, for three years preceding 1920-21, is Rs. 71·22 per square mile, which may be taken as the general average cost of work in a district like Mergui. Last season's cost-rates were weighted with large arrears of pay due to officers and establishment on account of the reorganization.

Recess Duties.—In recess the party was divided into three sections:—

No. 1 Section.—Mr. Hart in charge, completed the mapping of one-inch sheets 95 L/8, 96 J/1.2.3.5.6. The total area covered by these sheets is 1,750 square miles, but the land area mapped is only 246 square miles. Nevertheless, in the sea area there is a fair amount of work required to complete each sheet. This section has also done 69 square miles of half-inch mapping in sheet 95 F/NE. and completed and despatched half-inch sheets 95 J/SE, and 95 K/NE.

* The areas shown here as surveyed by each camp include 45 square miles of sea areas which have been excluded from the out-turn of the party in Table III.

No. 2 Section.—Mr. Cooper in charge, completed the mapping of one-inch sheets 96 I/12.8, 96 J/9.10.11.7. The total area of these sheets is 1,176 square miles, inclusive of 272 square miles sea area.

No. 3 Section.—Mr. Dickson in charge, completed the mapping of one-inch sheets 96 I/16, 96 J/12.8.13.14.15, 96 K/9.5, and 96 N/1, covering an area of 1,756 square miles, including 11.6 square miles sea area, and 885 square miles of unmapped area in Siam.

The cost-rate for one-inch mapping is Rs. 15.27 per square mile.

All the fair-mapping will be completed and the sheets despatched before the party takes the field. There will be no arrears sheets.

The two-inch mapping, of the reserved forests of Kyaikkamaw and Extension, Kyônkhawun, and Tagundaing, falling in sheets 95 E/13 and 94 H/16, will be commenced by this party and completed by the Drawing Office during the winter.

The Maymyo Drawing Office was transferred to the charge of No. 10 Party from 1st November 1921.

Miscellaneous.—The season brings to a close the completion of the survey of the Mergui district. In spite of the physical hardships and inconveniences endured yearly since 1915, it would be difficult to find a more interesting area in Burma. Its history from the year 1373 when the town of Tenasserim was built by the Kingdom of Siam, world wide commerce and connection with the great European Courts, is replete with historical interest and incident. Its rugged and wild landscapes with miles of dense forest growth, have an attraction and charm peculiarly their own. Many very interesting and rare specimens of butterflies were caught by Mr. Cooper last field season. Nineteen new species of the Indian *Lepidoptera* were obtained, at Hangapru the *Papilio sycorax*, and at the village of Naugin, on the coast, the *T-rias tilaha*. The former is very rare and said never to have been caught in India before, and is supposed to be peculiar to Borneo, of the latter 23 specimens were taken, and are described as belonging to the Malay States only.

Inspections.—No. 3 Camp was inspected in the field by the Superintendent, Eastern Circle in January. During the recess the party was inspected by the Surveyor General, and Superintendent, Eastern Circle, on the 9th August 1922.

NO. 12 PARTY (ASSAM).

BY BT.-LT.-COL. C. M. BROWNE, C.M.G., D.S.O., R.E.

The party carried out detail survey on the two-inch, one-inch and half-inch scales in the districts of Nowgong, Sibsāgar, Cāchār, Nāga Hills and in Manipur State and triangulation and traverse in Nāgā Hills, Manipur State and Sadiyā Frontier Tract. The country was almost entirely densely wooded and varied in elevation from a few hundred feet to over 9,000 feet.

PERSONNEL.
Class I Officer.
Lt.-Lt.-Col. C.M. Browne, C.M.G., D.S.O., R.E., in charge.

Class II Officers.
Mr. E. M. Kenny.
„ D. K. Rennick, M.B.E.
„ R. C. Hanson, from 16th February 1922.
„ Prafulla Chandra Mitra, B.A., up to 15th April 1922.

Upper Subordinate Service.

Mr. Girija Sonker Bāchi.
„ Atul Chandra Maulick, (on probation), from 17th October 1921.
„ Suresh Chandra Chatterjee, B.Sc. (on probation), from 23rd May 1922.

Lower Subordinate Service.

38 Surveyors, etc.

The field season extended over a period of a little more than 6 months. The health of the party was only fair, average daily sick in hospital being a little over 8 per diem; 3 khalāsīs died, one from cholera, one from pneumonia and one was drowned.

Towards the close of the field season, cholera was bad in the neighbourhood of the party headquarters, but inoculation was carried out with serum obtained from the Pasteur Institute at Shillong and only one case occurred and that was before the inoculation.

Plane-tableing.—The country surveyed was almost entirely dense jungle with scattered villages and there were some quite large areas (mostly in reserved forests) which were uninhabited.

Coolies were the only means of transport, except the three party elephants. Conveyance and jungle clearing charges were in consequence heavy. Work in the plains and low hills was carried out by plane-tableing traversing based on theodolite traverses and in the hills by interpolation.

The party was divided into three camps:—

No. 1 Camp, head-quarters Lumding, under Mr. E. M. Kenny with 9 surveyors surveyed 104 square miles on the half-inch scale, 439 square miles on the one-inch scale, and 134 square miles of reserved forests on the two-inch scale in parts of sheets 83 G/NW NK.

No. 2 Camp, head-quarters Mähür on the hill section of Assam-Bengal Railway, under Mr. D. K. Rennie, M. B. E., and one Upper Subordinate officer with 12 surveyors and one pupil surveyed 564 square miles on the one-inch scale and 779 square miles on the half-inch scale in sheet 83 G/SW. and in parts of sheets 83 G/NW. SE. NE.

No. 3 Camp, head-quarters Dimāpur, under Mr. R. C. Hanson with 7 surveyors surveyed 179 square miles on the one-inch scale in parts of sheet 83 G/NE. This camp was only formed towards the end of the field season.

The total area surveyed was 883 square miles on the half-inch scale and 1,182 square miles on the one-inch scale and 134 square miles on the two-inch scale, the cost-rate being Rs. 25.5, 55.2 and 111.8 respectively and the combined cost-rate Rs. 82.

Triangulation.—Triangulation was carried out by Mr. P. C. Mitra in sheets 82 L/SE, 82 P/SW., 83 I/NE. and 83 M/NW., and by Mr. G. S. Bagchi in sheets 83 G/SE, 83 K/SW. and 83 H/NE.

The country was mostly densely wooded hills rising to about 9,000 feet and a large amount of jungle clearing was necessary; labour and supplies were difficult to obtain.

In Mr. Mitra's area rain, mist, and haze interfered with the observations and his work had to close in March on account of them. A total area of 3,376 square miles was triangulated at a cost-rate of Rs. 7.0 per square mile.

Traversing.—Traversing was carried out to assist the detail surveyors in the plain portions of sheets 83 G/1.5 6.9.10.13 and in sheets 83 1/13.14, 83 M/1.2.5. 5 traversers were at first employed, later reduced to 4. The dense jungle made the work laborious and expensive and supplies, and even water, were in parts difficult to obtain. Most of the traversers suffered from sickness, the out-turn is consequently small and the cost-rate high.

277 linear miles were traversed covering an area of 1,017 square miles; 2,850 stations were observed at, of which 21 can be considered as permanent. The cost-rate per linear mile was Rs. 73.2.

Recess Duties.—The fair-mapping was divided into 3 sections:—

No. 1 Section, under Mr. E.M. Kenny, carried out the fair-mapping of 83 G/5 on the one-inch scale and maps of Dhansiri and Rangapahār reserved forests on the two-inch scale and part of 83 G/SW. on the half-inch scale.

No. 2 Section, under Mr. D.K. Rennie, M.B.E., carried out the fair-mapping on sheets 83 G/3.4 on the one-inch scale and of 83 G/SW. on the half-inch scale.

No. 3 Section, under Mr. R.C. Hanson, carried out the fair-mapping of sheets 83 G/9.13 on the one-inch and part of 83 G/NE. on the half-inch scale.

There were no arrears from last recess and it is confidently expected there will be none this recess except those, the survey of which, is not complete.

Lieut. H.A. Bazley, R.E., of No. 9 Party, temporarily at Calcutta, assisted very greatly by making the combined originals in Calcutta from photographs of the field sections, thereby saving much valuable time at the beginning of recess.

The policy of the party, in drawing its own forest sheets was continued and it has been able to complete them without detriment to its standard mapping.

The half-inch maps, being drawn simultaneously with the one-inch, has also proved successful and will lessen the work of the Circle Office.

Mr. G.S. Bagehi and 4 computers and 3 traversers completed the computations of the triangulation and traversing done during the field season and completed the four-inch boundary plots of the following forests:—Dhansiri and Rangapahār, Narpuh blocks I and II and will be submitted. Triangulation chart 83 C was compiled and will be submitted.

Inspections.—The Superintendent, Eastern Circle inspected the party in the field in December 1921.

No. 21 (BURMA FOREST) PARTY.

By H.W. BIGGIE.

This party continued forest survey operations in Upper and Lower Burma and the Southern Shan States. The country over which work was carried out consists generally of well-wooded hills.

PERSONNEL.

Class I Officers.

Mr. H. W. Biggie, in charge from 1st July 1922.

Class II Officers.

Mr. S. F. Norman, in charge, up to 30th June 1922.

Lieut. L. B. Fitz-Gibbon.

Capt. V. P. Wainright.

Capt. C. B. Sexton.

Mr. H. M. Critchell. (on probation).

Upper Subordinate Service.

Mr. Dalbir Rai, up to 1st June 1922.

„ Ghulam Hasan.

Lower Subordinate Service.

20 Surveyors, etc.

The field season was spread over a period of seven months from November 1921 to June 1922.

There was a good deal of sickness, principally due to *malaria*, in the forests. Among the lower subordinates two deaths occurred during the year, one from fever in the field and the second from plague in Maymyo.

Plane-tabling.—This was carried out by the party in the Mansi Division in the Upper Chindwin district of the Northern Forest Circle, and in the Bassein Division of the Delta Forest Circle, and by the Survey Training School in the Meiktila and Southern Shan States Forest Divisions in the Central Forest Circle. The area surveyed in the Mansi Division completed the Modè reserve which consists of well-wooded hills which are steep and rugged on their upper slopes. The country worked over in the Bassein Division includes portions of the eastern and western slopes of the Arakan Yoma. These are thickly clad in tree growth with scrub jungle in parts. Between the lower slopes and the Ngawun or Bassein river, the country has a very dense belt of bamboo called *kayin wa* in Burmese. With its growth of numerous single reeds with intervals of about one foot and which rise to an average height of 30 feet, it was a formidable obstacle to progress, and line clearing was a tedious and disheartening labour. One of the small reserves surveyed in Bassein lies in swampy ground on the left bank of the Bassein river. The country surveyed in Meiktila consists of low, well-wooded hills. In the Southern Shan States the Kalaw reserve and the town of Kalaw which is an exclusion in the centre of the reserve, were surveyed. Kalaw, which is the head-quarters of a sub-division is flat for the most part and is surrounded by undulating pine-clad hills, on the lower slopes of which numerous residential houses exist. The reserved area lies all round the town, and is hilly everywhere, the hills in the south rising to 5,000 feet.

Field work was distributed and completed as follows:—

Mr. Ghulam Hasan surveyed 3.65 square miles on the four-inch scale in the Modè reserve falling in 83 P/9 and moved into the Bassein area in March 1922, when he started plane-tabling on the two-inch scale, with one pupil under instruction.

No. 1 Camp.—Mr. Norman, in charge, with four pupils completed by the middle of February 1922, 9.26 square miles on the two-inch scale in the Shwemyindin reserve falling in 85 L/13.

No. 2 Camp.—Captain Wainright, in charge, with ten surveyors and two pupils, reinforced in February by four pupils from No. 1 Camp, completed 111.11 square miles on the two-inch scale in the Podaw, Kyeintali and Sitsayan reserves falling in 85 K/11. 12. 15. 16. This area includes 17.72 square miles of unclassified forest. He made over charge of this camp to Mr. Ghulam Hasan in the first week of May leaving in the camp eight surveyors and two pupils and took with him to Maymyo where he arrived about the middle of May, 2 surveyors and 4 pupils to form an advance drawing section.

Mr. Ghulam Hasan with eight surveyors and three pupils completed between the first week of May and the close of the field season, 26.50 square miles on the two-inch scale in portion of the Chaungtha reserve falling in 85 L/9.

Captain Sexton with eighteen pupils, working in pairs from the Survey Training School and one trained surveyor from the party surveyed 25.39 square miles on the two-inch scale in the Kubyin reserve falling in 93 D/5, and 16.21 square miles on the four-inch scale in the Kalaw reserve falling in 93 D/10. Of the latter area, the trained surveyor contributed 2.00 square miles in 26 working days. Maung Pe, A.T.M., from No. 10 Party and paid for by that party, assisted Captain Sexton in the supervision and instruction of pupils.

The cost-rates, calculated on the areas done by the party only, are :—two-inch, Rs. 338·1 per square mile ; four-inch, Rs. 1,059·9 per square mile.

A high degree of accuracy in the work was sought and obtained at some sacrifice in expenditure and out-turn, but the resulting maps should be found to be thoroughly reliable for any purpose. The precision, with which the survey was done, is more than is necessary for the requirements of the Forest Department and if minuteness was done away with, out-turns could be considerably improved without, in any way, lessening the utility of the maps.

The amount debitable to instruction in all classes of work during the year is Rs.13,544.

Triangulation.—This was carried out by Mr. Critchell over 100 square miles in 85 L/9.10.11 on the Arakan Yoma already described. It was his first experience and he encountered difficulties in dealing with the technicalities of the work. The cost-rate works out to Rs. 80·1 per square mile.

Traversing.—This was carried out in portions of 85 L/5.6.7.8.9.10.11 and 94 C/14, G/4.8, H/1.6.6 in the Bassein and Thaton Forest Divisions respectively. The country traversed in Bassein lies in the Arakan Yoma which has been described under the head Plane-tabling. In the Bassein Division the following reserves were traversed :—Chaungtha, Mēzali, Thitpòk, and the greater portion of Myittaya and Sinma. In the Thaton Division the following reserves were traversed :—Wetwundaung, Bilin, Panbein, Kyônsein, Danu, Kalamataung and Martaban. With the exception of Kyônsein all these reserves consist of low well-wooded hills. The ground in the Kyônsein reserve is generally flat ; and so far as information is available, fairly densely clad in tree and scrub jungle. About 200 exclusions, many being very small fruit gardens, lie scattered over the Thaton reserves and arrangements are being completed with the Forest Department to survey them on a scale larger—depending on their size—than 2 inches to one mile. In any case the scale of survey will not be larger than 8 inches to one mile. The Conservator, Working Plans Circle desires that they should be shown as insets in the blank portions of the published sheets.

Lieut. Fitz-Gibbon was in charge of the traverse work throughout the year, the work in the field being divided as follows :—

No. 1 Section, with head-quarters at Kanni, a village in the Bassein district, was supervised by Lieut. Fitz-Gibbon with two computers and eight traversers.

No. 2 Section was supervised by Surveyor Lalit Mohan Ganguly with three traversers he himself doing 103 linear miles of traversing, a very creditable performance.

590 linear miles consisting of 577 linear miles of boundary traversing and 13 linear miles of simple traversing and covering an area of 520 square miles were traversed for work on the two-inch scale and the cost-rate including the cost of computations in recess, works out to Rs. 104·1 per linear mile.

Recess Duties.—(a). There was one section employed on fair-drawing. This was under Captain Wainright assisted by Mr. Critchell and seven draftsmen.

The following reserves were fair-drawn :—Podaw, Kyeintali and Sitsayan and adjoining unclassified forest, covering a total area of 111·11 square miles in one sheet on the two-inch scale, including portions of 85 K/11.12.15.16 ; Shwemyindin 9·26 square miles on the two-inch scale in 85 L/13 ; portion of Chaungtha 26·50 square miles on the two-inch scale in 85 L/9 ; Kubyin 25·39 square miles on the two-inch scale in 93 D/5 ; Kalaw including Kalaw Town, which is an exclusion in the reserve, 16·21 square miles on the four-inch scale in 93 D/10. The estimated out-turns of fair-drawing for which credit has been taken are 44·4 square miles and 169·6 square miles on the four-inch and two-inch scales respectively. The cost-rates are :—four-inch, Rs. 140·6 per square mile ; two-inch Rs. 47·1 per square mile.

Arrears of fair-drawing show 5·0 square miles in the sheet containing the Podaw, Kyeintali and Sitsayan reserves. This is due to its name trace completed and submitted a second time in July 1922 to the Divisional Forest Officer concerned, having been destroyed by the capsizing of a boat which a subordinate, who was deputed to verify the names was using. The information reached the party in September and early action to get the remaining names verified has been taken.

40 square miles remain to be surveyed in the Chaungtha reserve during 1922-23 and this will be fair-drawn in 1923 and added to 26·50 square miles already drawn to be published in one sheet.

(b). Other recess duties included the fair-drawing by the Survey Training School on the four-inch scale, from four-inch surveys done by the Forest Department, of 2.83 square miles, covering Blocks XII and XIII of the Kuladan reserve in 84 C/15 in Akyab, and 7.00 square miles, being portion of Block XIV of the same reserve in 84 H/1 in the hill district of Arakan.

The traverse computations during recess were under Lieut. Fitz-Gibbon assisted by 11 computers, of whom 4 were pupils whose help became necessary. The pupils were quick to pick up the use of the traverse tables and have expedited the work which includes the final calculation of the co-ordinates of over 13,000 stations.

Four-inch boundary plots have been prepared for all reserves surveyed on the two-inch scale, and the cost of these is merged in that of the fair-drawing on the same scale.

Towards the end of August 1922, the work was taken in hand of projecting 40 plane-tables for original forest surveys on the two-inch scale, and for the addition of boundaries of old two-inch surveys of certain reserves of the South Pegu and Insein Forest Divisions during field season 1922-23. The plotting of some 13,500 traverse points for field work and the duplication where necessary of notifications and maps of reserves has also been taken in hand. These duplicates are issued to camp officers and they help in the adjustment of boundaries in the field. Copies of values of traverse points are also in hand for distribution to camp officers.

Miscellaneous.—A great difficulty in Bassein is the rationing of men with suitable transport. Elephants are the best means of dealing with this question. The Forest Department will not be able to supply the party with the full number of animals required for use during field season 1922-23, and portorage by Hazārībāgh men has been arranged to the extent required. The Deputy Commissioner, Bassein has also been requested to arrange for a first month's supply of rice at camp head-quarters to be taken over by camp officers as soon as they arrive in their ground. Subsequent requirements will be arranged for by them.

Inspections.—The Surveyor General inspected the party in recess. The Superintendent, Eastern Circle inspected the party in the field and recess.

TABLE I.
OUT-TURNS OF PLANE-TABLING 1921-22.

Scale.	Class of survey.	Circle.	Party.	Locality.	Out-turn, square miles.		Average number of fixings per square mile.		
					Total.	Average per man per month of 24 working days.	<i>In situ</i> (by resection).	Plane-table traverse.	
½-inch	Original Survey	N	No. 2	Central India	{ 283	49.6 (a)	6.4	0.1	
					{ 209	56.4 (b)	5.6	0.1	
		S	No. 5	Central India	1,526	} 42.9	6.1	0.7	
		S	No. 5	Gwalior	120				
		S	No. 6	Hyderābād (Deccan)	6,270	62.8	5.7	0.1	
		E	No. 10	Upper Burma	3,168	63.4	0.3	3.2	
E	No. 12	Assam	883	35.8	0.9	9.9			
½-inch	Supplementary Survey	S	No. 6	Hyderābād (Deccan)	365	...	...	...
1-inch	Original Survey	N	No. 4	Nepāl	294	40.5	9.0	6.3	
									S	No. 5	Central India	652	} 20.7	5.3	4.4
		S	No. 5	Central Provinces	1,474				
		S	No. 7	Madras	3,668	} 40.5	7.0	0.1	
		S	No. 7	Hyderābād (Deccan)	142				
		S	No. 8	Madras	970	25.8	7.3	0.3	
		E	No. 9	Bengal	{ (a)	401	18.8	5.4	19.5
		{ (b)			61	10.4	12.2	18.8	
		E	No. 11	Lower Burma	1,980	33.4	1.1	4.1	
		E	No. 12	Assam	1,182	15.0	2.8	16.5	
1-inch	Re-survey	N	No. 2	Central India, Rājputāna and United Provinces	{ 604	26.2 (a)	13.9	5.1	
					{ 1,821	20.8 (b)	14.8	7.9	
1-inch	Revision Survey	N	No. 2	Central India and United Provinces	{ 1,523	34.0 (a)	9.0	6.2	
					{ 1,171	26.4 (b)	7.9	5.8	
		N	No. 4	United Provinces & Bihār and Orissa	3,691	31.8	6.5	5.3	
1-inch	Supplementary Survey	S	No. 8	Bombay	3,386	28.6	6.9	0.4	
									S	No. 5	Central Provinces	615	43.7	1.5	2.8
		S	No. 7	Madras	1,919	87.7	1.5	0.3	
		S	No. 8	Madras	199	22.9	6.0	1.0	
		E	No. 9	Bihār and Orissa	(a)	1,844	24.9	8.0	1.6
(b)	1,423	15.1			9.2	3.8			
1-inch	Original Forest Survey	S	No. 5	Central India	278	20.3	8.5	4.9	

(a) By trained surveyors.

(b) By pupils.

TABLE I.—*Concluded.*OUT-TURNS OF PLANE-TABLING 1921-22.—*Concluded.*

Scale.	Class of survey.	Circle.	Party.	Locality.	Out-turn, square miles.		Average number of fixings per square mile.	
					Total.	Average per man per month of 24 working days.	<i>In situ</i> (by resection).	Plane-table traverse.
2-inch	Original Survey	N	No. 3	United Provinces and Nepāl	1,969	20·4	6·2	...
2-inch	Original Forest Survey	S	No. 7	Madras	333	8·4	25·4	8·2
		E	No. 9	Bihār and Orissa (a)	39	9·0	12·8	22·0
					3	2·9	48·7	72·3
		F	No. 11	Lower Burma	170	4·9	2·6	64·1
		E	No. 12	Assam	134	5·7	...	41·9
		E	No. 21	Upper Burma (c)	25	3·3	...	33·3
E	No. 21	Lower Burma	147	2·0	...	174·5		
4-inch	Original Survey	E	No. 21	Upper Burma (d)	20	0·8	...	251·2
4-inch	Original Forest Survey	S	No. 5	Central Provinces	14	2·9	25·3	69·3
6-inch	Original Survey	N	No. 20	Deolāli	40·21	1·9	Fixings per square mile. 52·9	Chains per square mile. 133·1
16-inch	Original Survey	N	No. 20	Bangalore	Acres. 617·00	Acres. 361·2	Fixings per acre. 0·3	Chains per acre. 2·0
		N	No. 20	Deolāli	1,447·00	165·4	0·3	5·2
16-inch	Revision Survey	N	No. 20	Bangalore	410·00	894·5	1·0	3·1
		N	No. 20	Deolāli	976·00	114·3	0·3	4·5
		N	No. 20	Ahmadābād	2,075·00	398·3	0·2	3·1
64-inch	Original Survey	N	No. 20	Deolāli	48·36	52·6	...	12·5
64-inch	Revision Survey	N	No. 20	Deolāli	33·00	29·3	...	19·3
		N	No. 20	Ahmadābād	25·00	42·9	...	12·3
One-inch to 50 feet	Original Survey	N	No. 20	Bangalore	65·63	15·7	...	14·7

(a) By trained surveyors.
by Survey Training School.

(b) By pupils.

(c) By Survey Training School.

(d) Done mostly

TABLE II.
DETAILS OF TRIANGULATION AND TRAVERSING 1921-22.

Scale.	Class of survey.	Circle.	Party.	Locality.	TRIANGULATION.							TRAVERSING.								
					Diameter of theodolite in inches.	Area in square miles.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Number of stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Number of intersected points fixed.	Linear error per mile in feet.	Area in square miles.	Linear miles chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1,000.		
1-inch	Triangulation	N	No. 1	District Dera Ghāzi Khān and Baluchistān	5	2,700	8.1	8.1	36	5.0	0.13	295	0.33	...	...	...	...	...
4-inch	Ditto	N	No. 2	Central India and Rājputāna	6	6,560	13.9	13.9	116	11.5	0.40	357	0.64	...	...	941.2 (acres)	1,188	2.8	0.5	
12-inch	Traverse	N	No. 2	Delhi Province	...	...	...	...	...	...	...	...	...	...	...	31.91	78.34	514	2.0	0.6
16-inch	Ditto	N	No. 2	United Provinces	...	...	...	...	...	...	...	...	...	...	...	1324.8 (acres)	35.35	623	2.0	0.6
64-inch	Ditto	N	No. 2	United Provinces	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1-inch	Triangulation	N	No. 4	Nepāl and Bihar and Orissa	6	58	3.9	4.1	4.0	26.3	1.3	11	0.99	...	...	...	...	...	...	...
1-inch	Traverse	N	No. 4	Nepāl	...	...	...	...	...	...	...	...	...	...	...	289	133	379	5.3	0.9

TABLE II—Continued.
DETAILS OF LEVELLING AND TRAVERSING 1921-22.

Scale	Class of survey.	Circle	Party.	Locality.	TRIANGULATION.								TRAVERSING AND LEVELLING.					
					Diameter of theodolite in inches.	Area in square miles.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Number of stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Number of intersected points fixed.	Linear error per mile in feet.	Area in square miles.	Linear inter chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1,000.
6-inch	Original	N No. 20	Deolali		6	...	...	...	...	...	...	...	...	...	29.95	75	4.2	0.6
1 inch to 50 feet	Ditto	N No. 20	Bangalore Civil and Military Station		6	...	...	...	...	...	...	...	...	...	1.05	16	3.8	0.1
16-inch	Revision	N No. 20	Ahmadabad		6	...	...	...	...	...	...	...	...	...	0.94	5	0.0	0.3
6-inch	Original	N No. 20	Deolali		...	...	...	...	...	...	...	...	...	...	34.16	595	}	}
16-inch	Ditto	N No. 20	"		...	...	...	...	...	...	...	...	...	24.78	492			
16-inch	Revision	N No. 20	Ahmadabad		...	...	...	...	...	...	...	...	...	...	24.40	235	...	0.2 inch per mile
1 inch to 50 feet	Original	N No. 20	Bangalore		...	...	...	...	...	...	...	...	...	...	13.49	115	...	0.5 inch per mile

TABLE II.—Concluded.
DETAILS OF TRIANGULATION AND TRAVERSING 1921-22.

Scale.	Class of survey.	Circle.	Party.	Locality.	TRIANGULATION.							TRAVERSING.							
					Diameter of theodolite in inches.	Area in square miles.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Number of stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Number of intersected points fixed.	Linear error per mile in feet.	Area in square miles.	Linear miles chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1,000.	
1/4-inch and 1-inch	Original Survey	S	No. 5	Central India, Central Provinces and Gwalior	5	540 3,870	* 54.0 38.5	45.0 31.7	6 33	9.5 7.9	0.00 2.59	4 68	0.00 4.81	...	...	...
2-inch	Ditto	S	No. 6	Hyderābād State	6	690	2.6	2.8	50	8.9	0.27	200	0.42	...	...	...
1-inch	Ditto	S	No. 7	Madras	6	4,462	8.5	7.1	67	7.0	0.15	456	0.56	...	...	...
1-inch	Revision Survey	S	No. 8	Madras and Poona	6	307	7.9	10.2	5	11.8	0.05	34	0.95	...	...	...
1-inch	Triangulation	E	No. 9	Bihār and Orissa	5 & 6	1,600	7.2	7.6	30	10.2	0.38	106	1.73	...	...	...
1-inch	Traversing	E	No. 9	Do.	5	226	662	4.8	2.0	
1/4-inch and 1-inch	Triangulation	E	No. 12	Assam	6	3,376	14.2	14.2	25	4.8	1.36	216	0.82	
1-inch	Traversing	E	No. 12	Do.
2-inch	Original Survey	E	No. 21	Lower Burma	6	100	16.7 (a)	25.0 (a)	6	20.0	540	276.95	2,850	4.3	2.4
															590.3	13,338	4.6	1.3	

(a) Additional points, previously fixed, will also be used in this area.

TABLE III.
COST-RATES OF SURVEY 1921-22.

Party.	Locality.	COST-RATES, REPPES, PLANE-TABLING, PER SQUARE MILE.												Total cost of party. Rs.	REMARKS.										
		1 1/2 inch		1 inch		2 inch		4 inch		6 inch		8 inch				16 inch		64 inch		1 inch to 50 ft.					
		Revision survey.	Original survey.	Revision survey.	Original survey.	Revision survey.	Original survey.	Revision survey.	Original survey.	Revision survey.	Original survey.	Revision survey.	Original survey.	Revision survey.	Original survey.	Revision survey.	Original survey.	Revision survey.	Triangulation per square mile.	Topographical.	Forest boundary.	Full mapping, per square mile.	Total plane-tableing out-turns on all scales, square miles.		
No 1	North-West Frontier Province, Punjab, Punjab States and United Provinces.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0.7 (a)	...	...	...	...	94,269	(a) Cost of completion of survey and computation left from last year. (b) Cost of completion of survey and triangulation mentioned in (e). (c) Complete cost of triangulation in Dera Ghazi Khan district, for surveys next year. (d) Cost-rate for 6,488 square miles of fair-mapping done during the year. (e) Total cost-rate for 7,777 square miles, including arrears of mapping done in the current and previous years, 1920-21 and 1921-22.
No 2	Central India, Delhi Province, Rajputana and United Provinces.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2.0	79.7 (f) 18.0 (g) 53.8 (h)	...	...	5,611 (i)	1,99,970 (m)	(f) For 64-inch Allahabad traverse and computation. (g) For 16-inch Allahabad traverse and computation. (h) For 12-inch Delhi traverse and computation. (i) 4-inch fair-mapping for 1/2 inch maps. (j) 1 1/2-inch fair-mapping for 1-inch maps. (k) 8-inch fair-mapping for 8-inch maps. (l) 8 inches area surveyed on 1-inch scale for Executive Engineer, Western Jumna Canal. (m) Includes amounts (viz. Rs. 9,401) debit-able to other departments.

TABLE II.—*Concluded.*
 DETAILS OF TRIANGULATION AND TRAVERSING 1921-22.

Scale.	Class of survey.	Party.	Locality.	TRIANGULATION.							TRAVERSING.									
				Diameter of theodolite in inches.	Area in square miles.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	Number of stations fixed.	Triangulation error in seconds.	Linear error per mile in feet.	Number of intersected points fixed.	Linear error per mile in feet.	Area in square miles.	Linear miles chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1,000.			
1/4-inch and 1-inch	Original Survey	S No. 5	Central India, Central Provinces and Gwalior	5	540	54.0	45.0	6	9.5	0.00	4	0.00	4	0.00	...	...	...
2-inch	Ditto	S No. 6	Hyderabad State	6	3,870	38.5	31.7	33	7.9	2.59	68	4.81	...	...	...	...	...
1-inch	Ditto	S No. 7	Madras	6	690	2.8	2.8	50	8.9	0.27	200	0.42	...	...	...	...	...
1-inch	Revision Survey	S No. 8	Madras and Poona	6	4,462	8.5	7.1	67	7.0	0.15	456	0.56	...	...	...	...	...
1-inch	Triangulation	E No. 9	Bihar and Orissa	5 & 6	1,600	7.2	7.6	30	10.2	0.38	106	1.73	...	...	...	...	...
1-inch	Traversing	E No. 9	Do.	5	540	226	662	4.8	2.0	
1/4-inch and 1-inch	Triangulation	E No. 12	Assam	6	3,376	14.2	14.2	25	4.8	1.36	216	0.82	
1-inch	Traversing	E No. 12	Do.
2-inch	Original Survey	E No. 21	Lower Burma	6	100	16.7	25.0	6	20.0	1,017	276.95	2,850	4.3	2.4	
						(a)	(a)								520	590.3	13,338	4.6	1.3	

(a) Additional points, previously fixed, will also be used in this area.

TABLE III.
COST-RATES OF SURVEY 1921-22.

Circle.	Party.	Locality.	COST-RATES, RUPEES, PLANE-TABLING, PER SQUARE MILE.													Total cost of party.	REMARKS.												
			1/2 & 1/4 inch Revision survey.	1/2 & 1/4 inch Original survey.	1/2 inch Revision survey.	1/2 inch Original survey.	1/2 inch Supplementary survey.	1/2 inch Original forest survey.	2-inch Original survey.	2-inch Original forest survey.	4-inch Original survey.	4-inch Original forest survey.	6-inch Original survey.	6-inch Original forest survey.	8-inch Original survey.			8-inch Original forest survey.	16-inch Original survey.	16-inch Revision survey. per acre.	64-inch Original survey. per acre.	64-inch Revision survey. per acre.	1-inch to 30 ft. Original per acre.	Triangulation per square mile.	Topographical.	TRAVERSING PER LINEAR MILE.	Fair-mapping, per square mile.	Total plane-tableing out-turns on all scales, square miles.	Rs.
N	No 1	North West Frontier Province, Punjab, Punjab States and United Provinces.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	94,269	(a) Cost of completion of survey from last year's survey and triangulation mentioned in (a). (b) Complete cost of survey and triangulation mentioned in (a). (c) One piece cost of mapping done in Decr Ghazi Khan district, for surveys next year. (d) Cost-rate for 6-488 square miles of fair-map done during the year. (e) Total cost-rate for 7,777 square miles, including areas of mapping done in the current and previous years, 1920-21 and 1921-22. (f) For 8-inch Allahabad traverse and computation. (g) For 16-inch Allahabad traverse and computation. (h) For 16-inch Delhi traverse and computation. (i) 1-inch fair-mapping for 3 inch maps. (j) 1 1/2 inch fair-mapping for 3 inch maps. (k) 1/2 inch fair-mapping for 6-inch maps. (l) Excludes area surveyed on 6-inch scale for Executive Engineer, K. J. M. S. (m) Inclusion amounts (viz. Rs. 9,401) debit-able to other departments.
N	No. 2	Central India, Delhi Province, Rajputana and United Provinces.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1,99,970 (m)	(a) 0.7 (a) (b) 6.8 (b) (c) 7.8 (c) (d) 8.1 (d) (e) 11.5 (e) (f) 79.7 (f) (g) 18.0 (g) (h) 58.8 (h) (i) 3.0 (i) (j) 6.7 (j) (k) 3.6 (k) (l) 5.611 (l)



PANORAMAS OF TRISUL.

PHOTOGRAPHS BY MR. R. B. WOOD.

PART II.—GEODETIC AND SCIENTIFIC OPERATIONS.

TRIGONOMETRICAL SURVEY.

ASTRONOMICAL LATITUDES.

During the year advantage was taken of the fact of Bt.-Major K. Mason, M.C., R.E., being in Kashmir, on other survey work, to get this officer to carry out Talcott observations for latitude at four stations of the Kashmir triangulation, namely:—Gogipatṛī, Poshkar, Zebanwan and Reban. The observations at the two former were of the nature of revision, the earlier observations at those two stations in 1860 having given indications of defects in the instrument used, with the result that the values of latitude then obtained have always been looked upon with some suspicion. The computation of this work is in hand but the results are not yet available.

The personnel of the party were employed at the Head-quarter offices of the Trigonometrical Survey.

PERSONNEL OF No. 13 PARTY.

Class I Officer.

Captain H.E. Roome, M.C., R.E., in charge.

Lower Subordinate Service.

1 Clerk.

1 Computer.

No. 14 PARTY—PENDULUM, No. 15 PARTY—TRIANGULATION AND

No. 19 PARTY—BASE LINE OPERATIONS.

No field operations were carried out by these three parties, the personnel being employed at the Head-quarter offices of the Trigonometrical Survey.

TIDAL OPERATIONS.

BY MAJOR C. M. THOMPSON, I. A.

During the year under report the registrations of the tidal curves by means of automatic tide-gauges were continued at the following ports:—

PERSONNEL OF No. 16 PARTY.

Class I Officers.

Major C. M. Thompson, I. A., in charge from 19th June 1922.

Captain E. A. Glennie, D. S. O., R. E., in charge from 10th May to 18th June 1922.

Class II Officers.

Mr. Hanuman Prasad, B. S., in charge till 9th May 1922.

.. D. H. Luxa.

Lower Subordinate Service.

21 Computers, etc.

Aden, Karāchi, Bombay (Apollo Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

These operations were conducted under the direction of this department, the immediate control of all the observatories being entrusted to the local officers of the ports concerned.

In addition to the above work, the predictions of the heights and times of high and low-water for the year 1921 at the following ports:—Bhaunagar, Chittagong and Akyab were compared against the actual observations of the heights and times of high and low-water as supplied by the Port officers of the above ports. These readings on tide-poles were taken during daylight throughout the year. The object of the above comparisons was to see whether the predictions, which were based on tidal observations taken many years ago, still maintained the required degree of accuracy.

TIDAL OBSERVATIONS AT BASRAH.

Hourly readings throughout the day and night of the height of the water against an ordinary wooden tide-pole were continued at Basrah. Copies of these readings were supplied to this department weekly by the Director, Inland Water Transport, Mesopotamia. The readings for the year commencing 1st January 1921, were reduced by the method of harmonic analysis, and the constants thus deduced, were used in the computation of data for the Basrah tide-tables for 1923, which were prepared with the aid of the tide-predicting machine recently erected in the office of the Superintendent of the Trigonometrical Survey, Dehra Dûn.

The tide-tables for Basrah for 1923 were published on the 12th June 1922, and have been despatched to the officials requiring them.

LIST OF TIDAL STATIONS.

The following is a complete list of the ports at which tidal registrations have been carried out from the commencement of the tidal operations in 1874 up to the present time. The stations at which automatic tide-gauges are still working are shown in italics: the others are minor stations which were closed after a few years on the completion of the requisite registrations.

List of Tidal Stations.

Serial No.	Stations	Automatic or Personal observations	Date of commencement of observations	Date of closing of observations	Number of years of observations	REMARKS
1	Suez	Automatic	1897	1903	7	
2	Perim	"	1898	1902	5	
3	Aden	"	1879	Still Working	43	
4	Masqât	"	1893	1898	5	
5	Bûshire	"	1892	1901	8	
6	Karâchi	"	{ 1868 1881	Still Working	{ *13 11	{ 54 } *Small tide-gauge working
7	Hanstal	"	1874	1875	1	} Tide-tables not published. Year 1904-05 is excluded.
8	Navânar	"	1874	1875	1	
9	Okha Point	"	{ 1874 Restarted 1904	1906	1	
10	Porbandar	Personal	1893	1894	2	} Years 1898, 1899 & 1902 are excluded.
10A	Porbandar	Automatic	1898	1902	2	
11	Port Albert Victor (Kâthiâwâr).	Personal	1881	1882	1	
11A	Port Albert Victor (Kâthiâwâr).	Automatic	1900	1903	4	
12	Bhaunagar	"	1889	1894	5	
13	Bombay (Apollo Bandar)	"	1878	Still Working	44	
14	Bombay (Prince's Dock)	"	1888	"	34	
15	Marmagao (Goa)	"	1884	1889	5	
16	Kârwâr	"	1878	1883	5	
17	Beyypore	"	1878	1884	6	
18	Cochin	"	1886	1892	6	
19	Tuticorin	"	1888	1893	5	
20	Minicoy	"	1891	1896	5	
21	Galle	"	1884	1890	6	
22	Colombo	"	1884	1890	6	
23	Trincomalee	"	1890	1896	6	
24	Pâmban Pass	"	1878	1882	4	
25	Negapatam	"	1881	1888	5	Years 1883 to 1885 are excluded.
26	Madras	"	{ 1880 Restarted 1895	1890 Still Working	{ 10 27	{ 37
27	Cocanâda	"	1886	1891	5	
28	Vizagapatam	"	1879	1885	6	
29	False Point	"	1881	1885	4	
30	Dublat (Sâgar Island)	"	1881	1886	5	
31	Diamond Harbour	"	1881	1886	5	
32	Kidderpore	"	1881	Still Working	41	
33	Chittagong	"	1886	1891	5	
34	Akyab	"	1887	1892	5	
35	Diamond Island	"	1895	1899	5	
36	Bassein (Burma)	"	1902	1903	2	
37	Elephant Point	"	{ 1880 Restarted 1884	1881 1888	5	Year 1860-81 is excluded.
38	Rangoon	"	1880	Still Working	42	
39	Amherst	"	1880	1886	6	
40	Moulmein	"	{ 1880 Restarted 1909	1886	6	{ 19
41	Mergui	"	1889	Still Working	13	
42	Port Blair	"	1880	1894	5	
43	Basrah	Personal	1916	Still Working	42	
				"	6	Observations taken on a tide-pole.

INSPECTION OF TIDAL OBSERVATORIES.

Under the orders of the Superintendent of the Trigonometrical Survey, with a view to economy in travelling expenses, Dr. J. de Graaff Hunter, M.A., Sc. D., F. Inst. P., Officer in charge of the Computing Office, inspected the tidal observatories at Madras and Aden; and Mr. E. C. J. Bond, V. D., Officer in charge of the Magnetic Party, inspected the tidal observatories at Bombay (Apollo Bandar), Bombay (Prince's Dock) and Karāchi.

Mr. D. H. Luxa, the tidal-assistant, inspected the tidal observatories at Kidderpore, Rangoon, Moulmein and Port Blair. The inspection of each observatory was carefully carried out, special attention being paid to the following points:—

- (a) Checking the working zero of the tide-gauge and comparing the same with the true zero.
- (b) Testing the stability of the tide-gauge, by check-levelling between its bed plate and the bench-mark of reference. This was done in every case except at Madras.
- (c) Testing the zero of the graduated staff with reference to the zero of the tide-gauge. This was done in every case except at Madras.
- (d) The cleaning and overhauling of all instruments thoroughly and getting them in perfect working order.
- (e) The final adjustment of the tide-gauge and working zero, after cleaning the whole apparatus.
- (f) Examination and cleaning of the observatory well and the inlet hole, and securing free communication between the sea and the well.
- (g) General examination of the observatory cabin with the object of getting any repairs done, if necessary.

REMARKS REGARDING THE WORKING OF EACH TIDAL OBSERVATORY.

Aden.—This observatory was inspected in March 1922, and appeared to have worked well since the last inspection and to be in good condition. There were in all 6 breaks in the registration of the tidal curves during the period under review. These stoppages occurred as follows:—

On the 7th August and 6th November 1921. These varied from 2½ to 3 hours respectively and were due to the choking of the inlet hole. To guard against this in future, the observatory clerk has been instructed to have the inlet hole examined, and cleaned, if necessary, every month. The other stoppages occurred on the 24th and 28th November and the 24th December 1921, and were due to the driving clock having stopped. The remaining stoppage on the 4th April 1921 was due to the pencil not marking.

Karāchi.—The observatory was inspected in March 1922. The tide-gauge was found to be working quite satisfactorily. There were two interruptions during the past year owing to the communication hole in the cylinder being blocked with mud. A diver was employed on the 14th January and again on the 15th and 16th March 1922, to remove the mud which had accumulated round the outside of the cylinder.

Bombay (Apollo Bandar).—The inspection of this observatory was carried out during February 1922. The tide-gauge was found to be working satisfactorily and there were no breaks in the registration of the tidal curves.

Bombay (Prince's Dock).—This observatory was inspected in February 1922. The tide-gauge clock was compared and found to be correct. The tide-gauge was clean and appeared to be working well. There were six interruptions in the registration of the tidal curves since this observatory was last inspected. These interruptions were due to the pencil wire breaking, and in each case a new wire was fixed and the pencil adjusted.

During the inspection it was noticed that the holes in the copper band were far too large for the studs on the wheel, and this resulted in the band slipping by about 1/10th of an inch either in one direction or the other, during both rising and falling tides, and that in consequence of this play, the pencil registrations on the diagram are liable to an error of about 0.02 of a foot with reference to the zero of the gauge.

Madras.—This tidal observatory was inspected during January and February 1922. The tide-gauge has worked quite satisfactorily since the last inspection in December 1920, except for a break in the registration of the tidal curves from the 9th to the 11th July and again on the 14th July 1921, caused through the tide-gauge clock failing to drive the drum. No spirit-levelling was carried out at this inspection.

Kidderpore.—This observatory was inspected in November 1921. The tide-gauge has worked very satisfactorily, not a single break in the tidal registration having occurred during the past year. The greatest error of the tide-gauge clock was found to have been 1^m 11^s fast on the 10th November 1921, when compared against the time-ball at Fort William, Calcutta.

The bottom of the cylinder was examined and found to contain a small quantity of mud, which was removed by a diver. The mud that had accumulated on the outside of the cylinder was removed twice during the year.

Rangoon.—This tidal observatory was inspected in December 1921. The tide-gauge was found to be working well.

During the inspection a diver was employed in removing the mud that had accumulated at the bottom of the cylinder, and in cleaning out the communicating hole between the cylinder and the river.

Since the last inspection of this observatory there were 9 breaks in the registration of the tidal curves varying from 1 to 16½ hours in duration. These were all due to the stoppage of the driving clock, except in one case, when the interruption was due to the chain and the band becoming entangled in the cylinder. A new tide-gauge clock was sent out from Dehra Dün, and this was connected with the gauge on the 1st August 1921. The new clock stopped on three occasions, but the stoppage in each case was due to the bridge connecting the Observatory with the river bank being under repairs.

Moulmein.—This observatory was inspected in November 1921. Since the last inspection of the tide-gauge, the following interruptions in the registration of the tidal curves occurred:—

1. From 6 p. m. 11th February to 7 a. m. 12th February 1921, due to the pencil failing to register, the pencil having become worn.

2. From 5 p. m. 30th May to 12 a. m. 31st May 1921, due to the screw and nut of the float having become undone. This resulted in the band slipping off the stud-wheel and falling into the cylinder; the shock thus occasioned, snapped the chain on the pencil traveller.

3. From 12 a. m. 5th June to 10.45 a. m. 6th June 1921, the band became kinked and eventually snapped, falling on to the float inside the cylinder.

4. From 1 a. m. till 7 a. m. on the 15th September 1921 and from 11 p. m. 26th November to 7.45 a. m. 27th November 1921, the pencil failed to register the tidal curves owing to its having become worn.

5. Except for the above interruptions, the tide-gauge has worked quite satisfactorily during the past year. Thieves broke into the Observatory cabin on the night of the 1st May 1921, and removed the brass slides from the sides and top of the tide-gauge clock, fortunately, without causing any break in the registration of the tidal-curve.

Port Blair.—The inspection of this observatory was carried out in December 1921. The cabin was found in a very clean, neat and tidy condition. The tide-gauge and the auxiliary instruments have all worked well and without a single interruption.

COMPUTATIONS AND REDUCTIONS OF OBSERVATIONS.

The only computation undertaken during the past year was in connection with the Port of Basrah, the hourly readings of water level supplied by the Director, Inland Water Transport, Mesopotamia, for the year 1921, being reduced by the method of harmonic analysis. The tidal constants deduced therefrom are shown in the attached table. These give the amplitudes (R) and the epochs (ζ) at Basrah. The values of (H) and (κ) are also given, and these are connected with (R) and (ζ) through the various astronomical quantities involved in the positions of the sun and moon, in such a way, that if the tidal observations were consistent from year to year, (H) and (κ) would result in being the same for each year's reductions.

The harmonic analysis of the tidal observations for the nine working ports, viz., Aden, Karachi, Bombay (Apollo Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, Moulmein and Port Blair, was discontinued this year, on the advice of Dr. Doodson, D.Sc., Tidal Institute, University of Liverpool, who considered that further continuance of the present methods of harmonic analysis would not, in view of the long periods during which they had already been applied, give a commensurate increase in the precision of the derived tidal constants. Moreover Professor Horace Lamb, F.R.S., Manchester University, stated that no important gain would result from the prolonged application of harmonic analysis to the records of any port, when once a reasonable set of constants had been secured. It was for this reason that the reduction of the tidal observations of various French ports had been discontinued.

It is hoped that it may be possible to take up intensive tidal research at selected points, in the near future.

PREPARATION OF DATA.

The following data were prepared during the year under report:—

- (a) Values of the tidal constants for the tide-tables for Basrah for 1923 and 1924.
- (b) Actual heights and times of high and low-water during 1920 and 1921 at 12 stations. These include 9 stations at which regular tidal observations by self-registering tide-gauges were carried out, and three stations at which the times and heights of high and low-water readings were taken during day-light only.
- (c) Comparisons of actual with predicted values for 1920 and 1921, the errors being tabulated in such a manner as to be of use in improving the future predictions, if possible.
- (d) In addition to the above, the values of the tidal constants for the 40 Indian ports, for the tide-tables for 1924 and 1925, were prepared for use in the tide-predicting machine now at Dehra Dün.

ERRORS IN PREDICTIONS.

The predicted times and heights for high and low-waters for the year 1921, as given in the tide-tables, have been compared with the actual values obtained from tidal observations at the nine stations now working, and at the three other stations where tidal registrations by self-registering tide-gauges were stopped, but at which the times and heights of high and low-waters were noted by a watch, and tide-pole readings during day-light. The errors of the predictions thus determined, are tabulated in the 6 tables herewith appended.

No. 1.

Percentages and amounts of the errors in the predicted times of high-water at the various tidal stations for the year 1921.

STATIONS.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of	Errors over	Errors over	Errors over	Errors over	
			5 minutes and under.	5 minutes and under 15 minutes.	15 minutes and under 20 minutes.	20 minutes and under 30 minutes.	30 minutes.	
			Per cent	Per cent	Per cent	Per cent	Per cent	
Aden	...	Auto.	700	35	47	8	6	4
Karachi	...	"	705	35	42	11	9	3
Bhaunagar	...	T.P.	365	64	36	0	0	0
Bombay	{ (Apollo Bandar)	Auto.	705	31	42	13	12	2
		"	705	35	45	10	7	3
Madras	...	"	701	24	37	10	17	12
Kidderpore	...	"	705	31	44	11	11	3
Chittagong	...	T.P.	365	13	48	19	13	7
Akyab	...	"	366	85	12	3	0	0
Rangoon	...	Auto.	700	32	47	11	9	1
Monmeim	...	"	698	25	43	14	14	4
Port Blair	...	"	706	45	44	6	4	1
Basrah	...	T.P.	705	7	16	6	15	56

No. 2.

Percentages and amounts of the errors in the predicted times of low-water at the various tidal stations for the year 1921.

STATIONS.	Automatic or tide-pole observations.	Number of comparisons between 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 ...	Auto.	097	31	43	10	8	5
Karachi ...	"	705	31	39	11	14	5
Bhannagar ...	T. P.	365	63	37	0	0	0
Bombay { (Apollo Bandar)	Auto.	704	26	46	12	12	4
	{ (Prince's Dock)	"	705	27	41	12	15	5
Madras ...	"	699	22	34	12	19	13
Kidderpore ...	"	706	33	41	12	10	4
Chittagong ...	T. P.	365	14	36	21	20	9
Akyab ...	"	365	79	19	2	0	0
Rangoon ...	Auto.	700	29	45	12	13	1
Moulmein ...	"	696	20	30	14	18	18
Port Blair ...	"	705	44	45	7	3	1
Barrah ...	T. P.	705	8	14	7	12	59

No. 3.

Percentages and amounts of the errors in the predicted heights of high-water at the various tidal stations for the year 1921.

STATIONS.	Automatic or tide-pole observations.	Number of comparisons between 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 ...	Auto.	700	6.7	96	4	0	0
Karachi ...	"	705	9.3	58	37	5	0
Bhannagar ...	T. P.	365	31.4	61	34	3	2
Bombay { (Apollo Bandar)	Auto.	705	13.9	71	24	3	2
	{ (Prince's Dock)	"	705	13.9	48	27	16	9
Madras ...	"	701	3.5	84	15	1	0
Kidderpore ...	"	705	11.7	49	23	10	18
Chittagong ...	T. P.	365	13.3	40	24	19	17
Akyab ...	"	365	8.3	67	30	3	0
Rangoon ...	Auto.	700	16.4	60	28	9	3
Moulmein ...	"	698	12.7	38	27	19	16
Port Blair ...	"	706	6.6	91	9	0	0
Barrah ...	T. P.	705	5.2	39	29	18	14

No. 4.

Percentages and amounts of the errors in the predicted heights of low-water at the various tidal stations for the year 1921.

STATIONS.	Automatic or tide-pole observations.	Number of comparisons between 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.
Aden ...	Auto.	697	6.7	98	2	0	0
Karachi ...	"	705	9.3	79	20	1	0
Bhaunagar ...	T.P.	365	31.4	55	39	4	2
Bombay { (Apollo Bandar)	Auto.	704	13.9	73	23	4	0
	(Prince's Dock)	"	705	13.9	56	30	10
Madras ...	"	699	3.5	93	6	1	0
Kidderpore ...	"	706	11.7	49	23	15	13
Chittagong ...	T.P.	365	13.3	16	23	22	39
Akyab ...	"	365	8.3	74	21	5	0
Rangoon ...	Auto.	700	16.4	42	32	15	11
Moulmein ...	"	696	12.7	46	22	18	14
Port Blair ...	"	705	6.6	96	4	0	0
Basrah ...	T.P.	705	5.2	26	20	19	35

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 1921.

STATIONS.	Automatic or tide-pole observations.	Mean range at springs in feet.	Average Errors					
			of time in minutes.		of height in terms of the range.		of height in inches.	
<i>Open Coast.</i>			H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Aden ...	Auto.	6.7	10	11	0.025	0.025	2	2
Karachi ...	"	9.3	10	12	0.036	0.027	4	3
Bhaunagar ...	T.P.	31.4	5	5	0.013	0.013	5	5
Bombay { (Apollo Bandar)	Auto.	13.9	11	12	0.018	0.018	3	3
	(Prince's Dock)	"	13.9	10	13	0.036	0.030	6	5
Madras ...	"	3.5	15	16	0.071	0.048	3	2
Akyab ...	T.P.	8.3	5	5	0.030	0.030	3	3
Port Blair ...	Auto.	6.6	8	8	0.025	0.025	2	2
General Mean	...	...	9	10	0.032	0.027	4	3
<i>Riverain.</i>								
Kidderpore ...	Auto.	11.7	11	11	0.050	0.043	7	6
Chittagong ...	T.P.	13.3	14	17	0.044	0.075	7	12
Rangoon ...	Auto.	16.4	10	11	0.020	0.030	4	6
Moulmein ...	"	12.7	12	18	0.046	0.046	7	7
Basrah ...	T.P.	5.2	40	44	0.112	0.160	7	10
General Mean	...	...	17	20	0.054	0.071	6	8

No. 6.

Summary for 1921.

Numbers of stations.	Predictions tested by	PERCENTAGE OF PREDICTIONS, AT HIGH AND LOW-WATER WITHIN					
		15 minutes of actuals.		8 inches of actuals.		one-tenth of mean range	
		High.	Low.	High.	Low.	High.	Low.
6 Open coast	S.R. Tide-gauge	77	72	94	97	97	99
2 „	Tide-pole	99	99	96	95	99	99
3 Riverain	S.R. Tide-gauge	74	66	75	71	92	94
2 „	Tide-pole	43	36	66	42	78	69

COMPARISONS OF THE PREDICTIONS FOR THE YEAR 1921 WITH THOSE FOR THE
PREVIOUS YEAR.

On comparing the tidal predictions at the nine working stations for the year 1921 against those for the year 1920, it was seen that the predictions of times for 1921 had improved at Aden and slightly at Rangoon, and had deteriorated at Bombay (Apollo Bandar), Madras and slightly at Moulmein. The predictions of heights had improved at Karāchi and at Kidderpore, and slightly at Rangoon, and had deteriorated slightly at Chittagong. The predictions of times and heights at all the other stations were practically of the same standard of accuracy as in 1920.

The greatest differences between the actual and predicted heights of low-water for 1921 at the riverain ports were as follows :—

- Kidderpore ... 2 feet 6 inches on 11th August 1921, actual being lower.
- Rangoon ... 2 feet 3 inches on 8th November 1921, actual being higher.
- Moulmein ... 2 feet 8 inches on 20th July 1921, actual being lower.

TIDE-TABLES.

The tide-tables for the year 1922 for Basrah and the Indian ports were received from England on the 26th and 29th September and 22nd November 1921, and were immediately despatched to the various Port authorities and other officials.

The tide-tables for 1923 for Basrah and the Indian ports were prepared and published at Dehra Dūn, and their despatch will be completed by about the end of October 1922.

The amount realized by the sale of tide-tables during the year ending 30th September 1922 was Rs. 3,563/12/0.

TIDE-PREDICTING MACHINE.

This machine was received from the National Physical Laboratory, Teddington, England, towards the end of September 1921, and was erected at Dehra Dūn, after necessary repairs had been carried out. The predictions for the 1923 tide-tables were run off on the machine and completed by the middle of August 1922.

PROGRAMME FOR SEASON 1922-23.

Tidal observations during the coming field season will be continued at the nine observatories still working, of which that at Bombay (Prince's Dock), has been kept in operation by the Port authorities solely for their own special purposes. Had they not wished to do so this observatory would have been closed.

LEVELLING.

BY BREVET-MAJOR K. MASON, M. C., R. E.

I. Composition of Party etc.—The party was increased to 3 single and 4 double detachments.

PERSONNEL OF No. 17 PARTY.

Class I Officers.

Bt.-Major K. Mason, M. C., R. E., in charge, up to 27th March 1922, and from 1st September 1922.

Major F. J. M. King, R. E., in charge from 28th March to 19th June 1922.

Captain E. A. Glennie, D. S. O., R. E., in charge from 20th June to 31st August 1922.

Class II Officers.

Mr. G. J. S. Rae.

" O. N. Pushong.

" R. B. Mathur, B. A.

" K. S. Gopalachari, B. A.

" N. N. Chuckerbutty, L. C. E.

Upper Subordinate Service.

Mr. K. K. Dass, B. A.

" S. C. Mukerjee.

" P. B. Roy.

" A. A. S. Matlub Ahmad.

" Abdul Majid.

Lower Subordinate Service.

11 Computers.

2 Recorders.

3 Clerks.

All but one double detachment took the field in the winter of 1921-22; while No. 2, working across the Pir Panjal range, did not commence work till April 1922.

Party head-quarters closed at Mussoorie on the 26th October 1921 when four of the detachments took the field. The recess season opened at Mussoorie on 18th April 1922, the various detachments, with the exception of No. 2, returning shortly afterwards.

II. Field detachments.—The field detachments were organized as follows:—

No. 1 A Detachment. Mr. N. N. Chuckerbutty.

No. 1 B Detachment. Mr. A. A. S. Matlub Ahmad.

No. 1 C Detachment. Mr. R. B. Mathur.

No. 2 Detachment. Mr. O. N. Pushong.
Md. Ishak Khan } (2nd Levellers).
Md. Faizul Hasan }

No. 3 Detachment. Mr. P. B. Roy.
Md. Ibrahim (2nd Leveller).

No. 4 Detachment. Mr. K. S. Gopalachari.
Mr. Abdul Majid (2nd Leveller).

No. 5 Detachment. Mr. S. C. Mukerjee.
Babu H. K. Kar (2nd Leveller).

III. Programme.—The three single detachments were engaged on the following lines for the new level net:—

1 A Detachment.—Viramgām to Tatta—line 104.

1 B Detachment.—Jacobābād to Khānpur—part of line 101.

Khānpur to Jhang—line 105.

Surat to Dhūlia—line 113.

1 C Detachment.—Khānpur to Mārwar Pāli—line 102.

These lines are shown on the diagrams facing page 64 of Volume XV, Records of the Survey of India. Their adjustment cannot be taken up until they have been levelled in the reverse direction.

The line from Karāchi to Kotri—part of line 101—had to be omitted from the programme owing to urgent work required by local governments, and the line Viramgām to Tatta could not be completed.

No. 1 C Detachment also levelled the line from Rohri to Jām Sāhib for the Sukkur barrage scheme, in order to relieve No. 5 double detachment of some of its programme.

No. 2 Double Detachment, working on the old simultaneous double levelling system, levelled from Wazīrābād *via* Siālkot to Jammu and thence by the Mahārāja's new motor road over the Pir Panjal range by the Banihāl pass, connected with the line 56E at Islāmābād in Kashmir, thus closing an important mountain circuit.

No. 3 Double Detachment, on the same system levelled for the Bengal Irrigation department and for the Nadiā rivers scheme, besides closing three circuits, viz.—

(1) Garhmuktesar to Aligarh.

(2) Jhānsi to Saugor.

(3) Jhārsugrā to Purūlia.

No. 4 Double Detachment worked in the Bombay Presidency.

Two lines, namely, (1) Nira Bridge to Bhātgar, and (2) Nira Bridge to Zalki were taken up for the Irrigation authorities, while the two lines Nāndgaon-Ahmadnagar, and Sholāpur-Bijāpur were undertaken to close circuits or for revision purposes.

The line Gooty to Ongole had to be omitted from the programme owing to lack of time.

No. 5 Double Detachment was entirely employed on work for the Sukkur barrage project, the whole cost of the detachment being borne by the Bombay government.

IV. Out-turn.—The total out-turn roughly consisted of—

(a) 1,452 miles of primary levelling in one direction for the new net.

(b) 812 miles of secondary levelling for closing and breaking circuits.

(c) 315 miles of secondary levelling for the Bengal government.

(d) 179 miles of secondary levelling for the Nira irrigation scheme, for the Bombay government.

(e) 889 miles of secondary levelling for the Sukkur barrage scheme, for the Bombay government.

In all, the heights of 78 primary bench-marks and 2,805 secondary bench-marks were determined. These include triangulation stations.

The detail of this out-turn is shown in table I at the end of this report.

Two records were made during the season, Mr. Roy's out-turn of 743 miles being just beaten by Mr. Mukerji's of 749 miles. Mr. Roy's country was more difficult than Mr. Mukerji's, but the latter completed the greater out-turn in the shorter time.

Both levellers are to be congratulated on their work.

V. Bench-marks.—With the exception of those in the Sukkur barrage area, bench-marks were constructed after the usual Survey of India types. Every effort was however made to use rock-cut bench-marks and this enabled a saving to be made on the cost of construction. In the Sukkur area a type designed by the Bombay engineers was submitted to and approved by the Superintendent of the Trigonometrical Survey. This type, known as Musto's type, has been taken into use by the Survey of India.

VI. Cost.—It is interesting to record the cost of the secondary work done for local governments. The Bombay government paid for the levelling in the Sukkur barrage and Nira canal areas. The total estimate for the two works was Rs. 22,000 and the total cost, Rs. 22,260/4/2, additional work having been asked for in the Sukkur area, which was not estimated for. This additional work cost Rs. 1,767, so that the work would have been completed within the estimate.

889 miles of levelling in the Sukkur area cost Rs. 16,619/0/2; 179 miles in the Nira area cost Rs. 5,641/4/0. The rate of the first was therefore Rs. 19/0 a mile, while that of the latter was as high as Rs. 30/0. A short programme, such as that in the Nira area, cannot be economical, when the cost of transporting the detachment to the area for a short time bears a high proportion to the total cost.

VII. The New Level Net.—The programme laid down for the new level net, —*vide* page 64, Vol. XV, Records of the Survey of India—could not be strictly adhered to. The line Karāchi to Kotri was not taken up and the line from Viramgām to Tatta was not completed. The programme laid down for the net was 1,248 miles in one direction; actually 1,452 miles were levelled. The reasons of this apparent inconsistency are

(a) that branch lines were longer than had been anticipated;

(b) the line Viramgām to Tatta was underestimated, and the country more difficult than had been expected;

(c) cross lines were taken up for seismological purposes on this latter line. It was no fault of the detachment officer concerned that his line was not completed.

In the coming field season almost the whole levelling for the new net, has had to give way to urgent work required by local governments for irrigation purposes. The party has been very largely increased, but even so it has been found impossible to continue the net this year. It is to be hoped that in next season's work the net will have first consideration, for in many cases the destruction of bench-marks on old lines has reached a very high proportion, and the reconstruction of a new net has become a matter of extreme urgency.

During the cold weather of 1921-22, a Committee, appointed at Dehra Dūn to consider the whole question of levelling in India, fully admitted the urgent necessity of completing the new net as early as possible and approved the programme as laid down in Records Volume XV.

VIII. Levelling publications.—The following levelling publications have passed through the press during the year under report :—

1st Edition of Levelling Pamphlet No. 62.

2nd Edition of Levelling Pamphlet No. 63.

Addenda slips to Levelling Pamphlets, Nos. 34, 35, 39, 40, 45, 53, 54.

Addenda slips to Addendum Pamphlet, No. 72.

IX. Miscellaneous.—

(a) *Protection and Maintenance of Triangulation Stations.*—The section of the Trigonometrical Office dealing with the protection of triangulation stations has been supervised during the year by the Officer in charge No. 17 Party (Levelling). There is nothing of special interest to report.

(b) *Triangulation Section, Computing Office.*—This section has been under the control of the Officer in charge No. 17 Party during the year. Most of the pamphlets containing the primary data of Burma have been published during the year and a number of Himālayan and trans-frontier pamphlets have been revised. The whole triangulation of Sir Aurel Stein's three Central Asian journeys was examined by Major Mason and a note prepared for his memoir.

(c) *Latitude observations.*—Before the close of the field season Major Mason handed over charge to Major King and carried out latitude observations at four hill stations in Kashmir.

(d) *Triangulation in Akora Practice Camp area.*—Early in September Major Mason carried out some minor triangulation for the military authorities in the Akora practice camp area.

X. Health.—Influenza affected No. 1 B Detachment in the field, one *khalasi* dying of pneumonia in Multān hospital. One *khalasi* of No. 1 C Detachment contracted illness, and was sent to his home where he died. With these exceptions the health of the whole party was excellent.

XI. Summaries.—Below are given detailed summaries of the work of the various detachments. At the end will be found tables as follows :—

Table I. Tabular out-turn of work.

II. Check levelling.

III. Revision levelling.

IV. List of Great Trigonometrical Survey stations connected by spirit-levelling.

XII. No. 1 A Detachment.—*Mr. N.N. Chuckerbutty, L.C.E.*, in charge. The line Viramgām to Tatta (No. 104) is composed of the following old lines :—

(a) No. 49 (Viramgām to Rājkot).

(b) No. 48 (Rājkot to Jorya).

(c) No. 47 (Jorya to Shikārpur, Cutch).

(d) No. 46 (Shikārpur, Cutch to Navānār).

(e) No. 44 (Navānār to Sujāwal).

(f) No. 45 (Sujāwal to Tatta).

Of the above, (f) and a portion of (e) were not levelled.

The total out-turn amounted to approximately 350 miles in the course of which 18 primary and 271 secondary bench-marks were connected; branch lines were run to 6 primary and 4 secondary G.T. stations; and the heights of selected bench-marks at Bhūj and 20 miles both north and south of this place were determined. These latter have been fixed for check-level work in the event of future earthquakes in this area, and were selected in agreement with the Geological Survey of India.

The levels were run along railway lines and cart tracks, the Rann of Cutch being crossed *en route*. The greater part of the country was gently undulating. Zeiss level No. 16298, staves Nos. 16 A and B, and standard steel tape No. 5 were used.

This is the first time the large Zeiss instrument has been used in the Survey of India, and it has been found highly satisfactory.

XIII. No. 1 B Detachment.—*Mr. A.A. S. Matlub Ahmad*, in charge.

(a) Jacobābād to Khānpur—part of line 101.

(b) Khānpur to Jhang—line 105.

(c) Surat to Dhūliā—line 113.

The above three lines were completed in the forward direction during the season.

A small portion of (a) and (b), from Khānpur to Bahāwalpur was entirely new, the remainder being mainly revision work over old lines, many of the bench-marks on which had been lost. Five principal stations of triangulation were connected.

The country traversed was mostly flat and sandy, and no especial difficulties were encountered. The Indus, Sutlej and Rāvi and minor rivers were crossed by bridges, no 'shots' exceeding 7 chains in length. Binocular level No. 2698, staves No. 20 A and B, and standard steel tape No. 3 were used.

XIV. No. 1 C Detachment.—Mr. R. B. Mathur, B.A., in charge.

(a) Khānpur to Mārwar Pāli—line 102.

(b) Rohri to Jām Sāhib.

Of the above (a) was levelled in the forward direction for the new net; (b) was levelled for the Sukkur barrage project.

A portion of line (a), from Lūni Junction to Mārwar Pāli is a revision of the old line 57 A; some old bench-marks were found intact and were re-connected but many had been lost or destroyed. The closing error on published values was approximately one foot in 371 miles.

Provisional values of the line Rohri to Jām Sāhib have already been supplied to the Sukkur barrage engineers, but final values must await the reverse levelling to Rohri.

The line from Khānpur to Mārwar Pāli crosses the heart of the Rājputāna desert and crosses the Bahāwalpur, Jaisalmer, and Jodhpur States. The country is a labyrinth of sand dunes and ridges for about 100 miles from Khānpur. The numerous dunes render levelling operations laborious and difficult. Vegetation and water are scarce and the whole tract is sparsely populated. From Khānpur the ground rises gently but steadily to about 40 miles beyond Jaisalmer, whence it slopes downwards to the Jodhpur-Bikaner railway.

Round Jaisalmer the ground is harder and less sandy, outcrops of rock being met with.

Zeiss level No. 16313, staves Nos. 1, 01, and standard steel tape No. 7 were used for the work.

After the completion of the lines (a) and (b) whole of the staff with the equipment was transferred to No. 2 Detachment, Mr. Mathur availing himself of average pay leave.

XV. No. 2 Detachment.—Mr. O. N. Pushong, in charge.

Muhd. Ishak Khan }
Muhd. Faiz-ul-Hasan } Second levellers.

Wazirābād to Islāmābād, Kashmir, via Siālkot and Jammu.

This line of levels was taken up to close the Kashmir circuit, the line from Rāwalpindi via the Jhelum valley having been levelled in the years 1911 & 1913. The country from Wazirābād to Jammu was fairly level but thereafter following the Mahārāja's new motor road, the line crossed several ridges, including the Pir Panjāl range by the Banihāl pass, 9,268 feet.

Mr. Pushong on his own initiative surveyed this road on the 1-inch scale, as it had not been constructed during the recent modern 1-inch surveys.

Mr. Pushong took the opportunity of training both his recorders as second levellers, and the difference between the 1st and 2nd leveller was satisfactorily low throughout. The closing error in Kashmir was only 3 inches in 193 miles.

The probable accidental error per mile according to the formula

$$P. E. = 0.6745 \sqrt{\frac{\sum d^3}{4M}} \text{ is } \pm 0.0035 \text{ foot.}$$

The new large Zeiss levels, Nos. 16313 and 3458, staves Nos. 1, 01, 17 A and 17 B, and standard steel tapes Nos. 7 and 2 were used throughout the work. The work forms a check on the statement made on page 66 of the Records Volume XV that the spirit-levelled height of Reban H. S. is 5 feet less than the triangulated height.

XVI. No. 3 Levelling Detachment.—Mr. P. B. Roy, in charge.

(a) Garhmuktesar to Aligarh.

(b) Jhānsi to Saugor.

(c) Jhārsugrā to Purūlia.

(d) Calcutta to Chuādānga.

(e) Jessore to Bārāsāt.

(f) Three branch lines to Barharwā, Dhuliān and Jangipur.

The total out-turn of this detachment was 743 miles, which was very satisfactory, and which would have been a record for any detachment in any season, had it not been beaten last year by No. 5 Detachment.

Lines (a), (b), (c), were undertaken to close circuits; (d) and (e) for the Bengal Irrigation department; and the three branch lines (f), which had to be omitted from the

previous season's work, as the bench-marks were not then ready, were undertaken for the Nadiā rivers scheme.

The field season was prolonged, and care had to be exercised to select suitable periods for levelling the various tracts.

The country was generally flat throughout; from Husainābād to Khulnā a very large number of rivers, *khāls*, and watercourses had to be crossed, and much of the country was liable to inundation.

The Betwā, at Jhararghāt was crossed by direct levelling; its width was 27 chains, and its bed was studded with rock islands. The instrument was set up on selected islands; no 'shot' exceeded 11 chains in length and the two levellers obtained identical results.

The Jamunā, near Husainābād, 25·5 chains wide, was crossed by the target method. 47 sets of observations were taken, and the difference of levels as obtained by first and second levellers was - 0·722 and - 0·709 foot respectively.

The Kabadak, at Baradal, was crossed by the target method. The width here was 14·30 chains and the difference of levels by the two levellers was 2·376 and 2·367 feet respectively.

The Sībsā, at Garuikhāli, was also crossed by the same method, where its width was 35·90 chains. The two results with 18 sets of observations were 1·610 and 1·612 feet.

Throughout the work the differences between the two levellers were satisfactory.

The probable errors of Mr. Roy's work according to the formula $0·6745 \sqrt{\frac{\sum d^2}{4M}}$ vary between $\pm 0·0035$ and $\pm 0·0037$ foot for the whole.

Zeiss level No. 3342, binocular level No. 6724, staves Nos. D, D1, 22 A, 23 A, and standard steel tape No. 4 were used by the detachment.

XVII. No. 4 Levelling Detachment.—Mr. K. S. Gopalachari, B.A., in charge.

Mr. Abdul Majid, 2nd leveller.

- (a) Nāndgaon-Ahmadnagar.
- (b) Nira bridge-Bhātgar.
- (c) Nira bridge-Zalki.
- (d) Sholāpur-Bijāpur.

The total out-turn was 360 miles.

As regards the line Nāndgaon to Ahmadnagar. It was originally intended to level from Manmād to Ahmadnagar, but owing to loss of bench-marks at the former place it was found impossible to check-level to the embedded mark here, and an extension had to be made to Nāndgaon. The work was therefore delayed at the commencement. Almost all of the old bench-marks on this line were lost or destroyed. This line was undertaken to close a circuit with the three lines (1) Kalyān-Nāndgaon, (2) Kalyān-Kedgaon, and (3) Poona-Ahmadnagar. The value of the Ahmadnagar Standard, now derived from Nāndgaon gives a discrepancy of 0·8 foot compared with its value derived from Poona. Check-levelling at both the Nāndgaon embedded B.M. and the Ahmadnagar Standard was satisfactory, but the embedded B.M. at Ahmadnagar shows a sinkage of 0·110 foot.

In view of the discrepancy of 0·8 foot at Ahmadnagar it has been decided to postpone the publication of the results of this line pending the levelling from Ahmadnagar to Dhond, which will be taken up during the season 1922-23, and which should disclose whether the error lies in the Nāndgaon or Poona sections of the circuit.

Lines (b) and (c), undertaken for the Nira right bank canal project, and the line from Sholāpur to Bijāpur call for no special remark. In both cases a very large proportion of old bench-marks were not found and have accordingly been considered destroyed.

With reference to the remark on page 67 of Volume IX, Records of the Survey of India, 1914-15, the revision of the line Sholāpur-Bijāpur confirms the old value of the bench-mark as derived from Sholāpur, thus throwing the error of +0·472 foot on the Bijāpur-Bāgalkot, which therefore should be revised at an early date.

The probable errors according to the formula $= 0·6745 \sqrt{\frac{\sum d^2}{4M}}$ are as follows

- (a) observations held in abeyance.
- (b) + 0·0033 foot.
- (c) $\pm 0·0046$ „
- (d) $\pm 0·0037$ „

Binoocular levels Nos. 6727 and 6728, staves Nos. 19 A, 19 B, E₁ and E₂ and standard steel tape No. 8 were used.

XVIII. No. 5 Detachment.—*Mr. S. C. Mukerjee*, in charge.

Babu H. K. Kar, 2nd leveller.

This detachment worked in the Sukkur barrage area throughout the field season. The work consisted of a network of lines of varying lengths, on both sides of the Indus from Sukkur southwards. The out-turn of 749 miles constitutes a record for any one detachment in any season's levelling.

The country generally was flat except for a few low sandhills, and throughout the work the difference between levellers was satisfactorily low. The mean probable error of the whole work lay between the limits ± 0.0026 and ± 0.0033 foot, and is well below the mean for the whole of India.

The work was expeditiously and efficiently carried out by Mr. Mukerjee, who was given every assistance by the engineer in charge of the Sukkur barrage scheme.

TABLE II.—CHECK-LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (-) starting bench-mark as determined by			Difference (Check—Original). The sign + denotes that the height was greater and the sign—less in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
				Miles.	Feet.	Date.		Feet.	Feet.
<i>(a) Line 104 (Virangām to Tatta). At Virangām.</i>							
1	46 A	Embedded B.M. at Virangām	0·0	0·000	1875-76	0·000	0·000
7	"	○ at Hāsulpur T.S.	4·0	+ 43·279	"	+ 43·447	+ 0·168
4	"	Upper flange of Ry. culvert No. 2	1·9	+ 2·600	"	+ 2·324	- 0·276
3	"	" " 3	0·8	- 1·646	"	- 1·398	+ 0·248
2	"	" " 4	1·0	- 2·090	"	- 2·151	- 0·061
42	41 M	" " No. 5 (old 4 A)	0·5	- 0·466	"	- 0·166	+ 0·300
41	"	" " No. 7 (old 6)	0·6	- 0·862	"	- 1·155	- 0·293
38	"	" " No. 11 (old 10)	2·0	- 7·424	"	- 7·460	- 0·036
87	"	" " No. 12 (old 11)	0·7	- 1·661	"	- 1·535	+ 0·126
35	"	Embedded B.M. at Jhund R.S.	0·8	- 4·066	"	- 4·054	+ 0·012
<i>At Rājkot.</i>							
75	41 J	Embedded B.M. at Rājkot	0·0	0·000	1875-76 1909-10	0·000	0·000
43	"	G. T. S. ○ B. M. at Carnegy fountain	0·0	+ 3·021	"	+ 3·006	- 0·015
74	"	" at bridge over Aji river. Rājkot	0·4	+ 3·130	1890-91	+ 3·123	- 0·007
42	"	G. T. S. ○ B. M. at clock tower, Rājkot	0·3	+ 11·493	1909-10	+ 11·492	- 0·001
76	"	G. T. S. Standard Bench-mark at Rājkot 1908	0·2	+ 7·568	"	+ 7·580	+ 0·012
77	"	T. G. Δ S. 1874 at C. B. P. No. 2	0·3	- 17·556	"	- 17·562	- 0·006
78	"	B.M. near C. B. P. No. 9	0·3	- 6·054	"	- 6·058	- 0·004
73	"	G. T. S. ○ B. M. at Museum and Library	0·2	+ 9·818	1875-76	+ 9·812	- 0·006
72	"	" at Telegraph office	0·1	- 1·076	1909-10	- 1·076	0·000
40	"	" at Alfred high school	0·1	- 0·011	1875-76	- 0·009	+ 0·002
71	"	○ at Mac Nagten Statue	0·5	+ 10·920	1909-10	+ 10·904	- 0·016
41	"	G. T. S. ○ B. M. at Rāj Kumār college	0·0	+ 1·026	1875-76	+ 1·018	- 0·008

TABLE II—CHECK-LEVELLING.—(Continued).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (-) starting bench-mark as determined by			Difference (Check—Original). The sign + denotes that the height was greater and the sign - less in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
			Miles.	Feet.	Date.	Feet.	Feet.
<i>At Jorya.</i>							
12	41 J	Embedded B.M. at Jorya	0·0	0·000	1874-75	0·000	0·000
13	"	G.T.S. ○ B.M. at Wasram Kumār's well	1·7	+ 15·046	"	+ 15·014	- 0·032
11	"	Embedded B.M. at Samarthal	3·7	- 4·872	"	- 4·944	- 0·072
*	"	G.T.S. ○ B.M. at Kharar-ka-deval	0·4	+ 2·848	"	+ 2·796	- 0·052
<i>At Nakhtarāna.</i>							
37	41 E	Embedded B.M. at Nakhtarāna	0·0	0·000	1874-75	0·000	0·000
39	"	G.T.S. ○ B.M. at Trikamdās-ka-dehri	3·4	+ 72·384	"	+ 72·394	+ 0·010
<i>(a₁) Parts of Lines 101 and 105 (Jacobābād to Jhang). At Jacobābād.</i>							
23	39 D	G.T.S. Standard Bench-mark 1908	0·00	0·000	1909-10	0·000	0·000
24	"	Iron plug Ex. En. office	0·03	- 1·420	"	- 1·417	+ 0·003
21	"	G.T.S. B.O.M. at Clock tower	0·56	+ 4·160	"	+ 4·130	- 0·030
22	"	G.T.S. ○ B.M. at Municipal office	0·97	- 3·478	"	- 3·495	- 0·017
19	"	G.T.S. ○ B.M. at Platform of R. S.	1·51	+ 2·847	"	+ 2·885	+ 0·038
18	"	G.T.S. □ B.M. at Railway Station	1·56	- 8·135	"	- 8·140	- 0·005
20	"	G.T.S. ○ B.M. at Lang. Shah's Takia	1·99	+ 6·686	"	+ 6·691	+ 0·005

* Geod. No. 2 of Line 47 A.

TABLE II.—CHECK-LEVELLING.—(Continued).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (–) starting bench-mark as determined by			Difference (Check—Original). The sign + denotes that the height was greater and the sign—less in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
				Miles.	Feet.	Date.		Feet.	Feet.
<i>At Shikārpur.</i>							
88	40 A	G.T.S. ○ at Railway Station B.M.	0·00	0·000	1909-10	0·000	0·000
76	"	G.T.S. ○ at waiting hall of R. S. B.M.	0·03	+ 0·541	"	+ 0·554	+ 0·013
78	"	G.T.S. B.O.M. at Railway Station A.D. 1905	0·09	– 5·833	"	– 5·832	+ 0·001
75	"	G.T.S. ○ at Govt. High School B.M.	0·41	+ 1·367	"	+ 1·366	– 0·001
74	"	G.T.S. ○ at Railway Rest House B.M.	0·62	+ 1·033	"	+ 1·031	– 0·002
81	"	G.T.S. ○ at Circuit House B.M.	1·66	– 0·638	"	– 0·614	+ 0·024
79	"	Iron Plug at Circuit House	1·72	+ 0·544	"	+ 0·511	– 0·033
80	"	G.T.S. ○ at Civil Judge's Court B.M.	1·85	– 0·282	"	– 0·259	+ 0·023
77	"	G.T.S. ○ at bridge 26 between P B.M. T.P. 27 9&8	2·22	+ 3·916	"	+ 3·919	+ 0·003
<i>At Ruk.</i>							
66	40 A	G.T.S. ○ at bridge No. 1 near Ruk B.M.	0·00	0·000	1909-10	0·000	0·000
64	"	G.T.S. ○ " " 35 " B.M.	0·64	– 1·264	"	– 1·682	– 0·418*
63	"	G.T.S. ○ " " 313 " B.M.	2·19	– 1·246	"	– 0·851	+ 0·395*
<i>At Rohri.</i>							
44	40 A	G.T.S. □ at Rohri Jn. R.S. B.M. A.D. 1904	0·00	0·000	1909-10	0·000	0·000
97	"	G.T.S. ○ at Rock Tomb of Shah B.M. Makh Sud Pir	1·72	+ 70·711	"	+ 70·795	+ 0·084
95	"	B.G. ○ at Gorkha Canal B.M. No. 10	1·05	– 16·738	"	– 16·676	+ 0·062

* Mark-stone shakes when train passes.

TABLE II.—CHECK-LEVELLING.—(Continued).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling			Distance from starting bench-mark. Miles	Observed height above (+) or below (-) starting bench-mark as determined by			Difference (Check—Original). The sign + denotes that the height was greater and the sign - less in 1921-22 than when originally levelled
Number.	Degree Sheet.	Description.		Original levelling		Check levelling 1921-22.	
				Feet.	Date.	Feet.	
<i>At Dhūlia.</i>							
107	46 L	G. T. S. S. B. M. at Dhūlia 1909	0·00	0·000	1909-10	0·000	0·000
106	"	G. T. S. O B. M. at Govt. High School	0·28	- 5·482	1883-84	- 5·600	-0·118
108	"	G. T. S. B. O. M. at Clock Tower	0·56	+ 2·520	"	+ 2·516	-0·004
109	"	G. T. S. B. O. M. at Circle Inspector's office	0·69	+ 5·208	"	+ 5·214	+0·006
110	"	G. T. S. O B. M. at Municipal School	0·91	+ 9·033	"	+ 9·053	+0·020
77	"	G. T. S. O B. M. at bridge new M. S. 211	1·06	- 2·651	"	- 2·657	-0·006
76	"	G. T. S. B. O. M. at M. S. No. 53	1·26	+ 4·318	1909-10	+ 4·318	0·000
111	"	G. T. S. O B. M. at Rock in situ near bridge No. 63	2·11	+24·617	1877-78 & 1883-84	+24·616	-0·001
75	"	G. T. S. O B. M. at bridge No. 68	2·14	+ 4·586	1909-10	+ 4·533	-0·053
112	"	G. T. S. O B. M. at Rock in situ near gate lodge No. 14	2·63	+21·417	1877-78 & 1883-84	+21·469	+0·052
<i>(c) Line 102 (Khānpur to Māwār Pāli). At Khānpur.</i>							
15	39 L	Standard Bench-marks at Khānpur	0·0	0·000	1909-10	0·000	0·000
16	"	Bridge over Hājiwāh	0·1	+ 3·635	"	+ 3·674	-0·011
17	"	Ry. Bridge over "	0·1	+ 1·780	"	+ 1·767	-0·013
18	"	Stone slab Khānpur station	0·4	+ 6·602	"	+ 6·569	-0·033
<i>(d) Line Rohri to Jām Sāhib. At Rohri.</i>							
44	40 A	Embedded B.M. at Rohri station	0·0	0·000	1921-22	0·000	...
220	"	Platform of Rohri station	0·0	+ 3·166	"	+ 3·165	-0·001
221	"	Bridge No. 189	0·4	- 3·004	"	- 2·999	+0·005
95	"	B.M. on Gorkha canal	1·0	- 16·676	"	- 16·672	+0·004
94	"	B.M. on Nāra canal	1·2	- 12·778	"	- 12·777	+0·001

TABLE II.—CHECK-LEVELLING.—(Continued).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original Levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (-) starting bench-mark as determined by			Difference (check—original). The sign + denotes that the height was greater and the sign—less in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
				Miles.	Feet.	Date.	Feet.
<i>At Jām Sāhib.</i>							
93	40B	Stone pillar in Jām Sāhib dak bungalow	0·0	0·000	1921-22	0·000	0·000
94	„	B.M. on steps of dak bungalow	0·1	+ 0·118	„	+ 0·121	-0·003
95	„	Iron pipe 2½ miles S. of Jām Sāhib	2·5	+ 0·119	„	+ 0·074	-0·045
92	„	Bridge on Daur Road	3·1	+ 3·239	„	+ 3·277	+0·038
<i>(e) Line Wazirābād to Islāmābād. At Islāmābād.</i>							
*22	43O	Stone monolith at Islāmābād	0·0	0·000	...	0·000	0·000
*23	„	Tree	0·3	+ 4·381	...	+ 4·399	+0·018
*24	„	Bungalow step	0·3	+ 6·945	...	+ 6·901	-0·044
*25	„	Rock	0·6	+168·885	...	+168·877	-0·008
*26	„	Rock	1·1	+495·658	...	+495·656	-0·002
<i>(f) Line 64 (Meerut to Lucknow). At Garhmuktesar.</i>							
124	53 L	Embedded B.M. Garhmuktesar	0·0	0·000	1914-15	0·000	0·000
126	„	Culvert No. 4	0·4	+ 1·690	„	+1·687	-0·003
127	„	Distant signal	1·0	+ 2·043	„	+2·048	+0·005
128	„	Slab of Railway bridge No. 53	1·3	- 9·199	„	-9·185	+0·014
<i>(g) Line 63 A (Gwalior to Jhānsi). At Jhānsi.</i>							
51	54 K	Standard B. M. Jhānsi	0·0	0·000	1906-07	0·000	0·000
50	„	Vestry entrance, St. Martin's	0·0	- 0·798	„	- 0·797	+0·001
49	„	Main „ „ „	0·1	- 0·747	„	- 0·749	-0·002
46	„	G. I. P. Railway office	0·8	+15·058	„	+15·063	+0·005
47	„	Railway officer's Rest-house	1·2	+23·353	„	+23·350	-0·003
48	„	Railway Institute	2·1	+ 8·548	„	+ 8·559	+0·011
44	„	S. end platform of Ry. station	2·5	+ 2·369	„	+ 2·378	+0·009
43	„	Centre of station platform	2·7	+ 2·405	„	+ 2·466	+0·061

* These bench-marks are on the line from Islāmābād towards Aish-Mukām.

Note.—The check-levelling at the Wazirābād end of the line has been treated as a branch line in order to give the bench-marks near and at Gujrat railway station published heights.

TABLE II.—CHECK-LEVELLING.—(Continued).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original Levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (-) starting bench-mark as determined by			Difference (check—original). The sign + denotes that the height was greater and the sign - less in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
				Miles.	Feet.	Date.		Feet.	Feet.
(h) Line 60 (Katni to Sironj). At Saugor.							
34	55 I	Standard B. M. Saugor	0·0	0·000	1898-99	0·000	0·000
33	"	St. Peters' church	0·0	+ 0·562	"	+ 0·565	+0·003
25	"	Bridge	0·4	-25·749	"	-25·752	-0·003
35	"	Bridge	0·8	-44·915	"	-44·920	-0·005
36	"	Station platform	1·3	-57·360	"	-57·338	+0·022
37	"	Home signal*	1·4	-55·585	"	-55·750	-0·165
38	"	Bridge No. 62	1·6	-60·328	"	-60·337	-0·009
(i) Line 40 (Bilāspur to Cuttack). At Jhārsugrā (Jharsuguda).							
4	73 C	Embedded B. M. Jhārsugrā	0·0	0·000	1891-92 93-94	0·000	0·000
3	"	Station platform	0·0	- 0·992	"	- 0·966	+0·026
1	"	Ry. opening	0·9	-24·756	"	-24·732	+0·024
2	"	Distant signal	1·1	-17·142	"	-17·091	+0·051
6	"	Bridge No. 1	1·6	-25·609	"	-25·553	+0·056
7	"	" " 2	4·0	-78·146	"	-78·102	+0·044
8	"	" " 8	5·6	-87·338	"	-87·304	+0·034
9	"	" " "	5·7	-87·168	"	-87·152	+0·016
10	"	" " 10	6·6	-56·605	"	-56·572	+0·033
11	"	" " 14	8·9	-48·062	"	-48·019	+0·043
12	"	Home semaphore	10·1	-67·023	"	-66·999	+0·024
13	"	Embedded at Lapanga	10·1	-66·795	"	-66·784	+0·011
(j) Line 70 B (Aurangābād to Barākar). At Purūlia.							
123	73 J	Embedded B. M. Purūlia	0·0	0·000	1916-17	0·000	0·000
122	"	Rock cut protected	0·9	+17·013	"	+17·015	+0·002
121	"	Circuit house	1·1	+21·037	"	+21·034	-0·003
120	"	Rock-cut	1·6	+33·385	"	+33·396	+0·011

* Receives new height.

TABLE II—CHECK-LEVELLING—(Continued).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (-) starting bench-mark as determined by				Difference (Check—Original). The sign + denotes that the height was greater and the sign - loss in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.		
				Miles.	Feet.	Date.	Feet.		Fect.
(k) Line 77 (Howrah to Rāmganj). At Calcutta.								
368	79 B	Standard B.M. at S.G.'s office	0·0	0·000	1882-83 1894-95	0·000	0·000	
367	„	S.G.'s office	0·0	- 0·496	„	- 0·497	- 0·001	
366	„	Photo-Litho office	0·2	- 1·650	„	- 1·644	+ 0·006	
365	„	M. I. office	0·3	- 0·324	„	- 0·335	- 0·011	
364	„	Sir James Outram Statue	0·9	+ 0·620	„	+ 0·584	- 0·036	
372	„	Embedded B.M. Sealdah	2·6	+ 1·572	„	+ 1·520	- 0·052*	
(l) Line 77 L (Chakdaha to Jayrāmpur). At Chuādānga.								
228	79 A	Embedded B.M. at Chuādānga	0·0	0·000	1920-21	0·000	0·000	
229	„	S. D. O's court	0·1	+ 2·915	„	+ 2·916	+ 0·001	
227	„	Munsif's court	0·1	+ 3·809	„	+ 3·795	- 0·014	
226	„	Hospital	0·3	+ 2·996	„	+ 2·989	- 0·007	
46	„	Bridge	1·2	+ 1·083	„	+ 1·090	+ 0·007	
(m) Line 77 M (Berhampore to Tinpahār). At Tinpahār.								
53	72 P	Culvert, Tinpahār	0·0	0·000	1920-21	0·000	0·000	
54	„	Embedded „	0·3	+ 19·289	„	+ 19·162	- 0·127*	
55	„	Platform of station „	0·3	+ 13·764	„	+ 13·746	- 0·018	
56	„	Island platform „	0·4	+ 9·942	„	+ 9·915	- 0·027	
198	72 O	Ry. bridge No. 294	0·5	+ 3·486	„	+ 3·488	+ 0·002	
197	„	Rock <i>in situ</i>	2·3	+ 50·788	„	+ 50·799	+ 0·011	
At Dhuliān.								
37	72 P	Embedded B.M. Dhuliān	0·0	0·000	1920-21	0·000	0·000	
36	„	Step Dhuliān P. Stn.	0·0	+ 4·543	„	+ 4·544	+ 0·001	
35	„	Stone block	1·8	- 1·839	„	- 2·045	- 0·206*	
34	„	Culvert No. 361	2·7	- 4·066	„	- 4·080	- 0·014	

* Disturbed.

TABLE II—CHECK-LEVELLING.—(Continued).
Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (-) starting bench-mark as determined by			Difference (Check—Original). The sign + denotes that the height was greater and the sign—less in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
				Miles.	Feet.	Date.		Feet.	Feet.
<i>At Jangipur.</i>							
77	78 D	Embedded B.M. Jangipur	0·0	0·000	1920-21	0·000	0·000
76	"	Steps S. D. O's court	0·0	+ 4·233	"	+ 4·234	+0·001
75	"	Culvert	0·4	+ 4·341	"	+ 4·346	+0·005
74	"	Culvert	0·7	+ 4·834	"	+ 4·835	+0·001
<i>(n) Line 33 A (Nāndgaon to Ahmadnagar). At Nāndgaon.</i>							
44	46 L	Embedded Nāndgaon	0·0	0·000	1877-78	0·000	0·000
34	"	" Mnumād	15·9	+ 344·972	"	+ 344·993	+0·021
<i>At Ahmadnagar.</i>							
14	47 I	Standard Ahmadnagar	0·0	0·000	1910-11	0·000	0·000
10	"	Embedded Ahmadnagar	1·5	-27·178	"	-27·291	-0·113
11	"	Verandah G. P. O.	1·4	-22·321	"	22·318	+0·003
12	"	Stone Junction of Gymkhana Roads	0·6	-36·166	"	-36·165	+0·001
13	"	Culvert at Trijunction of roads	...	- 8·693	"	- 8·694	-0·001
<i>(o) Line 26 B (Sholāpur to Bijāpur). At Sholāpur.</i>							
50	47 O	Standard Sholāpur	0·0	0·000	1879-80	0·000	0·000
49	"	Stone slab Engineer's office	0·0	- 2·250	"	- 2·244	+0·006
48	"	M. S. I. near Post office	0·3	- 26·302	"	- 26·262	+0·040
44	"	N. end of Rty. Station Sholāpur	1·6	- 66·965	"	- 66·924	+0·041
<i>At Bijāpur.</i>							
14	47 P	Standard Bijāpur	0·0	0·000	1879-80	0·000	0·000
16	"	Railway Station Bijāpur	1·4	+ 3·444	"	+ 3·487	+0·043
11	"	Bridge Hipargi Road	0·2	- 8·562	"	- 8·473	+0·089
12	"	Asar Mahal tank	0·4	+ 12·699	"	+ 12·705	+0·006
13	"	Darbār Hall, Bijāpur	0·8	+ 15·913	"	+ 15·918	+0·005
19	"	Malika Jahān's Masjid	1·0	+ 17·268	"	+ 17·264	-0·004
20	"	Khawāe Khān Guru's Tomb	1·3	+ 19·516	"	+ 19·514	-0·002
21	"	Tāj Bauli	1·6	+ 27·179	"	+ 27·199	+0·020
22	"	Municipal Canarese School	1·7	+ 31·805	"	+ 31·792	-0·013
23	"	Sholāpur gate	2·3	+ 26·277	"	+ 26·285	+0·008

TABLE II.—CHECK-LEVELLING.—(Continued).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (–) starting bench-mark as determined by			Difference (Check—Original). The sign + denotes that the height was greater and the sign—less in 1921-22 than when originally levelled.
Number.	Incase Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
				Miles.	Feet.	Date.		Feet.	Feet.
<i>(p) (Nira Canal Area). At Nira.</i>							
76	47 J	Embedded, Nira	0·0	0·000	1877-79	0·000	0·000
115	..	Shelka's Gumbad	5·3	+150·312	..	+150·280	+0·032
117	..	Bridge on Poona-Sātāra Road	7·5	+205·857	..	+205·856	+0·001
<i>(q) (Sukkur Barrage Area). At Shikārpur.</i>							
78	40 A	Embedded	0·0	0·000	1910-11	0·000	0·000
76	..	Step	0·1	+ 5·833	1904-06	+ 5·830	–0·003
88	..	Platform	0·1	+ 5·292	1910-11	+ 5·276	–0·016
74	..	Plinth	0·4	+ 2·400	1904-06	+ 2·392	–0·008
75	..	School	0·6	+ 1·367	..	+ 1·362	–0·005
<i>At Kambar</i>							
102	40 A	Embedded (Musto's Type)	0·0	0·000	1920-21	0·000	0·000
103	..	District bungalow	0·0	+ 2·494	..	+ 2·494	0·000
104	..	Mukhtiārkar's office	0·3	+ 1·719	..	+ 1·712	–0·007
<i>At Madad Chāndia.</i>							
22	35 M	Embedded (Musto's Type)	0·0	0·000	1920-21	0·000	0·000
24	..	Rail	2·5	+ 0·364	..	+ 0·342	–0·022
<i>At Mehar.</i>							
59	35 M	Embedded (Musto's Type)	0·0	0·000	1920-21	0·000	0·000
58	..	Inspection Bungalow	0·1	+ 0·965	..	+ 0·965	0·000
60	..	Mukhtiārkar's office	0·6	– 0·373	..	– 0·364	+0·009
<i>At Sehwan.</i>							
84	35 N	Embedded (Musto's Type)	0·0	0·000	1920-21	0·000	0·000
85	..	Platform	0·6	+ 3·333	..	+ 3·327	–0·006

TABLE II—CHECK-LEVELLING.—(Concluded).

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (-) starting bench-mark as determined by			Difference (Check—Original). The sign + denotes that the height was greater and the sign - less in 1921-22 than when originally levelled.
Number.	Degree Sheet.	Description.		Original levelling.		Check-levelling 1921-22.	
				Miles.	Feet.	Date.		Feet.	Feet.
<i>At Daur.</i>							
25	40 B	Pillar	0·0	0·000	1904-06	0·000	0·000
24	"	"	2·0	- 2·313	"	- 2·326	-0·013
23	"	"	4·0	- 4·250	"	- 4·211	+0·039
<i>At Lundo.</i>							
2	40 B	Embedded	0·0	0·000	1904-06	0·000	0·000
88	40 C	Drain	6·2	- 8·934	"	- 8·961	-0·027
86	"	Embedded	9·1	- 5·330	"	- 5·220	+0·110
<i>At Tando Adam.</i>							
75	40 C	Bridge	0·0	0·000	1904-06	0·000	0·000
76	"	Culvert	2·0	- 7·348	"	- 7·328	+0·020
<i>At Mahrābpur.</i>							
1	40 A	Bridge	0·0	0·000	1904-06	0·000	0·000
2	"	Drain	3·8	+ 0·619	"	+ 0·655	+0·036
7	"	Bridge	1·8	+ 1·061	"	+ 0·956	-0·105
8	"	Drain	3·8	+ 2·569	"	+ 2·546	-0·023
9	"	Culvert	6·0	+ 6·041	"	+ 5·976	-0·065
<i>At Hyderābād and between Hyderābād and Tando Muhammad Khān.</i>							
161	40 C	Standard Hyderābād	0·0	0·000	1909-10	0·000	0·000
160	"	St. Thomas' Church	0·0	+ 0·625	"	+ 0·624	-0·001
25	"	Culvert	6·2	-31·270	1904-06	-31·275	-0·005
24	"	Bridge	7·4	-32·544	"	-32·517	+0·027
23	"	Purāpet	8·2	-31·492	"	-31·515	-0·023
21	"	Embedded Thuthar	12·2	-36·176	"	-36·148	+0·028
10	"	" Tando Muhammad Khān	23·3	-39·253	"	-39·151	+0·102

TABLE III.—REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Number.	Degree Sheet.	Description.	Distance from starting bench-mark.		Difference between orthometric heights, above (+) or below (-) the starting bench-mark.			Difference (Revision-Original). The sign + denotes that the height was greater and the sign - less in 1921-22 than when originally levelled.
			Miles.	Feet.	From published heights	Date of Original levelling.	From revision 1921-22 (Unadjusted).		Feet.
(a) Line 102 (Lūni Junction to Mārwar Pāli) (part of Khānpur to Mārwar Pāli).								
1	45 G	Embedded B.M. at Lūni junction	...	0·0	0·000	1907-09	0·000	0·000
2	"	Mile-stone No. 158	...	1·3	- 1·893	"	- 1·916	- 0·023
3	"	Mile-stone No. 160	...	3·3	+ 11·312	"	+ 11·223	- 0·089
4	"	Mile-stone No. 162	...	5·3	+ 12·913	"	+ 12·805	- 0·108
5	"	Mile-stone No. 164	...	7·3	+ 11·152	"	+ 10·986	- 0·166
6	"	Embedded B.M. at Rohat station	...	7·8	+ 10·490	"	+ 10·294	- 0·186
8	"	Mile-stone No. 163	...	11·3	+ 18·546	"	+ 18·297	- 0·249
9	"	Mile-stone No. 170	...	13·3	+ 44·724	"	+ 44·507	- 0·217
10	"	Mile-stone No. 172	...	15·3	+ 35·527	"	+ 35·294	- 0·233
11	"	Embedded B.M. at Kairla station	...	16·4	+ 107·490	"	+ 107·260	- 0·230
12	"	Mile-stone No. 174	...	17·3	+ 105·940	"	+ 105·684	- 0·256
13	"	Mile-stone No. 176	...	19·3	+ 88·028	"	+ 87·760	- 0·268
14	"	Mile-stone No. 178	...	21·3	+ 108·249	"	+ 107·975	- 0·274
15	"	Mile-stone No. 180	...	23·3	+ 120·648	"	+ 120·382	- 0·266
16	"	Mile-stone No. 182	...	25·3	+ 124·712	"	+ 124·422	- 0·290
17	"	Embedded B.M. at Mārwar Pāli station	...	25·6	+ 123·253	"	+ 122·974	- 0·279
(b) Part of Line 62 (Meerut to Agra).								
375	53 H	Stone B.M. Walipur	...	0·0	0·000	1861-62	0·000	0·000
⁽⁷⁾ 380	"	M.S. Allahābād 343	...	4·6	- 11·675	"	- 12·000	- 0·325*
⁽⁹⁾ 388	"	Stone B.M. Khurja	...	11·0	- 23·030	"	- 23·008	+ 0·022*
⁽¹⁰⁾ 12	"	" " Sonna	...	24·6	- 48·493	"	- 48·314	+ 0·179*
1	54 I	" " Aligarh	...	28·5	- 64·961	"	- 64·810	+ 0·151
3	"	Well	...	38·9	- 60·333	"	- 60·203	+ 0·133
4	"	Distant Signal	...	39·5	- 57·701	"	- 57·557	+ 0·144
69	"	Judge's Court	...	40·3	- 63·833	"	- 63·686	+ 0·147
6	"	Post Office	...	40·7	- 63·801	"	- 63·659	+ 0·142
7	"	Standard B.M. Aligarh	...	41·2	- 57·943	"	- 57·792	+ 0·151
(c) Part of Line 26 A (Sholāpur to Bijāpur).								
1	47 O	Standard, Sholāpur	...	0·0	0·000	1879-80	0·000	0·000
2	"	Protestant Church Sholāpur	...	0·4	- 13·818	"	- 13·810	+ 0·008
3	"	↑ on Bridge	...	0·6	- 32·728	"	- 32·869	- 0·141
6	"	Bridge in Soregaon	...	4·3	- 63·812	"	- 63·742	+ 0·070
8	"	Temple Vandakbal	...	8·9	- 143·805	"	- 143·821	- 0·016
16	"	Embedded Takli	...	19·0	- 177·374	"	- 177·221	+ 0·153
20	"	Dipmal, Yalgi village	...	25·9	- 93·871	"	- 93·947	- 0·076
22	"	Zalki	...	30·9	- 5·632	"	- 5·691	- 0·059
23	"	Embedded Zalki village	...	30·9	- 9·627	"	- 9·582	+ 0·045
45	47 P	Shāhāpur gate	...	61·6	+ 402·976	"	+ 402·977	+ 0·001
46	"	Canarese School	...	62·2	+ 403·504	"	+ 403·482	- 0·022
47	"	Tāj Bauli	...	62·3	+ 403·878	"	+ 403·869	- 0·009
48	"	Khawas Khān's Guru's Tomb	...	62·6	+ 396·215	"	+ 396·205	- 0·010
49	"	Malika Jahān's Masjid	...	62·9	+ 393·967	"	+ 393·955	- 0·012
50	"	Darbār Hall Bijāpur	...	63·1	+ 392·612	"	+ 392·609	- 0·003
51	"	Aasar Mahal tank	...	63·5	+ 389·398	"	+ 389·397	- 0·001
52	"	Bridge on Hipargi road	...	63·7	+ 368·137	"	+ 368·221	+ 0·084
53	"	Standard Bijāpur	...	63·9	+ 376·699	"	+ 376·694	- 0·005

* Receives new height.

TABLE IV.

List of Great Trigonometrical Survey Stations connected by Spirit-levelling, Season 1921-22.

Name of station.	Height above mean sea-level			Difference Δ "-New	REMARKS.
	New spirit-levelling	Old spirit-levelling	Triangulation		
	Feet.	Feet.	Feet.	Feet.	
<i>Series 2 and 5. Budhon Meridional and Calcutta Longitudinal.</i>					
1. Budhon H.S. ...	1867·609	...	1867·0	- 0·6	Top mark-stone. (<i>Vide</i> Triangulation pamphlet 54 L).
<i>Series 5. Calcutta Longitudinal.</i>					
2. Calcutta base-line South end T.S. ...	13·857	...	13·0	- 0·9	Top of circular pillar. (<i>Vide</i> Triangulation pamphlet 79 B).
3. Ranjitgarh T.S. ...	878·895	...	879·5	+ 0·6	Ground floor mark-stone. (<i>Vide</i> Triangulation pamphlet 43 L or Syn. Vol. IV, where height of top of 20·5 ft. pillar is given as 900 ft.)
<i>Series 32. Great Indus.</i>					
4. Ghāzī Kuhāwar T.S.	133·596	...	134·0	+ 0·4	Ground level mark-stone. (<i>Vide</i> Triangulation pamphlet 35 M).
<i>Series 29. Gujrāt Longitudinal.</i>					
5. Hāsālpur T.S. ...	*132·989	132·821	134	+ 1·0	Top mark-stone. (<i>Vide</i> Triangulation pamphlet 46 A).
6. Ingridi T.S. ...	*141·518	151·018	152	+ 10·5	Top mark-stone. (<i>Vide</i> Triangulation pamphlet 41 N).
<i>Series 28 and 35. Kāthiāwār Meridional and Cutch Coast.</i>					
7. Vandhia S. ...	*115·259	115·846	116	+ 0·7	Top of circular pillar. (<i>Vide</i> Triangulation pamphlet 41 I).
<i>Series 35. Cutch Coast.</i>					
8. Bhachau H.S. ...	*302·715	303·148	301	- 1·7	Top of circular pillar. (<i>Vide</i> Triangulation pamphlet 41 I).
9. Sukhpur H.S. ...	*356·381	356·636	357	+ 0·6	Top of circular pillar. (<i>Vide</i> Triangulation pamphlet 41 I).
10. Charakda H.S. ...	*417·515	417·958	419	+ 1·5	Top of circular pillar. (<i>Vide</i> Triangulation pamphlet 41 E).
11. Sultān-ka-got T.S. ...	*188·836	188·945	188·0	- 0·8	Ground level mark-stone. (<i>Vide</i> Triangulation pamphlet 39 D).

* These values are provisional as the lines have only been levelled in one direction.

TABLE IV.—(Concluded).

List of Great Trigonometrical Survey Stations connected by Spirit-levelling, Season 1921-22.

Name of station.	Height above mean sea-level			Difference Δ—New	REMARKS.
	New spirit-levelling	Old spirit-levelling	Triangulation		
	Feet.	Feet.	Feet.	Feet.	
<i>Series 45. Sullej Meridional.</i>					
12. Chanikhān T.S. ...	*318·026	319·066	...	...	} Ground level mark-stone. (Vide Triangulation pamphlet 39 O).
13. Godri T.S. ...	*378·453	378·992	381	+2·5	
<i>Series 48. East Calcutta Longitudinal.</i>					
14. Basantia T.S. ...	17·088	...	21·0	+3·9	Ground floor mark-stone. (Vide Triangulation pamphlet 79 E).
15. Berghom T.S. ...	22·259	...	24·0	+1·7	Ground floor mark-stone. (Vide Triangulation pamphlet 79 B).
16. Bhaturia T.S. ...	18·555	...	20·0	+1·4	Ground floor mark-stone. (Vide Triangulation pamphlet 79 E).
17. Bira T.S. ...	27·001	...	28·0	+1·0	Ground floor mark-stone. (Vide Triangulation pamphlet 79 B).
<i>Series 62. Jodhpore Meridional.</i>					
18. Sandari H.S. ...	*847·049	...	846·0	-1·0	Foundation mark-stone (Vide Triangulation pamphlet 46 C).
<i>Series 64. Eastern Sind Meridional.</i>					
19. Vijnot T.S. ...	*256·514	257·472	263·0	+6·5	} Ground floor mark-stone. (Vide Triangulation pamphlet 39 H).
20. Vin T.S. ...	*242·162	243·188	249·0	+6·8	

* These values are provisional as the lines have only been levelled in one direction.

MAGNETIC SURVEY.

By E. C. J. BOND.

PERSONNEL OF No. 18 PARTY.

Class I Officer.

Mr. E. C. J. Bond, V.D., in charge.

Class II Officers.

Mr. N. R. Mazumdar.

.. Jiya Lal Sahgal, from the 16th March 1922.

Upper Subordinate Service.

Mr. B. B. Shome.

.. H. C. Banerjee, B.A.

Lower Subordinate Service.

1 Magnetic Observer.

10 Computers, etc.

The present report on the work of the Magnetic Party in 1921-22 comprises:—

I.—An account of the work during the field and recess seasons.

II.—A note on each of the observatories.

III.—Tables of the mean values of the magnetic elements, dates of magnetic disturbances, and hourly means and diurnal inequality of the magnetic elements at observatories in 1921.

I.—WORK DURING THE FIELD AND RECESS SEASONS.

1. *Work during the field season.*—Complete sets of magnetic observations were taken at the Dehra Dūn and Toungoo observatories for the comparison of instruments. The observatories at Alibāg (Bombay) and Kodaikānal, under the control of the Meteorological Department, were also visited by the officer in charge for the same purpose.

Double sets of magnetic declination, dip and horizontal force observations were taken during the field season at the six repeat stations—Quetta, Karāchi, Bina, Dibrugarh, Barrackpore and Waltair. These stations are visited annually to supplement the 5-yearly observations at all the repeat stations in India in order to obtain accurate values of the average annual change in the magnetic elements, as explained in last year's report.

The staff of the party at head-quarters were employed during the field season on the reduction of observations to the epochs 1909·0 and 1920·0.

Dr. J. de Graaff Hunter, M.A., Mathematical Adviser to the Survey of India, who proceeded to England on leave in March 1922, kindly offered to take a magnetometer with him for comparison against the Kew standard instrument. Magnetometer No. 10 (with magnet No. 10) was selected as being the most suitable, as it had been used for some time as an auxiliary instrument to the standard at the Dehra Dūn magnetic observatory. The comparison was decided upon with a view to affording a means of reducing the results of the magnetic observations in India to terms of the British standard at the Kew observatory.

Under the advice of Dr. Chree, F.R.S., Director of the National Physical Observatory at Kew, the Survey of India gilt inertia bar was sent to him for the redetermination of its moment of inertia, in order that the true value of the moment of inertia of magnet No. 10 might be ascertained during the comparative observations taken with that instrument at Kew.

During the field season the officer in charge of the party inspected the tidal observatories at Bombay (Apollo Bandar and Prince's Dock) and Karāchi. The inspections of these and other such observatories were formerly carried out by the officer in charge of No. 16 Party (Tidal), but it has been decided that the inspection of the tidal observatories at Bombay (Apollo Bandar and Prince's Dock), Karāchi, Madras, Kidderpore (Calcutta), Rangoon, Moulmein and Port Blair will, as far as is practicable, be carried out in future by No. 18 Party, in addition to the magnetic work.

2. *Work during the recess.*—The computation of the observations taken at repeat stations, and at observatories for the comparison of instruments, and the computation and tabulation of the provisional values of declination, dip, horizontal force and vertical force at the three observatories Dehra Dūn, Toungoo and Kodaikānal for 1921 have been completed. The mean values of these elements for the year, derived from the measurement of traces of all available days, excluding those of great disturbance, are given in Table III at the end of this report.

Publication of the results of the magnetic survey.—The final reduction of the observations at the observatories and in the field and at repeat stations to the epochs 1909·0 and 1920·0 is very nearly completed and it is hoped that the tables of results and the necessary

maps etc., most of which have already been sent to press, will be ready for publication with the Magnetic Volume about the middle of next year.

Special observations.—In response to a request by Dr. L.A. Bauer, Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, to all countries for co-operation in special simultaneous magnetic observations in connection with the solar eclipse of the 21st September 1922, magnetic observations were taken at the three observatories Dehra Dūn, Toungoo and Kodaikānal in accordance with the general scheme of work proposed by the Department of Terrestrial Magnetism.

The observations for declination at each of these observatories were taken simultaneously for every minute from 1 hour 28 minutes to 8 hours 2 minutes, A.M., Greenwich civil mean time, on the 20th, 21st and 22nd September 1922. At the Dehra Dūn observatory, observations of horizontal force and dip were taken in addition, during the same interval of time, on the above three days. It was not possible to observe more than the one element at Toungoo and Kodaikānal where the observatory staffs are small.

The three observatories were within the limits of the zone of visibility of the eclipse and it is hoped that the results of the observations obtained in India will be of value to Dr. Bauer in his investigation of the effects of the eclipse on the Earth's magnetism.

3. *Programme for 1922-23.*—During the ensuing field season observations will be taken for the comparison of instruments at the Dehra Dūn and Toungoo observatories. The Kodaikānal and Alibāg observatories, under the control of the Meteorological Department, will also be visited for the same purpose.

Magnetic observations will be taken at the repeat stations Quetta, Karāchi, Bina, Dibrugarh, Barrackpore, Waltair and Moulmein in Burma, for the purpose of supplementing the observations taken at all the repeat stations every 5 years, and in order to obtain reliable values of the annual changes in the magnetic elements.

The tidal observatories at Karāchi, Bombay (Apollo Bandar and Prince's Dock), Madras, Kidderpore, Rangoon and Moulmein, which are *en route* to the magnetic observatories and repeat stations, will be inspected.

II.—THE OBSERVATORIES IN 1921-22.

Dehra Dun Observatory.

1. The magnetographs, with a few exceptions, have worked satisfactorily during the year under report.

The clock which works the drums of the declination and horizontal force magnetographs stopped on the 15th December. After oiling it worked well, but a week later it stopped again and continued to stop frequently up to the end of the month, when it was removed, opened up and cleaned. The axles of the drum were also cleaned and oiled and the clock then worked satisfactorily. On the 17th January, however, it stopped again. It was removed, taken to pieces and thoroughly cleaned in the Trigonometrical Survey workshops on the 19th, after which no further trouble was experienced.

The arrester of the vertical force magnetograph went out of adjustment on the 12th December. It was put into proper working order on the 15th.

The vertical force magnetograph was adjusted on the 7th July on account of the magnet line being near the edge of the magnetogram, owing to secular change.

The galvanometer used in connection with the earth-inductor was reported to be working badly towards the end of August and the observer in his attempt to adjust it snapped the suspension fibre. The instrument was put into proper working order on the 31st August.

Magnetometer No. 5 (with magnet No. 5B) was introduced as an auxiliary instrument in place of No. 10 which was taken to England by Dr. deGraaff Hunter for comparison against the Kew standard. The results of the substituted instrument, in the hands of the new observer, have unfortunately not been very satisfactory.

A large crack in the thick cement plastering on the north wall of the passage in the observatory was repaired early in July as a precautionary measure against any excessive flow of water into the observatory during the monsoons.

The percolation of water into the passage of the observatory began this year at the end of August when the water rose to 6 inches. Pumping was resorted to immediately and was kept up day and night as there was no sign of the water diminishing until the 6th September. On the recurrence of heavy rain the water gradually rose again to 12 inches on the 14th September, in spite of continuous pumping. After that date the water gradually decreased until it finally subsided in the first week of October.

Besides the danger to the observatory from repeated inundations during the monsoons, there is now an additional menace in the introduction of electric trams into Dehra Dūn, which will necessitate the removal of the observatory without delay. Every endeavour is being made to get the necessary funds sanctioned for transferring the observatory to a suitable place at a safe distance from the disturbing effects of the electric tramway.

It is proposed to build the new observatory above ground level so that the risk of inundations, as experienced in the underground observatory at Dehra Dūn, may be avoided.

It is unfortunate that the present observatory, the principal base station of the magnetic survey of India which has been in existence for the past 22 years, should have to be abandoned. It is hoped, however, that it will be possible to preserve the continuity of the magnetic records by operating the old and new observatories together under undisturbed conditions for a few months at least before discontinuing observations at Dehra Dūn.

2. *Mean values of the declination and H. F. constants.*—The table below gives the mean monthly values of the magnetic collimation, the distribution constants $P_{1.2}$ and $P_{2.3}$, and the accepted values of p and q used in determining the value of the distribution factor. The values of the moment " m " in the table were derived from vibration observations taken with the chronograph.

Mean values of the constants of magnet No. 17 in 1921.

MONTHS.	DECLINATION CONSTANTS.	H. F. CONSTANTS.					
	Mean magnetic collimation.	DISTRIBUTION FACTORS.			MEAN VALUES OF m .		
		$P_{1.2}$	$P_{2.3}$	Accepted values.		Monthly means.	Accepted m .
				p	q		
January ...	- 6 46	6.03	7.06	7.30	- 362	807.02	806.92 throughout
February ...	- 6 40	5.86	7.24			807.01	
March ..	- 6 44	5.74	7.13			806.99	
April ...	- 6 44	5.70	6.87			806.81	
May ...	- 6 44	5.83	6.87			806.85	
June ...	- 6 47	5.81	7.01			806.81	
July ...	- 6 53	5.76	7.24			806.80	
August ...	- 7 0	5.80	6.95			806.81	
September ..	- 7 1	5.81	6.69			806.87	
October ...	- 7 0	5.77	7.16			806.91	
November ...	- 6 57	5.80	6.93			807.03	
December ...	- 6 59	5.87	6.91			807.08	

3. *Mean base line values.*—The table below gives the mean monthly observed and accepted values of the declination and horizontal force base lines: the accepted values have been used to compute the values of these elements for 1921. The horizontal force base lines have been derived from H as determined with the moment of inertia and distribution coefficient used in the computations for 1915.

Base line values of magnetographs in 1921.

MONTHS.	DECLINATION.		HORIZONTAL FORCE.	
	Mean value of Base line.	Base line accepted	Mean value of Base line.	Base line accepted
	° ' "	° ' "	C. G. S.	C. G. S.
January	... 1 3·7	1 3·7	·32673	·32673
February	... 1 4·1	1 4·1	·32673	·32673
March	... 1 4·0	1 4·0	·32677	·32677
April	... 1 4·3	1 4·3	·32682	·32682
May	... 1 4·4	1 4·4	·32680	·32680
June	... 1 4·6	1 4·6	·32678	·32678
July	... 1 4·8	1 4·8	·32674	·32674
August	... 1 4·6	1 4·6	·32667	·3·667
September	... 1 4·5	1 4·5	·32672	·32672
October	... 1 4·9	1 4·9	·32669	·32669
November	... 1 4·9	1 4·9	·32663	·32663
December	... 1 4·8	1 4·8	·32657	·32657

4. *Mean scale value and temperature range.*—The mean scale values for 1921 for an ordinate of 1/25 inch are :—

Horizontal Force 4·36 gammas.

Declination 1·03 minutes.

Vertical Force 8·31 to 8·93 from 1st January to 15th July.

10·47 „ 10·87 from 16th July to 16th August.

6·71 „ 7·46 from 19th August to 31st December.

The mean temperature for the year was 26°·9 C.; with maximum and minimum monthly values of 27°·0 C. and 26°·6 C. The temperature of reduction is 27°·0 C.

5. *Mean monthly values and annual changes.*—The following table shows the monthly mean values of the magnetic elements for 1920 and 1921 and the annual changes for that period. The annual changes for horizontal force are deduced from the values of H corrected for the moment of inertia and the distribution factor used in the computations for 1915.

Annual changes at Dehra Dūn in 1920-21.

MONTHS.	HORIZONTAL FORCE ·32000 C. G. S. +			DECLINATION E. 1° +			DIP N. 41° +			VERTICAL FORCE ·32000 C. G. S. +		
	1920.	1921.	Annual change.	1920.	1921.	Annual change.	1920.	1921.	Annual change.	1920.	1921.	Annual change.
	γ	γ	γ	'	'	'	'	'	'	γ	γ	γ
January	966	946	- 20	54·4	48·9	- 5·5	57·6	62·3	+ 4·7	920	990	+ 70
February	967	953	- 14	53·6	48·6	- 5·0	57·9	62·2	+ 4·3	926	995	+ 69
March	956	956	0	53·6	48·3	- 5·3	59·0	62·6	+ 3·6	936	1007	+ 71
April	950	960	+ 10	53·1	47·7	- 5·4	59·6	62·9	+ 3·3	943	1016	+ 73
May	961	938	- 23	52·7	47·5	- 5·2	59·2	64·4	+ 5·2	945	1022	+ 77
June	969	945	- 24	52·2	47·2	- 5·0	59·1	64·5	+ 5·4	951	1030	+ 79
July	966	954	- 12	51·8	46·7	- 5·1	59·5	64·4	+ 4·9	955	1039	+ 84
August	957	942	- 15	51·3	46·4	- 4·9	60·5	65·0	+ 4·5	965	1037	+ 72
September	940	940	0	51·1	46·1	- 5·0	61·3	65·3	+ 4·0	966	1041	+ 75
October	929	936	+ 7	50·4	46·1	- 4·3	61·6	65·5	+ 3·7	964	1042	+ 78
November	924	935	+ 11	49·9	45·8	- 4·1	61·8	65·6	+ 3·8	959	1042	+ 83
December	926	929	+ 3	49·4	45·4	- 4·0	61·8	65·1	+ 4·3	961	1046	+ 85
Means	951	945	- 6	52·0	47·1	- 4·9	59·9	64·2	+ 4·3	949	1025	+ 76

Toungoo Observatory.

The magnetographs have worked very well during the year under report.

On the 14th May the base line light on the visual scale was not discernible and it was discovered that water had lodged in the scale box owing to the observatory leaking after a heavy fall of rain. The water was removed and the light adjusted. Necessary repairs to the roof of the observatory were carried out by the Public Works Department on the 17th June.

2. *Mean values of the declination and H. F. constants.*—The table below gives the mean monthly values of the magnetic collimation and distribution constants $P_{1,2}$ and $P_{2,3}$ for magnets Nos. 19 A and 20 and the accepted values of p and q used in determining the distribution factor for magnet 19 A. The values of the moment "m" as obtained from this revised distribution factor are given for magnet No. 19 A.

The distribution factor for magnet No. 20, denoted by "P" in the table, is the approximate expression $(1 + \frac{P}{r^2})^{-1}$, which has been used in the computation of $\frac{m}{H}$. The correct value of the distribution factor for this magnet, which will include the Q term in the expression $(1 + \frac{P}{r^2} + \frac{Q}{r^4})^{-1}$, will be computed later on when sufficient data are available for an accurate determination, as it is only from an extended series of deflection observations that a reliable value of the distribution coefficient can be obtained. The provisionally accepted value of "m", given in the table for magnet No. 20, has been determined from the approximate expression used for the distribution factor.

The values of "m" for both magnets Nos. 19 A and 20 were derived from vibration observations taken with the chronograph.

The monthly mean values of "m" for magnet No. 20 are fairly steady and are much more satisfactory as compared with the rapidly decreasing values of the moment of magnet No. 19 A previously in use at the observatory.

Mean values of the constants of magnets Nos. 19 A and 20 in 1921.

MONTHS.	DECLINATION CONSTANTS.	H. F. CONSTANTS.					
		DISTRIBUTION FACTORS.			MEAN VALUES OF m.		
		$P_{1,2}$	$P_{2,3}$	Accepted values.		Monthly means.	Accepted m.
p	q						
January	- 11 23	8.38	7.86	10.19	- 546	864.12	864.12 to Feb.
February	- 11 30	8.39	7.81				
March	- 7 26	6.90	7.96	p = 6.99		931.14	931.36 from March
April	- 7 27	6.99	6.06			930.98	
May	- 7 25	7.05	7.60			931.19	
June	- 7 28	6.87	7.78			931.30	
July	- 7 15	7.01	7.51			931.34	
August	- 7 23	7.12	7.87			931.40	
September	- 7 13	6.97	7.64			931.40	
October	- 7 15	6.95	7.34			931.39	
November	- 7 16	7.02	7.52			931.41	
December	- 7 15	6.94	7.31			931.47	

Magnet No. 19 A was used up to February.

" No. 20 " " from March.

3. *Mean base line values.*—The table below gives the mean monthly observed and accepted values of the declination and horizontal force base lines. The accepted values have been used to compute the values of these elements for 1921. The horizontal force base lines for January and February have been derived from H as determined with the moment of inertia and distribution coefficient used in the computations for 1915. The base lines for the remainder of the year have been derived from H as determined with the moment of inertia obtained for magnet No. 20 at Toungoo in February 1921 and the approximate expression of the distribution coefficient referred to in the preceding para.

The value of the instrumental difference, using these provisional constants, is $19A - 20 = 4$ gammas for horizontal force. The instrumental difference for declination between 19A and 20 is *nil*.

Base line values of magnetographs in 1921.

MONTHS.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of Base line.	Base line accepted.	REMARKS.	Mean value of Base line.	Base line accepted.	REMARKS.
January ...	1 14.7	1 14.7	Magnet No. 19A used up to end of February and No. 20, from March. Difference between 19A and 20 is <i>nil</i> .	C. G. S. 38641	C. G. S. 38641	Magnet No. 19A used up to end of February.
February ...	1 14.4	1 14.4		38643	38643		Magnet No. 20 used from 1st March.
March ...	1 14.1	1 14.1		38947	38947	Difference 19A-20 is 4γ.
April ...	1 14.1	1 14.1		38947	38947		(1) Up to 12th May.
May ...	1 14.2	1 14.2		38945(1) 38939(2)	38945(1) 38939(2)	(2) From 13th to 31st May.
June ...	1 14.3	1 14.3		38933	38933	
July ...	1 14.6	1 14.6		38928	38928	
August ...	1 14.5	1 14.5		38926	38926	
September ...	1 14.2	1 14.2		38928	38928	
October ...	1 14.3	1 14.3		38924	38924	
November ...	1 14.2	1 14.2		38921	38921	
December ...	1 14.3	1 14.3		38916	38916	

4. *Mean scale values and temperature range.*—The mean scale values for 1921 for an ordinate of 1/25 inch are:—

Horizontal Force 5.36 gammas to 28th February.

5.20 " from 28th February to the end of the year.

Declination 1.04 minutes.

Vertical Force 5.77 gammas to 5th May.

5.83 " from 5th May to the end of the year.

The mean temperature for the year was 89°·2 Fahr. with maximum and minimum monthly values of 89°·5 and 89°·0 Fahr. The temperature of reduction is 89°·0 Fahr.

5. *Mean monthly values and annual changes.*—The table below shows the monthly mean values of the magnetic elements for 1920-21, and the annual changes for that period. The annual changes for horizontal force are deduced from the values of H corrected for the moment of inertia and distribution factor as referred to in para. 3.

Annual changes at Toungoo in 1920-21.

MONTHS.	HORIZONTAL FORCE 39000 C. G. S. +			DECLINATION W. 0' +			DIP N. 23' +			VERTICAL FORCE 16000 C. G. S. +		
	1920.	1921.	Annual change.	1920.	1921.	Annual change.	1920.	1921.	Annual change.	1920.	1921.	Annual change.
January ...	106	125	+23	22.3	25.6	+3.3	7.7	7.2	-0.5	705	704	+3
February ...	113	130	+30	22.6	25.6	+3.0	7.8	7.0	-0.8	708	707	+1
March ...	107	142	+39	22.7	25.4	+2.7	7.7	6.8	-0.9	703	706	+5
April ...	105	143	+42	23.0	25.7	+2.7	8.2	6.8	-1.4	710	707	-1
May ...	114	117	+7	23.5	26.0	+2.5	7.7	6.4	-1.3	707	690	-15
June ...	128	132	-2	23.4	26.4	+3.0	7.7	6.7	-1.0	712	697	-13
July ...	118	132	+18	23.6	26.9	+3.3	7.8	6.7	-1.1	710	701	-7
August ...	109	128	+23	23.9	27.1	+3.2	7.9	7.1	-0.8	706	704	0
September ...	103	132	+33	24.5	27.6	+3.1	7.9	7.3	-0.6	705	708	+5
October ...	110	131	+25	24.7	28.0	+3.3	7.7	7.4	-0.3	704	710	+8
November ...	121	135	+18	24.8	28.1	+3.3	7.6	7.2	-0.3	707	708	+3
December ...	133	134	+5	25.3	28.6	+3.3	7.3	7.2	-0.1	709	708	+1
Means ...	114	132	+22	23.7	26.8	+3.1	7.7	7.0	-0.7	707	704	-1

* The H. F. and V. F. values for 1920 are in terms of Magnet 19 A and those for 1921 are in terms of Magnet 20. The annual changes have been corrected for the difference between Magnets 19 A and 20.

Kodalkanal Observatory.

This observatory is under the control of the Meteorological Department, but the absolute observations and the records of the self-registering instruments are forwarded periodically by the Director of the observatory, for computation and for record in No. 18 Party (Magnetic).

The working of the magnetographs has been fairly satisfactory. The clock which works the drums of the declination and horizontal force magnetographs was reported to have stopped very often during the year. The cause of these stoppages is not stated but they are probably due to the clock requiring a thorough cleaning.

The base line value of the declination rose to 0'·8 on the 18th January and returned to its normal value on the 21st February. The cause of the change, from a scrutiny of the records, is traceable to lost motion in the tangent screw of the magnetometer which is reported to have been cleaned on the 18th January.

At the request of the Director, the officer in charge of the magnetic party, during his visit to the observatory for taking the annual comparative observations, adjusted the horizontal force magnetograph on the 1st March, on account of the shift in the magnet line to the edge of the magnetogram, due to secular change.

2. *Mean values of the declination and H. F. constants.*—The table below gives the mean monthly values of the magnetic collimation, the distribution constants P_{1.2} and P_{2.3} and the accepted values of p and q used in determining the values of the distribution factor. The values of the moment "m" are also given, as determined by this revised distribution and the moment of inertia used for the computations in 1915. The values of "m" in the table were derived from vibration observations taken with the chronograph.

Mean values of the constants of magnet No. 16 in 1921.

MONTHS.	DECLINATION CONSTANTS.		H. F. CONSTANTS.				
	Mean magnetic collimation.	P _{1.2}	P _{2.3}	Accepted values		MEAN VALUES OF m.	
				p	q	Monthly means.	Accepted m.
January ...	- 3 15	6.58	8.40	11.30	- 1621	882.24	881.74 throughout
February ...	- 3 20	6.58	8.35			882.21	
March ...	- 3 17	6.56	8.73			882.07	
April ...	- 3 18	6.54	8.65			882.01	
May ...	- 3 17	6.58	8.58			882.03	
June ...	- 3 15	6.56	8.45			882.11	
July ...	- 3 16	6.54	8.46			882.13	
August ...	- 3 14	6.64	8.54			882.14	
September ...	- 3 13	6.60	8.56			882.10	
October ...	- 3 13	6.61	8.41			882.11	
November ...	- 3 16	6.63	8.44			882.16	
December ...	- 3 17	6.60	8.62			882.11	

3. *Mean base line values.*—The table below gives the mean monthly observed and accepted base line values of the declination and horizontal force magnetographs: the accepted values have been used to compute the values of these elements for 1921. The horizontal force base line values have been derived from H as determined with the moment of inertia and distribution coefficient used in the computations for 1915.

Base line values of magnetographs in 1921.

MONTHS.	DECLINATION.		HORIZONTAL FORCE.	
	Mean value of Base line.	Base line accepted.	Menu value of Base line.	Base line accepted.
	° ' "	° ' "	C. G. S.	C. G. S.
January	2 58·2	2 58·2	·37340	·37340
February	2 58·0	2 58·0	·37345	·37345
March	2 58·2	2 58·2	·37344	·37344
April	2 57·9	2 57·9	·37343	·37343
May	2 57·9	2 57·9	·37344	·37344
June	2 58·2	2 58·2	·37339	·37339
July	2 58·0	2 58·0	·37337	·37337
August	2 57·7	2 57·7	·37334	·37334
September	2 57·5	2 57·5	·37336	·37336
October	2 57·2	2 57·2	·37335	·37335
November	2 57·4	2 57·4	·37336	·37336
December	2 57·5	2 57·5	·37337	·37337

4. *Mean scale values and temperature range.*—The mean scale values for 1921 for an ordinate of 1/25 inch are :—

Horizontal Force 5·95 gammas.

Declination 1·03 minutes.

Vertical Force 8·07 gammas to 13th June.

8·84 gammas from 14th June.

The mean temperature for the year was 17°·7 C.; with maximum and minimum monthly values of 18°·3 C. and 16°·6 C. The temperature of reduction is 19°·0 C.

5. *Mean monthly values and annual changes.*—The table below gives the monthly mean values of the magnetic elements for 1920 and 1921 and the annual changes for that period. The annual changes for horizontal force are deduced from the values of H corrected for the moment of inertia and the distribution factor used in the computations for 1915.

Annual changes at Kodaikānal in 1920-21.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S. +			DECLINATION W. 1° +			DIP N. 4° +			VERTICAL FORCE ·03000 C. G. S. +		
	1920.	1921.	Annual change.	1920.	1921.	Annual change.	1920.	1921.	Annual change.	1920.	1921.	Annual change.
January ...	775	812	+ 37	47·5	52·6	+ 5·1	34·4	37·2	+ 2·8	021	055	+ 34
February ...	779	827	+ 48	47·9	53·3	+ 5·4	34·7	37·3	+ 2·6	025	057	+ 32
March ...	767	832	+ 65	48·0	53·3	+ 5·3	35·6	37·5	+ 1·9	034	060	+ 26
April ...	765	831	+ 66	48·6	53·5	+ 4·9	36·2	38·0	+ 1·8	040	060	+ 20
May ...	777	813	+ 36	49·0	53·7	+ 4·7	36·6	38·7	+ 2·1	046	072	+ 26
June ...	791	818	+ 27	49·8	54·4	+ 4·6	36·1	38·8	+ 2·7	042	074	+ 32
July ...	794	833	+ 39	50·6	54·4	+ 3·8	36·3	39·1	+ 2·8	044	079	+ 35
August ...	795	833	+ 38	51·0	54·5	+ 3·5	36·7	39·1	+ 2·4	049	078	+ 29
September ...	792	814	+ 52	51·0	54·7	+ 3·7	36·4	38·0	+ 2·5	045	077	+ 32
October ...	798	842	+ 44	51·5	54·7	+ 3·2	36·7	38·8	+ 2·1	049	076	+ 27
November ...	799	848	+ 49	51·9	55·3	+ 3·4	36·8	39·0	+ 2·2	050	078	+ 28
December ...	806	862	+ 46	52·3	55·9	+ 3·6	37·1	39·1	+ 2·0	054	080	+ 26
Means ...	787	832	+ 45	49·9	54·2	+ 4·3	36·1	38·5	+ 2·4	042	071	+ 29

III.—TABLE OF RESULTS.

Mean values of the magnetic elements at observatories in 1921.

Observatory.	Latitude and Longitude.				Dip.		Declination.		H. F.	V. F.
	°	'	"		°	'	°	'	C. G. S.	C. G. S.
Dehra Dūn ...	{ 30	19	19	N. }	N. 45	4·2	E. 1	47·1	·82945	·33025
	{ 78	3	19	E. }						
Toungoo ...	{ 18	55	45	N. }	N. 23	7·0	W. 0	26·8	·39132	·16704
	{ 96	27	3	E. }						
Kodaikānal ...	{ 10	13	50	N. }	N. 4	38·5	W. 1	54·2	·37832	·03071
	{ 77	27	46	E. }						

Lat. 10 13 50 N.
Long. 77 27 16 E.

K = Kodukūāni

Classification and dates of Magnetic disturbances in 1921.

Lat. 30 19 19 N.
Long. 78 3 19 E.

D = Dehra Dūn
T = Youngoo

1921 Dates.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
1	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
2	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
3	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
4	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
5	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
6	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
7	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
8	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
9	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
10	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
11	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
12	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
13	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
14	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
15	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
16	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
17	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
18	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
19	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
20	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
21	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
22	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
23	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
24	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
25	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
26	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
27	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
28	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
29	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
30	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
31	S	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
C	12	12	14	14	16	16	11	11	13	13	11	11	11	11	11	11	11	11	11	11	11	11	11	11
S	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
V.G.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trace lost	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C = Calm. S = Slight. G = Great. V.G. = Very Great. M = Moderate. G = Great. V.G. = Very Great. — = Trace lost.

Hourly Means of the Declination at Dehra Dun in 1921, determined from all available days. Declination = $E. I^\circ + \text{tabular quantity}$.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar. }	49.0	48.9	48.9	48.7	48.5	48.4	48.4	48.6	49.4	49.7	49.2	48.1	47.5	47.9	48.6	49.3	49.6	49.3	49.2	49.3	49.2	49.1	49.1	49.1	49.0	48.9
	48.8	48.8	48.6	48.6	48.4	48.4	48.3	48.5	49.2	49.7	48.8	48.6	47.5	47.0	47.3	48.0	48.7	48.9	48.8	48.3	48.9	48.8	48.7	48.7	48.6	48.6
	48.5	48.5	48.4	48.3	48.1	48.0	48.1	48.5	49.8	50.6	49.5	49.6	47.7	46.3	46.1	46.9	48.0	48.5	48.4	48.3	48.2	48.2	48.3	48.4	48.5	48.3
	46.5	46.5	46.5	46.3	46.1	46.0	46.0	46.7	47.4	47.1	46.4	45.5	44.6	44.5	45.1	45.8	46.2	46.0	45.9	45.9	46.0	46.0	46.1	46.3	46.4	46.1
	46.1	46.2	46.2	46.0	45.7	45.6	45.3	45.4	46.0	46.4	46.1	45.5	45.1	45.1	45.4	45.4	45.6	45.8	45.8	46.0	45.9	46.0	46.0	46.0	46.1	45.8
Summer { April May June July Aug. Sep. }	46.7	46.6	46.5	46.5	46.7	46.9	47.4	48.4	48.9	49.1	48.2	45.3	45.1	45.4	45.7	45.7	45.5	45.7	46.7	46.7	46.7	46.5	46.5	46.3	46.4	46.1
	47.4	47.4	47.4	47.2	47.0	46.9	46.8	47.0	47.8	48.2	47.9	47.1	46.3	46.0	46.4	46.9	47.3	47.4	47.3	47.3	47.3	47.3	47.3	47.3	47.4	47.2
	48.0	48.2	48.1	48.1	47.9	47.9	48.2	49.1	50.1	50.2	49.3	47.5	46.0	45.1	45.1	45.6	46.6	47.3	47.7	47.6	47.4	47.6	47.7	47.9	47.9	47.7
	47.9	48.0	48.1	48.0	48.4	48.6	49.6	50.7	50.9	50.9	47.9	46.9	44.7	44.4	44.3	44.8	45.6	46.4	47.1	47.4	47.0	46.9	47.0	47.2	47.5	47.5
	47.8	47.8	47.9	47.9	48.0	48.3	49.5	50.8	50.2	49.4	47.9	46.2	44.8	44.3	44.4	45.0	46.8	46.8	46.8	46.8	46.8	46.7	46.9	47.0	47.2	47.5
Means	47.2	47.4	47.4	47.2	47.0	46.9	46.8	47.0	47.8	48.2	47.9	47.1	46.3	46.0	46.4	46.9	47.3	47.4	47.3	47.3	47.3	47.3	47.3	47.3	47.4	47.2
	48.0	48.2	48.2	48.1	47.9	47.9	48.2	49.1	50.1	50.2	49.3	47.5	46.0	45.1	45.1	45.6	46.6	47.3	47.7	47.6	47.4	47.6	47.7	47.9	47.9	
	47.9	48.0	48.1	48.0	48.4	48.6	49.6	50.7	50.9	50.9	47.9	46.9	44.7	44.4	44.8	45.6	46.4	47.1	47.4	47.0	46.9	47.0	47.2	47.5	47.5	
	47.8	47.8	47.9	47.9	48.0	48.3	49.5	50.8	50.2	49.4	47.9	46.2	44.8	44.3	44.4	45.0	46.8	46.8	46.8	46.8	46.8	46.7	46.9	47.0	47.2	47.5
	47.0	47.2	47.6	47.6	47.6	47.9	49.0	49.8	49.6	48.8	47.5	45.8	44.4	43.8	44.1	44.4	45.2	46.0	46.5	46.4	46.4	46.2	46.5	46.7	47.1	46.7
Means	47.2	47.4	47.5	47.6	47.6	47.8	48.7	49.7	50.0	49.2	47.6	45.7	44.4	44.0	44.3	45.0	45.9	46.6	46.9	46.7	46.6	46.6	46.8	47.0	47.2	46.9

Diurnal Inequality of the Declination at Dehra Dun in 1921, deduced from the above table.

Hours	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar. }	+0.1	0.0	0.0	-0.2	-0.4	-0.5	-0.3	+0.5	+0.8	+0.3	-0.6	-1.4	-1.0	-0.3	+0.4	+0.7	+0.4	+0.3	+0.4	+0.3	+0.2	+0.2	+0.2	+0.2	+0.1
	+0.2	+0.2	0.0	0.0	-0.2	-0.3	-0.1	+0.6	+1.1	+0.9	0.0	-1.1	-1.6	-1.3	-0.6	+0.1	+0.3	+0.2	+0.3	+0.2	+0.2	+0.1	0.0	+0.1	+0.2
	+0.2	+0.2	+0.1	0.0	-0.2	-0.3	+0.2	+1.6	+2.3	+2.2	+1.3	-0.6	-2.0	-2.2	-1.4	-0.3	+0.2	+0.1	+0.1	0.0	-0.1	-0.1	0.0	+0.1	+0.2
	+0.4	+0.4	+0.4	+0.2	0.0	-0.1	-0.1	+0.6	+1.3	+1.0	+0.8	-0.6	-1.5	-1.6	-1.0	-0.3	+0.1	-0.1	-0.2	-0.2	-0.2	-0.1	0.0	0.0	+0.2
	+0.3	+0.4	+0.4	+0.2	-0.1	-0.2	-0.5	-0.4	+0.2	+0.6	+0.3	-0.3	-0.7	-0.7	-0.4	-0.2	0.0	0.0	+0.2	+0.1	+0.2	+0.2	+0.1	+0.1	+0.2
Summer { April May June July Aug. Sep. }	+0.2	+0.2	+0.2	0.0	-0.2	-0.3	-0.4	-0.2	+0.6	+1.0	-0.1	-0.9	-1.2	-0.8	-0.3	+0.1	+0.2	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.2	+0.2
	+0.3	+0.5	+0.5	+0.4	+0.2	+0.5	+1.4	+2.4	+2.5	+1.6	-0.2	-1.7	-2.6	-2.6	-2.1	-1.1	-0.4	0.0	-0.1	-0.3	-0.1	0.0	+0.2	+0.2	
	+0.4	+0.5	+0.6	+0.5	+0.6	+0.9	+3.2	+3.4	+2.4	+0.4	-1.6	-2.6	-3.1	-2.7	-2.0	-1.1	-0.4	-0.1	-0.5	-0.6	-0.5	-0.3	-0.1	0.0	+0.2
	+0.3	+0.6	+0.6	+0.7	+0.8	+1.1	+2.3	+3.1	+3.0	+2.2	+0.7	-1.0	-2.4	-2.8	-2.8	-1.4	-0.8	-0.4	-0.4	-0.5	-0.3	-0.2	0.0	0.0	+0.3
	+0.3	+0.5	+0.9	+0.9	+0.9	+1.2	+2.3	+3.1	+2.9	+2.1	+0.8	-0.9	-3.3	-2.9	-2.6	-2.3	-1.5	-0.7	-0.2	-0.3	-0.5	-0.5	-0.2	0.0	+0.4
Means	0.0	+0.3	+0.4	+0.6	+0.7	+1.1	+2.3	+3.5	+3.6	+2.3	+0.1	-2.0	-3.1	-2.8	-1.6	-0.7	0.0	+0.4	-0.1	-0.2	-0.3	-0.2	-0.1	0.0	0.0
	+0.4	+0.4	+0.5	+0.6	+0.6	+0.8	+1.3	+2.3	+2.8	+2.0	+0.1	-1.8	-2.9	-3.2	-2.4	-1.2	-0.2	+0.1	-0.1	-0.3	-0.2	-0.1	0.0	+0.2	+0.3
	+0.3	+0.5	+0.6	+0.7	+0.7	+0.9	+1.6	+2.8	+3.1	+2.3	+0.7	-1.2	-2.5	-2.9	-2.6	-1.9	-1.0	-0.3	0.0	-0.2	-0.3	-0.3	-0.1	+0.1	+0.3
	+0.3	+0.5	+0.6	+0.7	+0.7	+0.9	+1.6	+2.8	+3.1	+2.3	+0.7	-1.2	-2.5	-2.9	-2.6	-1.9	-1.0	-0.3	0.0	-0.2	-0.3	-0.3	-0.1	+0.1	+0.3
	+0.3	+0.5	+0.6	+0.7	+0.7	+0.9	+1.6	+2.8	+3.1	+2.3	+0.7	-1.2	-2.5	-2.9	-2.6	-1.9	-1.0	-0.3	0.0	-0.2	-0.3	-0.3	-0.1	+0.1	+0.3

NOTE.—When the sign is + the magnet points to the east, and when - to the west of the mean position.

Hourly Means of Horizontal Force in C.G.S. units corrected for temperature at Dehra Dun in 1921, from all available days. Horizontal Force = 32000 C.G.S. + tabular quantity.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means	
Winter { Jan. Feb. Mar.	943	946	945	949	950	951	951	951	948	941	939	949	956	958	964	957	949	943	939	940	939	940	949	941	941	946	946
	949	950	949	951	952	953	953	953	950	946	945	949	958	964	964	962	958	954	950	946	945	949	949	947	947	947	953
	949	949	952	954	955	956	956	958	960	963	963	968	971	970	967	965	959	952	948	943	947	946	949	952	951	951	956
Summer { Oct. Nov. Dec.	931	932	933	935	934	936	935	935	933	931	938	943	946	946	948	945	940	935	931	930	932	932	932	933	933	932	936
	930	930	929	929	932	932	932	931	928	941	946	949	949	949	945	938	933	931	929	928	927	928	928	930	931	933	
	922	924	925	927	927	928	930	932	939	941	941	942	942	939	936	931	927	926	925	925	922	922	923	924	925	928	929
Means	937	939	939	941	942	943	944	945	946	947	948	952	954	953	950	945	941	938	937	941	942	943	944	946	946	947	947
Summer { April May June	957	955	955	956	958	957	959	957	956	958	963	971	978	978	979	974	971	964	957	954	953	952	954	956	956	959	960
	937	937	938	937	936	938	938	935	940	930	933	943	948	948	952	950	947	942	934	931	932	935	938	939	941	941	938
	945	944	945	944	946	947	948	944	941	939	939	946	953	953	957	956	951	947	944	942	939	940	940	941	944	945	945
Summer { July Aug. Sep.	951	950	950	952	952	953	953	952	950	951	954	957	964	964	968	966	962	955	949	948	948	949	950	951	952	952	954
	942	940	940	940	940	939	941	939	932	929	935	943	952	952	957	951	947	945	941	938	937	938	939	941	943	945	942
	938	942	940	940	941	941	940	938	929	926	926	926	946	946	955	953	945	945	941	939	938	936	938	938	940	941	940
Means	945	945	945	945	946	946	947	944	940	939	942	949	957	961	960	956	950	944	942	941	942	943	944	946	946	947	947

Diurnal Inequality of the Horizontal Force at Dehra Dun in 1921, deduced from the above table.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar.	7	0	-1	+3	+3	+4	+5	+5	+2	-5	-7	+3	+10	+12	+11	+6	+3	7	7	6	7	7	7	7	7	7
	-3	-4	-3	-2	-1	0	+4	+2	+3	+3	+2	+5	+9	+11	+9	+5	+1	-3	-4	-4	-7	-8	-6	-6	-6	-1
	-7	-4	-1	-2	-1	0	0	+2	+4	+4	+7	+12	+15	+14	+11	+3	-4	-8	-8	-7	-9	-10	-7	-4	-5	-5
Summer { Oct. Nov. Dec.	5	4	3	1	2	0	-1	-1	-3	-2	+2	+7	+10	+12	+9	+4	-1	5	6	5	4	4	3	3	4	4
	-5	-6	-6	-6	-3	-3	0	+2	+7	+9	+11	+14	+14	+10	+3	-2	-4	-6	-6	-7	-8	-7	-5	-4	-4	-2
	-7	-5	-4	-4	-2	-1	+1	+1	+3	+10	+12	+13	+10	+7	+2	-3	-3	-4	-4	-7	-7	-6	-5	-4	-4	-1
Means	-6	-4	-4	-2	-1	0	+1	+2	+3	+4	+5	+9	+11	+10	+7	+2	-2	-5	-6	-7	-8	-7	-5	-5	-3	
Summer { April May June	3	6	5	4	2	-0	-1	-3	-4	-8	-3	+11	+18	+19	+14	+11	+4	-3	-6	-7	-8	-6	-6	-4	-4	
	-1	1	0	-1	-2	-0	0	-3	-4	-2	+3	+5	+10	+14	+12	+9	+4	-4	-7	-6	-3	-3	-0	+1	+3	
	0	-1	0	-1	+1	+2	+3	-1	-4	-6	-6	+1	+8	+12	+11	+6	+2	-1	-3	-6	-6	-5	-4	-1	0	
Summer { July Aug. Sep.	3	4	4	2	2	1	1	2	-4	-3	0	+3	+10	+14	+12	+8	+1	5	6	6	4	3	3	2	2	
	-3	-4	-4	-2	-2	-3	-1	-2	-1	-3	-7	+1	+10	+15	+15	+9	+5	+1	-5	-4	-6	-4	-3	-1	+1	
	-2	+2	0	+1	+1	+1	0	-3	-11	-14	-12	-4	+6	+13	+17	+13	+5	+1	-1	-4	-2	-4	-2	+1	+1	
Means	-2	-2	-2	-1	-1	-1	0	-3	-7	-8	-5	+2	+10	+14	+13	+9	+3	-3	-5	-6	-5	-4	-3	-1	0	

Note.—When the sign is + the H.F. is greater, and when - it is less than the mean.

Hourly Means of Vertical Force in C.G.S. units (corrected for temperature) at Dehra Dun in 1921, from all available days. Vertical Force = 32000 C.G.S. + tabular quantity.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar.	991	991	990	991	990	990	990	991	993	991	986	984	987	989	989	991	991	991	990	991	991	991	991	991	992	990
	997	997	996	996	996	996	997	997	998	998	993	987	986	987	987	993	995	995	995	996	996	996	997	997	997	995
	1012	1012	1011	1012	1011	1011	1011	1014	1016	1016	1006	991	987	989	989	995	1002	1006	1008	1009	1009	1010	1011	1011	1011	1007
Summer { Oct. Nov. Dec.	1044	1044	1043	1043	1042	1042	1042	1045	1041	1040	1035	1034	1039	1038	1039	1040	1043	1043	1043	1044	1044	1044	1044	1044	1043	1042
	1043	1043	1042	1042	1042	1042	1042	1043	1043	1041	1036	1039	1038	1038	1039	1040	1043	1043	1044	1044	1044	1044	1044	1043	1042	
	1046	1046	1046	1046	1046	1046	1046	1046	1047	1048	1047	1046	1046	1046	1046	1046	1046	1045	1046	1046	1046	1046	1045	1045	1045	
Means	1022	1022	1022	1022	1021	1021	1021	1023	1024	1022	1017	1014	1013	1015	1015	1017	1021	1021	1021	1022	1022	1022	1022	1022	1022	1020
Summer { April May June	1021	1021	1021	1021	1021	1021	1023	1025	1023	1019	1010	998	1000	1004	1004	1007	1013	1016	1017	1016	1017	1018	1020	1021	1021	1022
	1027	1027	1027	1027	1027	1025	1023	1025	1023	1016	1009	999	1004	1009	1014	1019	1022	1023	1024	1023	1025	1026	1026	1027	1027	1026
	1037	1037	1036	1037	1037	1037	1039	1042	1033	1025	1020	1009	1012	1017	1020	1026	1029	1032	1032	1032	1034	1034	1035	1035	1035	1039
Summer { July Aug. Sep.	1044	1044	1044	1043	1044	1045	1045	1048	1042	1034	1027	1018	1021	1024	1024	1030	1035	1038	1041	1041	1042	1042	1043	1043	1043	1039
	1041	1041	1041	1041	1041	1041	1041	1041	1038	1031	1024	1023	1023	1028	1033	1037	1039	1041	1041	1039	1040	1040	1040	1042	1041	1037
	1044	1044	1044	1043	1043	1043	1045	1046	1043	1037	1029	1028	1031	1035	1039	1043	1045	1044	1044	1043	1044	1045	1045	1045	1045	1041
Means	1036	1036	1035	1035	1035	1036	1040	1039	1034	1027	1020	1012	1015	1020	1024	1029	1032	1033	1033	1033	1034	1035	1035	1036	1035	1031

Diurnal Inequality of the Vertical Force at Dehra Dun in 1921, deduced from the above table.

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean	
Winter { Jan. Feb. Mar.	+2	+2	+1	+1	+1	+2	+2	+3	+3	-1	-4	-6	-3	-1	+1	+1	-1	-1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	
	+5	+5	+5	+5	+5	+4	+4	+7	+9	-2	-2	-8	-9	-6	-6	-2	0	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	
	+5	+5	+5	+4	+4	+4	+4	+4	+5	-1	-1	-16	-20	-18	-12	-5	-1	0	+1	+1	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	
Summer { April May June	+6	+5	+5	+5	+5	+7	+9	+9	+7	+3	-6	-18	-16	-12	-9	-3	0	+1	+1	+1	+2	+4	+5	+5	+5	+5	+5	+5	+5	+5	+5	+5	+5
	+7	+6	+6	+6	+6	+7	+7	+7	+3	-5	-10	-22	-18	-13	-10	-4	-1	+2	+2	+2	+3	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4
	+5	+5	+5	+5	+5	+6	+6	+6	+5	-5	-12	-21	-18	-15	-9	-4	-1	+2	+2	+2	+3	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4
Summer { July Aug. Sep.	+5	+4	+4	+4	+4	+4	+4	+4	+4	+2	-4	-13	-14	-9	-4	0	+2	+4	+2	+2	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3
	+3	+3	+3	+3	+3	+3	+3	+3	+2	-4	-12	-13	-10	-6	-2	+2	+4	+3	+2	+2	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3
	+5	+5	+5	+5	+5	+5	+5	+5	+3	-4	-11	-19	-16	-11	-7	-2	+1	+2	+2	+2	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3
Means	+5	+5	+4	+4	+4	+4	+4	+4	+3	-4	-11	-19	-16	-11	-7	-2	+1	+2	+2	+2	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3

NOTE.—When the sign is + the V.F. is greater, and when - it is less than the mean.

Hourly Means of the Dip at Dehra Dun in 1921, determined from all available days. Dip = $N. 43^\circ + \text{tabular quantity}$.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter. { Jan. Feb. Mar.	2.5	2.4	2.3	2.2	2.1	2.1	2.0	2.1	2.3	2.6	2.5	1.8	1.6	1.6	1.8	2.1	2.2	2.4	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.3
	2.5	2.4	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.0	1.5	1.3	1.2	1.4	1.8	2.1	2.3	2.5	2.6	2.7	2.6	2.6	2.6	2.5	2.2
	3.3	3.1	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.5	2.0	1.1	0.9	1.2	1.6	2.3	2.8	3.1	3.1	3.2	3.2	3.1	3.1	3.1	3.1	2.6
	5.9	5.8	5.8	5.6	5.7	5.5	5.6	5.7	5.8	5.5	5.0	4.8	4.6	4.6	5.0	5.4	5.6	5.8	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.5
Summer. { April May June	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.1	4.0	3.9	3.6	3.2	3.1	3.2	3.5	3.9	4.1	4.3	4.4	4.5	4.5	4.5	4.4	4.4	4.3	4.1
	3.4	3.5	3.5	3.4	3.3	3.3	3.4	3.5	3.5	3.2	2.5	1.4	1.2	1.3	1.7	2.2	2.7	3.1	3.2	3.3	3.5	3.5	3.4	3.4	3.3	2.9
	4.7	4.7	4.6	4.7	4.8	4.8	4.8	4.8	4.8	4.5	4.0	2.9	2.9	3.0	3.3	3.7	4.2	4.7	4.9	4.8	4.7	4.7	4.6	4.6	4.4	4.4
	4.8	4.8	4.8	4.8	4.8	4.8	4.9	5.0	5.0	4.8	4.5	4.2	3.3	3.1	3.4	3.9	4.3	4.6	4.7	4.8	4.9	4.9	4.9	4.9	4.8	4.7	4.5
Autumn. { July Aug. Sep.	4.8	4.9	4.9	4.8	4.8	4.8	5.0	5.0	4.8	4.3	3.8	3.2	3.0	2.9	3.3	3.8	4.3	4.8	4.8	4.9	4.8	4.8	4.8	4.8	4.8	4.4
	5.2	5.3	5.3	5.3	5.2	5.3	5.3	5.5	5.5	5.3	4.6	4.2	3.7	3.7	4.0	4.5	4.8	5.2	5.3	5.4	5.3	5.3	5.2	5.2	5.0	5.0
	5.5	5.3	5.4	5.4	5.3	5.3	5.5	5.6	5.9	5.8	5.3	4.8	4.4	4.2	4.3	4.7	5.2	5.4	5.4	5.5	5.6	5.6	5.6	5.5	5.4	5.3
	Mean	4.7	4.8	4.8	4.7	4.7	4.7	4.9	4.9	4.9	4.6	4.1	3.3	3.1	3.0	3.3	3.8	4.3	4.6	4.7	4.8	4.8	4.8	4.8	4.7	4.6	4.4

Diurnal Inequality of the Dip at Dehra Dun in 1921, deduced from the above table.

Hours	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Mean
Winter.	+0.2	+0.1	0	-0.2	-0.3	-0.2	0	-0.1	0	+0.3
	+0.3	+0.2	+0.3	+0.4	+0.4	+0.3	+0.3	+0.3	+0.2	+0.1
	+0.7	+0.5	+0.4	+0.4	+0.3	+0.3	+0.3	+0.2	+0.1	+0.1
	+0.4	+0.3	+0.3	+0.1	0	0	0	0	0	0
Summer.	+0.5	+0.6	+0.6	+0.5	+0.4	+0.4	+0.4	+0.4	+0.3	+0.3
	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
	+0.4	+0.5	+0.5	+0.4	+0.4	+0.4	+0.4	+0.4	+0.3	+0.3
	+0.2	0	+0.1	0	0	0	0	0	0	0
Autumn.	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4
	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5
	+0.2	0	+0.1	0	0	0	0	0	0	0
Mean	+0.3	+0.4	+0.4	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
	+0.5	+0.6	+0.6	+0.5	+0.4	+0.4	+0.4	+0.4	+0.3	+0.3
	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
	+0.4	+0.5	+0.5	+0.4	+0.4	+0.4	+0.4	+0.4	+0.3	+0.3

Note.—When the sign is + the Dip is greater, and when - it is less than the mean.

Hourly Means of the Declination at Tongoo in 1921, determined from all available days. Declination = $W. O^\circ$ + tabular quantity.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar.	25.7	25.7	25.7	25.8	25.8	25.9	25.9	25.6	25.2	25.1	25.7	26.4	26.6	26.3	25.7	25.2	24.7	24.9	25.4	25.1	25.1	25.3	25.6	25.6	25.6	25.6
	25.5	25.6	25.6	25.7	25.7	25.8	25.8	25.8	24.4	24.9	25.0	25.7	26.4	26.4	26.0	25.6	25.1	24.9	25.4	25.4	25.4	25.4	25.5	25.5	25.6	25.6
	25.3	25.2	25.3	25.4	25.6	25.8	25.9	25.4	24.4	24.0	23.9	24.5	25.6	26.7	27.0	26.2	25.3	25.1	25.3	25.3	25.4	25.4	25.5	25.5	25.5	25.4
Winter { Oct. Nov. Dec.	27.8	27.7	27.7	27.9	28.1	28.4	28.5	28.6	28.1	27.7	28.1	28.7	29.0	28.8	28.4	27.8	27.5	27.7	27.9	28.0	28.1	28.1	28.2	28.1	28.1	28.0
	28.0	28.1	28.2	28.2	28.3	28.4	28.4	28.5	28.1	27.7	28.0	28.0	28.0	28.3	28.4	28.4	28.1	28.1	28.2	28.0	28.1	28.2	28.2	28.1	28.1	28.1
	28.5	28.5	28.6	28.8	29.1	29.3	29.3	29.4	29.4	28.8	28.4	28.3	28.3	28.3	28.4	28.4	28.1	28.1	28.2	28.4	28.4	28.3	28.5	28.5	28.5	28.6
Means	26.8	26.3	26.8	27.0	27.2	27.2	27.2	27.1	26.6	26.3	26.5	26.9	27.3	27.4	27.3	26.9	26.4	26.4	26.4	26.7	26.7	26.8	26.9	26.9	26.8	26.9
Summer { April May June	25.5	25.4	25.4	25.7	25.9	25.5	25.5	24.7	24.2	24.1	24.5	25.5	26.5	27.3	27.4	26.9	26.1	25.6	25.6	25.9	25.9	26.0	26.0	25.9	25.7	25.7
	26.1	25.8	25.7	25.7	25.7	25.7	25.7	23.4	23.3	23.5	26.0	27.1	27.9	28.0	27.7	27.0	26.2	25.7	26.0	26.4	26.4	26.5	26.5	26.3	26.1	26.0
	26.4	26.2	26.0	25.9	25.6	24.6	24.1	24.2	25.0	26.1	27.2	28.1	28.1	28.2	28.0	27.6	27.0	26.6	26.4	26.8	26.8	26.7	26.7	26.6	26.4	26.4
Summer { July Aug. Sep.	26.9	26.7	26.6	26.5	26.4	26.2	26.5	24.4	24.5	25.4	26.6	27.6	28.4	28.5	28.3	28.0	27.6	27.2	27.2	27.4	27.5	27.5	27.4	27.1	26.9	26.9
	27.4	27.3	27.1	26.9	26.8	26.5	25.0	23.9	24.1	25.5	27.2	28.5	29.2	29.2	28.9	28.2	27.4	26.9	27.0	27.4	27.5	27.5	27.4	27.5	27.4	27.1
	27.5	27.4	27.4	27.3	27.2	26.5	25.5	25.4	25.4	26.4	27.8	28.9	29.8	29.8	29.2	28.1	27.3	27.2	27.2	27.7	27.8	27.8	27.8	27.7	27.5	27.6
Means	26.6	26.5	26.4	26.3	26.2	25.2	24.3	24.3	24.3	25.2	26.4	27.5	28.3	28.5	28.3	27.6	26.9	26.5	26.7	27.0	27.0	27.0	27.0	26.9	26.7	26.6

Diurnal Inequality of the Declination at Tongoo in 1921, deduced from the above table.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar.	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.5	-0.6	-1.0	-0.7	-0.1	+0.4	+0.9	+0.7	+0.2	+0.2	+0.5	+0.6	+0.3	+0.0	+0.0	+0.0
	+0.1	0.0	0.0	+0.1	+0.1	+0.2	+0.2	+0.2	+0.3	+0.3	+0.4	+0.5	+0.8	+0.8	-0.4	0.0	+0.5	+0.7	+0.2	+0.2	+0.2	+0.2	+0.2	+0.1	+0.1	0.0
	+0.2	+0.2	+0.1	0.0	-0.2	-0.4	-0.5	-0.5	-0.4	-0.1	+1.0	+0.9	-0.2	-1.3	-1.6	-0.8	+0.1	+0.3	+0.1	+0.1	+0.1	0.0	0.0	-0.1	-0.1	+0.1
Winter { Oct. Nov. Dec.	+0.2	+0.3	+0.3	+0.3	+0.1	-0.1	-0.4	-0.5	-0.8	-0.9	-0.7	-1.0	+0.1	+0.1	+0.1	+0.2	+0.5	+0.2	+0.2	0.0	0.0	-0.1	-0.1	0.0	0.0	+0.2
	+0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.9	0.6	+0.4	+0.1	+0.1	+0.3	+0.2	+0.2	+0.5	+0.3	+0.3	+0.2	+0.2	+0.1	+0.1	0.0	0.0	+0.1
	+0.1	+0.1	+0.1	0.0	-0.1	-0.3	-0.3	-0.2	-0.2	-0.8	-0.2	+0.3	+0.3	+0.3	+0.2	+0.2	+0.5	+0.5	+0.5	+0.2	+0.2	+0.1	+0.1	0.0	0.0	+0.1
Means	+0.1	+0.1	+0.1	0.0	-0.1	-0.3	-0.3	-0.2	+0.3	+0.6	+0.4	0.0	-0.4	-0.5	-0.4	0.0	+0.5	+0.5	+0.2	+0.2	+0.1	+0.1	0.0	0.0	+0.1	0.0
Summer { April May June	+0.2	+0.3	+0.3	+0.3	0.0	-0.2	+0.2	+1.0	+1.5	+1.6	+1.2	+0.2	-0.8	-1.6	-1.7	-1.2	-0.4	+0.1	+0.1	-0.2	-0.2	-0.3	-0.3	-0.2	+0.1	0.0
	-0.1	+0.2	+0.3	+0.3	+0.3	+0.5	+1.8	+2.6	+2.7	+1.5	0.0	-1.1	-1.9	-2.0	-1.7	-1.0	-0.2	+0.3	0.0	-0.4	-0.4	-0.5	-0.4	-0.3	-0.1	0.0
	0.0	+0.2	+0.4	+0.5	+0.5	+0.8	+1.8	+2.3	+2.2	+1.4	+0.3	-0.8	-1.7	-1.8	-1.6	-1.2	-0.6	-0.2	0.0	-0.4	-0.4	-0.3	-0.3	-0.2	0.0	0.0
Summer { July Aug. Sep.	0.0	+0.2	+0.3	+0.4	+0.5	+0.7	+1.7	+2.5	+2.4	+1.6	+0.3	-1.5	-1.5	-1.6	-1.4	-1.1	-0.3	-0.3	-0.3	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	0.0
	-0.3	-0.2	0.0	+0.2	+0.3	+0.6	+1.1	+2.1	+3.0	+1.6	-0.1	-1.4	-2.1	-2.1	-1.8	-1.1	-0.3	+0.2	+0.1	-0.3	-0.4	-0.4	-0.4	-0.3	-0.3	0.0
	+0.1	+0.2	+0.2	+0.2	+0.3	+0.4	+1.1	+2.1	+2.2	+1.2	-0.2	-1.3	-2.2	-2.2	-1.6	-0.5	+0.3	+0.4	-0.1	-0.2	-0.3	-0.2	-0.2	-0.1	+0.1	0.0
Means	0.0	+0.1	+0.2	+0.3	+0.3	+0.4	+1.4	+2.3	+2.3	+1.4	+0.2	-0.9	-1.7	-1.9	-1.7	-1.0	-0.3	+0.1	-0.1	-0.4	-0.4	-0.4	-0.4	-0.3	-0.1	0.0

NOTE.—When the sign is + the magnet points to the east, and when - to the west of the mean position.

Hourly Means of Horizontal Force in C.G.S. units (corrected for temperature) at Youngoo in 1921, from all available days. Horizontal Force = 59000 C.G.S. + tabular quantity.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar.	115	117	119	120	123	124	125	126	127	131	137	142	147	142	138	132	124	121	118	114	112	112	113	115	116	116
	125	129	130	130	131	133	136	139	142	146	157	163	167	163	156	146	138	133	130	129	126	124	124	126	126	125
	129	129	129	133	133	134	136	137	144	166	169	179	170	171	161	149	136	131	129	129	128	127	128	130	129	142
Summer { Oct. Nov. Dec.	120	121	121	122	125	125	126	126	130	139	149	158	161	161	152	142	134	128	123	121	121	123	122	124	124	131
	126	126	127	126	127	130	131	135	141	149	156	161	161	163	146	139	133	129	125	125	124	123	124	124	127	135
	124	125	126	127	127	129	131	136	141	147	151	155	154	148	143	136	131	128	125	125	124	124	124	124	127	134
Means	123	124	125	126	128	129	131	133	138	145	153	160	162	155	146	139	132	128	125	124	123	122	123	124	125	134
Summer { April May June	129	130	132	131	133	134	134	136	142	156	170	178	178	174	165	153	144	137	134	132	129	127	129	130	130	143
	107	108	107	109	109	113	115	119	123	132	144	150	144	138	129	119	110	104	104	104	108	107	108	109	110	117
	110	112	112	114	114	116	119	123	127	136	145	149	150	145	138	127	116	109	110	112	110	108	108	110	111	122
Summer { July Aug. Sep.	121	122	122	122	124	126	129	131	136	144	154	159	162	155	150	140	129	129	119	121	121	122	122	123	123	132
	118	118	121	121	122	122	122	125	130	136	142	146	150	148	143	136	126	120	118	120	118	119	120	121	123	129
	122	124	127	127	127	128	128	125	127	134	145	150	153	152	146	137	131	126	126	126	126	124	124	124	125	132
Means	118	120	120	121	121	123	124	126	130	140	150	155	156	153	146	135	126	119	118	119	119	118	119	120	121	129

Diurnal Inequality of the Horizontal Force at Youngoo in 1921, deduced from the above table.

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean	
Winter { Jan. Feb. Mar.	7	-8	-6	-9	-9	-8	-9	-9	-8	-5	-2	-2	-2	-3	-6	-6	-6	-5	-4	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	
	-10	-10	-10	-9	-8	-6	-5	-4	-3	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	
	-14	-14	-13	-9	-8	-8	-6	-5	-4	-2	+1	+2	+3	+3	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4	
Summer { Oct. Nov. Dec.	-11	-10	-10	-9	-8	-7	-7	-7	-6	-5	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	
	-12	-9	-8	-9	-8	-6	-5	-4	-3	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	
	-10	-9	-8	-8	-7	-5	-4	-3	-2	-1	+1	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	
Means	-11	-10	-9	-8	-6	-5	-4	-3	-2	+1	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	
Summer { April May June	-14	-13	-11	-12	-10	-9	-9	-8	-7	-6	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	
	-10	-9	-10	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8
	-12	-10	-10	-8	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6
Summer { July Aug. Sep.	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
	-11	-6	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7
	-12	-8	-5	-5	-5	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4
Means	-11	-9	-9	-8	-6	-5	-4	-3	-2	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	

NOTE.—When the sign is + the H.P. is greater, and when - it is less than the mean.

Hourly Means of Vertical Force in C.G.S. units (corrected for temperature) at Youngoo in 1921, from all available days. Vertical Force = 16000 C.G.S. + tabular quantity.

Hours	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means		
Winter { Jan. Feb. Mar.	708 711 712	708 711 712	708 711 712	708 711 711	708 711 711	708 711 712	710 712 713	707 712 713	707 712 713	709 706 704	690 700 692	684 694 689	700 698 692	700 698 692	704 702 699	706 709 707	706 709 707	704 708 707	705 707 707	707 709 708	707 710 710	707 710 710	707 711 711	708 711 711	708 711 713	704 707 706	
	Summer { July Aug. Sep.	704 709 713	704 710 713	704 710 714	714 710 710	714 710 709	715 709 709	715 713 717	710 708 707	703 692 696	697 687 688	692 674 676	700 694 689	700 694 689	700 694 689	708 704 708	708 709 715	708 709 712	708 709 712	709 709 710	709 709 711	709 709 711	710 709 712	711 710 713	711 711 713	715 711 713	710 708 708
		Means	711	711	711	711	711	712	710	705	699	697	697	700	708	707	705	705	705	708	709	710	710	711	711	711	707
Spring { April May June		712 694 700	711 694 700	711 694 700	711 694 699	711 695 700	714 700 704	715 688 701	709 688 690	702 679 690	696 674 687	692 674 687	692 676 685	696 681 686	696 681 686	701 697 694	708 692 697	710 692 692	709 692 692	708 691 697	708 692 697	709 692 698	710 692 698	711 694 699	712 694 700	712 694 700	712 694 700	707
	Means	705	705	705	705	706	710	708	701	692	696	697	693	699	703	703	705	705	705	702	703	704	705	705	706	701	

Diurnal Inequality of the Vertical Force at Youngoo in 1921, deduced from the above table.

Hours	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means			
Winter { Jan. Feb. Mar.	+4 +4 +0	+4 +4 +6	+4 +4 +6	+4 +4 +5	+4 +4 +5	+4 +4 +6	+4 +5 +7	+3 +5 +5	+3 +5 +5	-6 -5 -2	-13 -7 -9	-14 -12 -4	-10 -13 -17	-4 -9 -14	7 0 -7	7 0 -1	7 0 +1	7 0 +1	+3 +2 +2	+3 +3 +3	+3 +3 +4	+3 +3 +4	+3 +4 +5	+3 +4 +4	+3 +4 +4	+4 +4 +6		
	Summer { July Aug. Sep.	+3 +5 +5	+4 +4 +3	+4 +4 +3	+4 +4 +2	+4 +4 +3	+4 +4 +5	+4 +5 +9	0 +2 +1	0 +2 +1	-7 -8 -12	-13 -16 -17	-10 -11 -20	-5 -4 -8	-5 -4 -10	0 +2 +6	0 +5 +7	0 +5 +4	0 +5 +4	+1 +2 +2	+1 +2 +3	+1 +2 +3	+1 +2 +3	+1 +2 +3	+1 +2 +3	+1 +2 +3	+1 +2 +3	+5
		Means	+4	+4	+4	+4	+4	+4	+3	-2	-8	-10	-10	-7	-4	0	+1	+1	+1	+2	+2	+3	+3	+4	+4	+4		
Spring { April May June		+5 +3 +3	+4 +4 +3	+4 +4 +2	+4 +4 +2	+4 +4 +3	+4 +4 +5	+4 +5 +10	+2 +2 +1	-5 -11 -7	-11 -16 -10	-15 -16 -11	-15 -14 -12	-11 -14 -12	-11 -9 -6	0 +3 +7	0 +2 +2	0 +2 +2	0 +2 +2	+1 +1 +0	+1 +2 +1	+1 +2 +1	+1 +2 +1	+1 +2 +3	+1 +2 +3	+1 +2 +3	+1 +2 +3	+5
	Means	+4	+4	+4	+4	+4	+4	+4	-5	-11	-15	-15	-11	-6	0	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3			
	Means	+4	+4	+4	+4	+4	+4	+4	-5	-11	-15	-15	-11	-6	0	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3			

Note.—When the sign is + the V.F. is greater, and when - it is less than the mean.

Hourly Means of the Dip at Tougoo in 1921, determined from all available days. Dip = N. 23° + tabular quantity.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means	
Winter { Jan. Feb. Mar.	7.8	7.7	7.7	7.7	7.6	7.5	7.5	7.6	7.4	6.6	5.8	5.6	5.8	6.4	6.8	7.1	7.4	7.3	7.5	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.2
	7.7	7.6	7.6	7.6	7.5	7.4	7.4	7.4	7.3	6.6	5.9	5.3	5.1	5.6	6.1	6.8	7.2	7.2	7.3	7.4	7.6	7.7	7.7	7.7	7.7	7.7	7.0
	7.7	7.7	7.6	7.5	7.4	7.4	7.4	7.4	7.4	7.1	6.2	4.6	4.4	4.8	5.7	6.5	7.0	7.2	7.3	7.3	7.4	7.6	7.5	7.5	7.6	7.7	6.8
Summer { Oct. Nov. Dec.	8.1	8.0	8.0	8.0	8.0	7.9	8.0	8.0	7.5	6.6	5.9	5.6	5.8	6.4	7.0	7.5	7.7	7.5	7.7	7.8	7.9	7.9	7.9	7.9	7.9	7.9	7.4
	7.7	7.6	7.6	7.6	7.6	7.5	7.4	7.3	7.1	6.7	6.2	5.9	6.0	6.3	6.5	6.9	7.2	7.3	7.5	7.6	7.7	7.7	7.7	7.7	7.7	7.6	
	7.7	7.6	7.6	7.6	7.4	7.4	7.4	7.2	7.0	6.8	6.6	6.3	6.2	6.4	6.5	6.8	7.1	7.4	7.5	7.5	7.6	7.6	7.6	7.6	7.6	7.6	7.2
Means	7.8	7.7	7.7	7.7	7.6	7.5	7.5	7.5	7.2	6.6	6.0	5.6	5.6	6.0	6.4	6.9	7.3	7.3	7.5	7.6	7.7	7.7	7.7	7.7	7.7	7.7	7.2
Summer { April May June	7.6	7.6	7.5	7.5	7.4	7.4	7.6	7.5	7.0	6.0	5.2	4.6	4.6	5.0	5.7	6.6	7.0	7.9	7.2	7.2	7.4	7.6	7.6	7.6	7.6	7.6	6.8
	7.0	7.0	7.0	6.9	6.9	7.0	7.3	7.0	6.2	5.1	4.3	4.2	4.5	5.0	5.8	6.5	6.9	7.1	7.0	6.9	6.8	6.9	7.0	7.0	7.0	6.9	6.4
	7.4	7.3	7.3	7.3	7.2	7.2	7.4	7.0	6.5	5.8	5.3	5.1	5.0	5.6	6.0	6.6	7.1	7.3	7.1	7.1	7.2	7.2	7.3	7.4	7.3	6.7	
Summer { July Aug. Sep.	7.3	7.3	7.3	7.3	7.2	7.2	7.3	7.1	6.5	5.7	5.2	5.0	5.0	5.4	5.9	6.5	7.0	7.3	7.2	7.1	7.2	7.2	7.2	7.2	7.2	7.2	6.7
	7.8	7.6	7.7	7.8	7.8	7.8	8.2	7.9	6.9	5.9	5.4	5.2	5.2	5.7	6.2	6.9	7.5	7.7	7.5	7.5	7.6	7.6	7.6	7.6	7.6	7.1	
	7.9	7.9	7.8	7.8	7.8	7.8	8.0	8.1	7.3	6.3	5.4	5.2	5.4	6.0	6.8	7.5	7.8	7.7	7.5	7.5	7.6	7.6	7.8	7.8	7.8	7.3	
Means	7.5	7.5	7.4	7.4	7.4	7.4	7.6	7.4	6.7	5.8	5.1	4.9	5.0	5.5	6.1	6.8	7.2	7.4	7.3	7.2	7.3	7.4	7.4	7.4	7.4	6.8	

Diurnal Inequality of the Dip at Tougoo in 1921, deduced from the above table.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means	
Winter { Jan. Feb. Mar.	+0.6	+0.5	+0.5	+0.5	+0.4	+0.3	+0.3	+0.4	+0.2	-0.6	-1.4	-1.6	-1.4	-0.8	-0.4	-0.1	+0.3	+0.1	+0.3	+0.6	+0.6	+0.6	+0.6	+0.6	+0.6	+0.6	
	+0.7	+0.6	+0.6	+0.6	+0.5	+0.4	+0.4	+0.4	+0.2	-0.4	-1.1	-1.7	-1.9	-1.4	-0.9	-0.2	+0.2	+0.2	+0.3	+0.3	+0.6	+0.6	+0.6	+0.6	+0.6	+0.6	
	+0.9	+0.8	+0.7	+0.7	+0.6	+0.6	+0.6	+0.6	+0.3	-0.6	-1.5	-2.2	-2.4	-2.0	-1.1	-0.3	+0.2	+0.4	+0.5	+0.5	+0.6	+0.6	+0.6	+0.6	+0.6	+0.6	
Summer { Oct. Nov. Dec.	+0.7	+0.6	+0.6	+0.6	+0.5	+0.5	+0.6	+0.6	+0.1	-0.8	-1.5	-1.8	-1.6	-1.0	-0.4	+0.1	+0.3	+0.1	+0.3	+0.4	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	
	+0.5	+0.4	+0.4	+0.4	+0.4	+0.3	+0.2	+0.2	-0.1	-0.5	-1.0	-1.3	-1.2	-0.9	-0.7	-0.2	0.0	+0.1	+0.3	+0.3	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	
	+0.4	+0.4	+0.4	+0.4	+0.4	+0.2	+0.2	+0.2	-0.2	-0.4	-0.6	-0.9	-1.0	-0.8	-0.7	-0.4	-0.1	+0.2	+0.3	+0.3	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	
Means	+0.6	+0.5	+0.5	+0.5	+0.4	+0.3	+0.3	+0.3	0.0	-0.6	-1.2	-1.6	-1.6	-1.2	-0.8	-0.3	+0.1	+0.1	+0.3	+0.4	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	
Summer { April May June	+0.8	+0.8	+0.7	+0.7	+0.6	+0.6	+0.8	+0.7	+0.2	-0.8	-1.6	-2.2	-2.2	-1.9	-1.1	-0.2	+0.2	+0.4	+0.4	+0.6	+0.6	+0.6	+0.6	+0.6	+0.6	+0.6	
	+0.6	+0.6	+0.6	+0.6	+0.5	+0.5	+0.6	+0.6	-0.2	-1.3	-2.1	-2.2	-1.9	-1.4	-0.6	+0.1	+0.3	+0.7	+0.6	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	
	+0.7	+0.6	+0.6	+0.6	+0.5	+0.5	+0.7	+0.3	-0.2	-0.9	-1.4	-1.6	-1.7	-1.1	-0.7	-0.1	+0.4	+0.6	+0.4	+0.4	+0.5	+0.5	+0.6	+0.6	+0.6	+0.6	
Summer { July Aug. Sep.	+0.6	+0.6	+0.6	+0.6	+0.5	+0.5	+0.6	+0.4	-0.2	-1.0	-1.5	-1.7	-1.7	-1.3	-0.8	-0.2	+0.3	+0.6	+0.5	+0.4	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	
	+0.7	+0.5	+0.6	+0.7	+1.1	+0.7	+1.1	+0.7	-0.2	-1.2	-1.7	-1.9	-1.9	-1.4	-0.9	-0.2	+0.4	+0.6	+0.4	+0.4	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	
	+0.6	+0.6	+0.5	+0.5	+0.5	+0.5	+0.7	+0.8	0.0	-1.0	-1.9	-2.1	-1.9	-1.3	-0.5	+0.2	+0.6	+0.4	+0.2	+0.3	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	
Means	+0.7	+0.6	+0.6	+0.6	+0.5	+0.5	+0.6	+0.5	-0.1	-1.0	-1.7	-1.9	-1.9	-1.3	-0.7	0.0	+0.4	+0.6	+0.5	+0.4	+0.5	+0.6	+0.6	+0.6	+0.6	+0.6	

Note.—When the sign is + the Dip is greater, and when - it is less than the mean.

Hourly Means of the Declination at Kodaikanal in 1921, determined from all available days. Declination = $W. I^\circ + \text{tabular quantity}$.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means	
Winter { Jan. Feb. Mar.	52.7	52.8	52.9	53.0	53.1	53.1	53.1	52.7	52.4	52.4	53.0	53.4	53.3	52.8	52.4	52.0	51.8	52.1	52.4	52.2	52.3	52.3	52.6	52.6	52.7	52.7	52.6
	53.2	53.2	53.3	53.4	53.5	53.5	53.6	53.5	53.2	52.9	53.2	53.6	54.1	54.0	53.6	53.3	52.9	52.8	53.0	52.9	53.0	53.0	53.2	53.2	53.2	53.3	53.3
	53.4	53.4	53.5	53.6	53.7	53.7	53.7	53.5	53.0	52.6	52.5	52.7	53.3	53.3	53.7	54.0	53.6	53.1	53.2	53.3	53.3	53.4	53.4	53.4	53.4	53.4	53.3
Summer { Oct. Nov. Dec.	54.5	54.5	54.6	54.7	54.9	54.8	54.8	54.4	54.4	54.7	55.1	55.7	55.7	55.1	54.7	54.3	54.2	54.5	54.6	54.6	54.7	54.7	54.7	54.6	54.6	54.7	54.7
	55.2	55.2	55.3	55.5	55.6	55.6	55.9	56.0	55.7	55.4	55.5	55.6	55.4	54.9	54.9	55.0	55.1	55.1	55.1	55.1	55.2	55.2	55.3	55.3	55.3	55.3	55.3
	55.8	55.8	55.9	56.0	56.2	56.5	56.7	57.0	56.7	56.4	56.2	55.9	55.7	55.3	54.9	54.8	55.4	55.4	55.5	55.5	55.6	55.7	55.8	55.8	55.8	55.9	55.9
Means	54.1	54.2	54.3	54.4	54.6	54.6	54.6	54.5	54.2	54.1	54.3	54.5	54.6	54.3	54.2	53.9	53.7	53.8	54.0	54.0	54.0	54.1	54.2	54.2	54.2	54.2	54.2
Summer { April May June	53.2	53.2	53.2	53.2	53.4	53.5	53.2	52.6	52.6	52.9	53.2	53.8	54.5	54.7	54.5	54.0	53.6	53.4	53.3	53.5	53.5	53.7	53.7	53.6	53.4	53.5	
	53.7	53.5	53.4	53.5	53.4	53.3	52.5	51.8	51.9	52.7	53.9	54.7	55.3	55.2	54.7	54.3	53.8	53.4	53.6	54.0	54.1	54.1	54.1	54.0	53.9	53.7	
	54.2	54.1	54.0	54.0	53.9	53.8	53.0	52.5	52.7	53.6	54.7	55.3	55.9	56.0	55.5	54.8	54.4	54.4	54.4	54.7	54.7	54.8	54.6	54.6	54.4	54.4	
Summer { July Aug. Sep.	54.3	54.2	54.1	54.0	54.0	53.9	53.3	52.7	52.7	53.5	54.5	55.3	55.8	56.2	56.3	55.6	55.3	54.9	54.5	55.0	55.0	55.0	54.9	54.6	54.3	54.4	
	54.8	54.6	54.5	54.4	54.2	53.9	53.1	52.2	52.3	53.3	54.7	55.7	56.4	56.2	55.8	55.1	54.4	54.0	54.3	54.7	54.8	54.8	54.9	54.9	54.8	54.5	
	54.7	54.7	54.6	54.6	54.5	54.4	53.8	52.9	53.1	54.0	55.1	56.0	56.7	56.3	55.7	54.8	54.2	54.3	54.7	54.8	54.9	54.9	54.8	54.7	54.7	54.7	
Means	54.2	54.1	54.0	53.9	53.8	53.2	52.5	52.5	52.6	53.3	54.4	55.1	55.8	55.7	55.3	54.7	54.2	54.0	54.1	54.5	54.6	54.6	54.5	54.3	54.2	54.2	54.2

Diurnal Inequality of the Declination at Kodaikanal in 1921, deduced from the above table.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means
Winter { Jan. Feb. Mar.	+0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.5	-0.1	+0.2	+0.2	-0.4	-0.8	-0.7	-0.2	+0.2	+0.6	+0.8	+0.5	+0.2	+0.4	+0.3	+0.3	0	0	0	-0.1
	+0.1	+0.1	+0.1	0	-0.1	-0.2	-0.3	-0.2	+0.1	+0.1	+0.1	-0.5	-0.8	-0.7	-0.3	0	-0.4	-0.5	+0.3	+0.4	+0.3	+0.2	+0.1	+0.1	+0.1	+0.1
	+0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.4	-0.2	+0.3	+0.3	+0.8	+0.6	0	-0.4	-0.7	-0.3	+0.2	+0.3	+0.1	0	0	0	-0.1	-0.1	-0.1	-0.1
Summer { Oct. Nov. Dec.	+0.2	+0.2	+0.2	+0.1	0	-0.2	-0.1	+0.3	+0.3	0	-0.4	-1.0	-1.0	-0.4	0	+0.4	+0.5	+0.2	+0.1	+0.2	+0.2	+0.1	0	0	0	+0.1
	+0.1	+0.1	+0.1	0	-0.2	-0.3	-0.6	-0.7	-0.4	-0.1	-0.2	-0.3	-0.1	+0.2	+0.4	+0.3	+0.3	+0.2	+0.2	+0.4	+0.3	+0.2	+0.1	+0.1	+0.1	+0.1
	+0.1	+0.1	0	-0.1	-0.3	-0.6	-0.8	-1.1	-0.8	-0.5	-0.3	0	+0.2	+0.6	+0.6	+0.6	+0.5	+0.5	+0.4	+0.3	+0.2	+0.1	+0.1	+0.1	+0.1	+0.1
Means	+0.1	0	0	-0.1	-0.2	-0.4	-0.4	-0.3	0	+0.1	-0.1	-0.3	-0.4	-0.1	0	+0.3	+0.5	+0.4	+0.2	+0.2	+0.2	+0.1	0	0	0	
Summer { April May June	+0.3	+0.3	+0.3	+0.3	+0.1	0	+0.3	+0.9	+0.9	+0.6	+0.3	-0.3	-1.0	-1.2	-1.0	-0.5	-0.1	+0.1	+0.2	C	-0.2	-0.2	-0.1	+0.1	+0.2	
	+0.2	+0.3	+0.3	+0.2	+0.3	+0.4	+1.2	+1.9	+1.8	+1.0	-0.2	-1.0	-1.6	-1.3	-1.0	-0.6	-0.1	+0.3	+0.1	0	-0.3	-0.4	-0.3	-0.2	0	
	+0.2	+0.3	+0.4	+0.4	+0.5	+0.6	+1.4	+1.9	+1.7	+0.8	-0.3	-0.9	-1.3	-1.6	-1.1	-0.4	0	0	0	-0.3	-0.4	-0.3	-0.2	0	+0.2	
Summer { July Aug. Sep.	+0.1	+0.2	+0.3	+0.4	+0.5	+1.1	+1.7	+1.7	+0.9	+0.9	-0.1	-0.9	-1.4	-1.2	-0.9	-0.5	-0.1	0	-0.1	-0.6	-0.6	-0.6	-0.4	-0.4	-0.3	
	-0.3	-0.1	0	+0.1	+0.3	+0.6	+1.4	+2.3	+2.2	+1.3	-0.2	-1.2	-1.9	-1.7	-1.3	-0.6	+0.1	+0.5	+0.2	-0.2	-0.3	-0.4	-0.4	-0.4	-0.3	
	0	0	+0.1	+0.1	+0.2	+0.3	+0.9	+1.8	+1.6	+0.7	-0.4	-1.3	-2.0	-1.8	-1.0	-0.1	+0.5	+0.4	0	-0.1	-0.2	-0.1	-0.1	0	0	
Means	0	+0.1	+0.2	+0.2	+0.3	+0.4	+1.0	+1.7	+1.6	+0.9	-0.2	-0.9	-1.6	-1.5	-1.1	-0.5	0	+0.2	+0.1	-0.3	-0.4	-0.3	-0.3	-0.1	0	

NOTE.—When the sign is + the magnet points to the east, and when - to the west of the mean position.

Hourly Means of Horizontal Force in C.G.S. units (corrected for temperature) at Kodaiikanal in 1921, from all available days. Horizontal Force = 37000 C.G.S. + tabular quantity.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means	
Winter { Jan. Feb. Mar. }	786	798	799	812	803	813	812	806	821	841	837	861	852	836	819	806	808	806	800	793	793	792	792	793	796	812	
	804	814	808	812	813	814	815	815	815	814	814	805	881	845	845	830	821	818	816	811	808	805	806	806	807	827	
	806	809	813	813	815	816	815	821	839	866	893	904	896	874	851	832	820	816	810	810	809	809	809	809	809	862	
	Summer { Oct. Nov. Dec. }	822	824	825	829	829	828	827	834	852	874	892	896	885	868	851	840	836	833	830	829	827	826	825	825	824	842
		834	834	834	834	837	836	839	846	859	872	883	884	877	870	860	853	845	840	838	835	834	833	834	835	837	848
		839	839	840	841	842	841	845	853	862	870	876	881	878	877	870	864	852	845	843	841	841	840	839	841	842	852
		817	819	820	822	823	823	824	829	843	862	879	885	878	865	849	837	830	826	824	820	819	818	818	818	819	835
	Summer { April May June July Aug. Sep. }	811	811	811	813	814	813	814	820	839	866	885	895	887	869	844	828	822	821	819	814	810	810	810	809	812	831
		796	797	798	799	798	799	801	803	831	858	870	868	858	842	821	805	795	794	796	797	797	795	799	799	800	813
		805	805	807	807	805	809	813	816	830	846	859	866	859	846	828	812	805	805	806	802	801	802	800	802	804	818
		819	819	820	821	822	822	823	827	838	857	874	878	874	866	840	832	821	817	821	821	821	820	820	820	820	833
		817	817	817	819	818	818	822	828	843	862	876	882	879	867	832	817	817	821	817	818	817	817	817	817	817	833
Means	812	813	814	815	815	815	817	823	839	861	877	882	875	860	842	825	816	815	816	814	812	812	812	813	814	829	

Diurnal Inequality of the Horizontal Force at Kodaiikanal in 1921, deduced from the above table.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means	
Winter { Jan. Feb. Mar. }	-16	-14	-13	-10	-9	-9	-7	-11	-6	+9	+29	+45	+49	+40	+24	+6	+6	-6	-12	-16	-19	-19	-20	-19	-16	-16	
	-11	-18	-18	-15	-14	-13	-12	-12	-11	-2	+21	+45	+59	+54	+38	-18	-3	-6	-9	-11	-16	-19	-21	-21	-20	-20	
	-26	-23	-19	-19	-17	-16	-17	-11	+7	+34	+61	+72	+64	+42	+42	+19	0	-12	-16	-16	-21	-22	-23	-23	-23	-23	
	Summer { Oct. Nov. Dec. }	-20	-18	-17	-14	-14	-14	-15	-8	+10	+32	+57	+54	+43	+26	+9	-2	-6	-9	-12	-14	-15	-16	-17	-17	-18	-18
		-14	-14	-14	-14	-11	-12	-9	-2	+11	+24	+35	+36	+29	+22	+12	+5	3	8	10	-13	-14	-15	-14	-13	-11	-10
		-15	-13	-12	-11	-10	-11	-7	+1	+10	+18	+24	+9	+26	+25	+18	+11	0	7	9	-9	-11	-12	-13	-11	-10	
		Means	-18	-16	-15	-13	-12	-12	-11	-6	+8	+27	+44	-50	+43	+30	+14	+2	-5	-9	-11	-15	-16	-17	-17	-17	-16
	Summer { April May June July Aug. Sep. }	-20	-17	-18	-18	-17	-18	-17	-11	+8	+35	+54	+64	+56	+37	+13	-3	-9	-10	-12	-17	-21	-21	-21	-22	-19	-19
		-16	-16	-15	-11	-15	-14	-12	-4	+18	+45	+37	+55	+45	+29	+8	-8	-19	-19	-17	-17	-16	-15	-15	-15	-13	-13
		-13	-11	-11	-11	-19	-9	-5	-2	+12	+28	+41	+48	+41	+25	+10	-6	-13	-13	-12	-16	-17	-18	-18	-16	-14	-14
		-14	-14	-13	-12	-11	-11	-10	-6	+5	+24	+46	+45	+41	+33	+16	1	-12	-16	-12	-12	-12	-13	-13	-13	-13	-13
		-19	-16	-16	-15	-15	-15	-11	-9	-1	-1	+20	+44	+49	+46	+34	+19	1	-12	-16	-14	-15	-16	-16	-16	-16	-16
Means	-17	-16	-15	-14	-14	-14	-12	-6	+10	+32	+48	+53	+46	+31	+13	-4	-13	-14	-13	-15	-17	-17	-17	-16	-16		

NOTE.—When the sign is + the H.F. is greater, and when - it is less than the mean.

Hourly Means of Vertical Force in C.G.S. units (corrected for temperature) at Kodaiikanal in 1921, from all available days. Vertical Force = 0.3000 C.G.S. + tabular quantity.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	:3	Mid.	Means
Winter { Jan. Feb. Mar.	081	062	062	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063
	081	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063	063
	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068	068
Nov. { Oct. Nov. Dec.	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081
	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081	081
	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084	084
Means	073	074	074	074	074	074	075	074	072	066	060	056	056	057	058	061	063	063	068	069	070	071	072	073	074	068
Summer { April May June	074	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073
	074	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073	073
	089	080	081	080	080	081	082	080	077	069	062	059	060	064	068	073	075	075	075	073	073	075	076	077	079	080
July { July Aug. Sep.	083	082	083	084	083	084	086	083	083	076	071	067	067	070	072	077	080	080	080	078	077	078	079	081	081	082
	083	082	083	084	083	084	086	083	083	076	071	067	067	070	072	077	080	080	080	078	077	078	079	081	081	082
	084	085	085	085	085	085	089	087	078	066	058	052	053	060	070	076	080	078	077	078	079	081	082	084	084	085
Means	081	081	081	081	081	082	085	084	077	068	061	056	056	060	065	072	076	076	075	075	076	078	079	080	081	074

Diurnal Inequality of the Vertical Force at Kodaiikanal in 1921, deduced from the above table.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	:3	Mid.	Means
Winter { Jan. Feb. Mar.	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8
Nov. { Oct. Nov. Dec.	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8	+8
Means	+5	+6	+6	+6	+6	+6	+7	+6	+4	-2	-8	-12	-12	-11	-10	-7	-5	-3	0	+1	+2	+8	+4	+5	+6	
Summer { April May June	+8	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7
	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7
	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
July { July Aug. Sep.	+4	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3
	+4	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3	+3
	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7	+7
Means	+7	+7	+7	+7	+7	+8	+11	+10	+3	-6	-13	-18	-18	-14	-9	-2	+2	+2	+1	+1	+2	+8	+4	+5	+7	

NOTE.—When the sign is + the V.F. is greater, and when - it is less than the mean.

Hourly Means of the Dip at Kodrikhal in 1921, determined from all available days. Dip = N. F. + tabular quantity.

Table with 24 columns (Hours 1-24) and 13 rows (Months: Jan, Feb, Mar, Oct, Nov, Dec, Means, April, May, June, July, Aug., Sep., Means). Each cell contains a numerical value representing the dip at that hour and month.

Diurnal Inequality of the Dip at Kodrikhal in 1921, deduced from the above table.

Table with 24 columns (Hours 1-24) and 13 rows (Months: Jan, Feb, Mar, Oct, Nov, Dec, Means, April, May, June, July, Aug., Sep., Means). Each cell contains a numerical value representing the diurnal inequality of the dip.

Note.—When the sign is + the Dip is greater, and when - it is less than the mean.

THE COMPUTING OFFICE.

By MAJOR C. M. THOMPSON, I. A.
Computing Section.

PERSONNEL.

Class I Officers.

Dr. J. do Graaff Hunter, M. A., Sc. D., F. Inst. P.,
in charge till 29th March 1922.
Captain E. A. Glennie, D. S. O., R. E., in charge
from 30th March to 9th May 1922.
Major C. M. Thompson, I. A., in charge from 10th
May 1922.

*Computing Office.**Head Computer.*

Rai Sahib Ishan Chandra Deva, B. A., till 30th
June 1922, when he retired.
Babu Mukundananta Acharya from 1st July 1922.
19 Senior and 4 Junior Computers.
In addition 13 Computers from parties worked
during a portion of the year.

work of computer Mannatha Nath Chattarji is specially worthy of mention, in connection with the tide-prediction for the riverain ports.

(b) The reduction of the observations for latitude at 4 stations in Kashmir by Bt.- Major K. Mason, M. C., R. E., is in hand.

(c) The astronomical latitudes observed by Major H. T. Morshead, D. S. O., R. E., at Thākurganj and Dumlungi were checked and computed with a view to an investigation into the gravitational effects at these stations.

(d) The triangulation executed by Bt.- Major E. O. Wheeler, M. C., R. E., during the Everest expedition was reduced.

(e) Corrections to latitude, longitude, azimuth and logsides derived from the adjustment of the pendant portion of the Burma Coast Series were computed.

(f) For purposes of investigation the topographical effects for 59 pendulum stations, of which the Hayford corrections have been published in Professional Paper 15, pages 176-178, have been separated from the compensation effects.

(g) Seven tables, in addition to the 23 mentioned in Records Volume XVI were computed to complete Auxiliary Tables Part III (5th Edition).

Adjustments.—

(a) The adjustment of the minor triangulation falling in degree sheets 39 A and 39 E, N. W. Frontier, was taken in hand, in accordance with the new method devised by Dr. Hunter.

(b) The minor triangulation connecting the Madras Longitudinal Series with the Cuddapah Series was adjusted in compliance with a request from the Superintendent, Southern Circle.

(c) Curves were prepared for the graphical adjustment of triangulation falling in sheets 92 C, D, and G, and furnished to the Superintendent, Eastern Circle.

Miscellaneous.—

(a) A report was compiled for submission at the first General Conference (Geodetic) held at Rome in April 1922.

(b) Rectangular Co-ordinates were computed from the spherical co-ordinates for the traverse stations in Gorakhpur Cantonment.

(c) Latitude, longitude and azimuth were computed for a number of stations in order to complete the records of Captain Deasy's exploration work of 1896 and 1897-98.

(d) Further computations in continuation of those noted in Records Volume XVI were carried out with a view to investigating the formulæ for barometric heights.

(e) The times of sunset and sunrise for latitudes varying between 8° and 32° were computed in compliance with an extra departmental requisition.

(f) Data were computed for the preparation of a slide rule by the Mathematical Instrument Office, Calcutta.

(g) The Theoretical Value of gravity (γ) for Fyzābād was computed.

Triangulation Pamphlets.—60 pamphlets were printed and 50 issued during the year. Pamphlets for 75 sheets were compiled and those for 58 sheets were compared. Compilation is in progress with a view to publishing the results of the Mesopotamian triangulation in supplementary pamphlets.

Isostasy.—The only contribution on this subject to be recorded in this report was the publication of Survey of India Professional Paper No. 18 by Lt.-Col. H. McC. Cowie, R. E., entitled "A criticism of Mr. R. D. Oldham's Memoir—'The Structure of the Himalayas and of the Gangetic Plain, as elucidated by Geodetic Observations in India'."

Computations.—The following computations were carried out during the year:—

(a) Data were compiled for the prediction of tides for 1923 by means of the tidal machine for 40 ports. In addition, the actual preparation of the tide-tables for 9 riverain ports, included in the above, was undertaken in this office. The

Levelling.—

(a) A first edition of levelling pamphlet 62 has been published.

(b) A large number of supplementary slips containing the additional work of season 1920-21 have been printed for incorporation in the existing pamphlets 34, 35, 39, 40, 45, 47, 53, 54 and 72.

(c) A reprint of levelling pamphlet 63 having been called for, on account of important revisions as well as additional new work in that sheet, a corrected 2nd edition has been prepared and is at press.

(d) The pamphlet of Levelling of Precision in Mesopotamia is under reprint.

Revision.—

(a) Part III of the Auxiliary Tables, 5th edition 1922 (revised and extended), has been completed and a small edition printed. A number of tables have also been prepared for Part IV (Geodetic) of the same.

(b) Chapter III (1914) of the Hand-book of Topography, the revision of which has been held over owing to many important changes, is now almost completed, and the draft nearly ready for the press. There may be further delay in the publication of this chapter owing to pressure of work in the printing office.

(c) The remodelling of professional forms is in steady progress. 11 Topo., 3 Lat. and 4 Lat. have been revised in addition to 19 forms noted in last year's report. A new resection form 26 Topo. is at press.

Requisitions.—279 requisitions for data were received from departmental and non-departmental officials. In some cases these requisitions were met by the supply of printed publications, in others it was necessary to extract the required information from manuscript records.

Printing Section.

The following were printed in the course of the year :—

Mr. Surat Kumar Mukerji.

- 1 Assistant Supervisor.
- 1 Computer.
- 2 Clerks.
- 29 Compositors.
- 7 Distributors.
- 3 Pressmen.
- 1 Stereotyper.
- 3 Machine Printers.
- 6 Inkmen.
- 1 Roller moulder.
- 13 Book-binders.

Vol. XV (1919-20) of the Records of the Survey of India; Memoir on the Maps of Chinese Turkistan and Kansu (Sir A. Stein, K.C.I.E.), to be published as a Records Vol.; Explorations in the Eastern Karakoram and the Upper Yarkand Valley (Lt.-Col. H. Wood, R.E.), to be published as a Miscellaneous Paper; Tide Tables for Indian Ports 1923; 60 Triangulation Pamphlets; Levelling Pamphlet No. 62, and addenda or slips to Pamphlets Nos. 34, 35, 39, 40, 45, 47,

53, 54 and 72; Auxiliary Tables Part III; Appendix to Levelling of Precision; The Auto-Stereo Plotter, a translation from the French of Paul Corbin (Lt.-Col. H. McC. Cowie, R.E.), to be published as a Departmental Paper (incomplete); Note on the stage reached by the Geodetic Operations of the Survey of India in 1920 (Lt.-Col. H. McC. Cowie, R.E.).

A beginning has also been made on the Records Vol. (1920-21), Topo. Hand-book, Chapter II (revised), Author's Catalogue of Books of Trig. Survey Office Library.

In addition to the above many thousands of copies of Professional and other forms together with much miscellaneous work have been printed.

In the Book-binding Section the work dealt with comprises 300 copies of Survey Records Vol. XV; Tide Tables, Indian Ports 1923, Part I, 850 copies; Part II 220 copies (out of 980 copies); Tidal Pamphlets 1923, 1,450 copies (out of 2,950 copies); 3,700 Triangulation Pamphlets; 400 Levelling Pamphlets; 200 Auxiliary Tables, Part III; 650 copies of miscellaneous publications and Library books.

Workshop.

The workshop was principally occupied during the year on the following :—

(i) Repairs to the Tide-Predicting Machine and other Scientific instruments of the department. Repairs to wood work of the office buildings in general and furnitures of the Trigonometrical offices and Parties.

(ii) Erection of racks and almirahs in the Computing and Photo-Zinco offices, and of galvanised iron tanks for water supply to the Photo-Zinco office, construction of packing cases and overhauling of apparatus for photo work for the Mount Everest Expedition, and also other miscellaneous work for the different sections of the Trigonometrical Survey.

PERSONNEL.*Class II Officer.*

Hai Sahib Hanuman Prasad.

- 1 Head Artificer.
- 20 fitters and carpenters.

Observatories.

Seismography and Meteorology.—The Omori Seismograph was in operation throughout the year and the usual daily meteorological observations were made. The Photo-helio observatory continued its work as in past years. The following statements show the earthquakes recorded and the number of days on which solar photographs were taken.

1. *Statement of earthquakes recorded during the year 1921-22.*

No.	Month and Date.	Time of beginning (corrected)		Duration.	Distance of Epicentre.		REMARKS. Intensity &c.
		Dehra.	Simla (from W. R.*)		Dehra.	Simla (from W. R.*)	
		<i>hrs mts</i>	<i>hrs mts</i>	<i>m</i>	<i>miles</i>	<i>miles</i>	
1	15-10-21	22 16	22 19	34	500	500	Medium.
2	8-11-21	21 39	22 43	45	3,185	2,500	Moderate.
3	11-11-21	6 50	6 50	20	280	200	Slight.
4	12-11-21	0 14	...	85	2,100	...	Great.
5	16-11-21	2 09	2 09	84	200	250	„
6	17- 1-22	9 40	9 40	81	4,970	5,000	Moderate.
7	1- 2-22	19 12	19 13	73	6,300	5,000	„
8	30- 7-22	1 57½	...	1½	70	...	Slight.
9	13- 8-22	5 47	5 48	40	3,000	3,000	Moderate.
10	17- 8-22	5 55	...	11	280	...	„
11	26- 8-22	1 05	1 05	30	1,600	1,500	„
12	2- 9-22	0 54	0 54	68	3,000	3,000	Great.
13	15- 9-22	1 11	1 11	43	3,430	3,000	Moderate.

* W. R. means Daily Weather Report published at Simla.

2. *Statement showing the number of days on which solar photographs were taken during the year 1921-22.*

Month.	No. of days.	8" Negatives.		12" Negatives.		No. of days on which sun was invisible.	Month.	No. of days.	8" Negatives.		12" Negatives.		No. of days on which sun was invisible.
		Good.	Bad.	Good.	Bad.				Good.	Bad.	Good.	Bad.	
October ...	30	56	6	...	...	1	April ...	28	43	6	...	...	2
November ...	28	49	6	...	...	2	May ...	28	49	6	...	...	3
December ...	24	38	5	...	...	7	June ...	23	37	5	...	...	7
January ...	22	36	6	...	...	9	July ...	16	21	3	...	...	15
February ...	19	33	5	...	...	9	August ...	10	15	2	...	...	21
March ...	26	46	6	...	...	5	September ...	21	40	4	...	...	0
							Total ...	275	463	60	...	...	90

PART III.—SPECIAL REPORTS.

TRAVERSE SURVEY OF ALLAHĀBĀD CITY.

By D.C. PURI.

The traversing of the remaining municipal areas of the city of Allahābād, commenced in 1920-21, was continued on the 1st December 1921 and completed in February 1922.

A preliminary reconnaissance was carried out by Mr. Puri and by the two traversers. Lieut.-Colonel S.W.S. Hamilton, D.S.O., R.E., inspected the area on the 1st December and discussed the work with the Chief Engineer.

The whole of the area north of Canning Road and the Fort Cantonment was first surrounded by a main traverse, commencing from Fort Cantonment boundary pillar No. 38 and closing on traverse station No. 330 of last year's work. This main circuit takes in the whole of the area except a small portion west of Stanley Road, which was surrounded by an exterior block.

The main circuit was then cut up into 4 blocks Nos. 5, 6, 7 and 8; 5 and 6 being the areas Dārāganj and Katra Colonelganj respectively, to be surveyed on the sixty-four-inch scale, while Nos. 7 and 8 are for survey on the sixteen-inch scale.

In blocks Nos. 5 and 6, sub-traverses were run along nearly every street and road in the area, while in the case of blocks Nos. 7 and 8 enough sub-traverses were run to provide the detail surveyors with ample data on which to base their work.

On the completion of this area the Chief Engineer asked for some additional sub-traverses in the area done last year, where the plane-tablers were finding difficulty with the points. Consequently, about 20 small lines were run, with total of 156 stations and 4.05 linear miles of chaining.

The Chairman of the Improvement Trust had also asked for a traverse in the Naini area south of the river and a small area south-west of the city. This too was taken in hand as it was thought desirable to finish all possible traverse work in Allahābād now and so avoid the expense of further visits in the near future. For this purpose a main circuit was run, round this area, from a point of last year's traverse, west of Rūprājpur, on the railway line, and south-west of the New Cantonment, to a point near the Jumna bridge, where it was connected by a triangle with the traverse on the other bank of the Jumna river, done last year. After this 5 sub-traverses were run through this area.

For method, measurements, etc., the same precautions were taken as in 1920-21 and the same traversers were employed.

This year no off-sets were taken, as it was found that those taken last year were not made use of in any way by the detail surveyors employed by the Trust and their measurement was therefore a waste of time.

The computations were carried out *pari passu* with the traverse in the field by 2 computers. All co-ordinates also were worked out so that no further work was left to be done in recess.

21 plot charts for Katra and Colonelganj for the sixty-four-inch survey were urgently asked for by the Chief Engineer while in the field. All these were therefore completed by Mr. D. C. Puri while at Allahābād in February 1922. These were again checked by the computers and handed over to the Chief Engineer. The remaining plot charts, viz., 9 for the sixty-four-inch survey and 44 for the sixteen-inch survey, have been completed in Mussoorie during the recess season and together with the computations have been despatched to the Chief Engineer.

The total number of linear miles chaining done this year for area to be surveyed on the sixty-four-inch scale was 31.30, while the number of stations at which the theodolite was set up was 623. Also 4.05 linear miles and 156 stations were done in last year's work, while the number of stations and linear miles for the sixteen-inch was 514 stations and 78.34 linear miles, making a total of 113.69 linear miles and 1,293 stations of observation. The average angular error is 2 seconds per angle and the linear error per 1,000 feet is 0.18.

SETTLEMENT OF THE BOUNDARY BETWEEN MYSORE STATE AND THE
SOUTH KANARA DISTRICT OF THE MADRAS PRESIDENCY.

By V. W. MORTON.

The settlement and demarcation of the boundary line was continued from the last season's work and the following officers were deputed on the 1st December 1921.—

Mr. T. Hanumantha Rao, representing the Mysore Durbar.
 „ K. Raman Nayar, „ „ Madras Government.
 „ J. O'B. Donaghey, Survey of India officer.

Scope of work.—The Survey officer was responsible for determining the position of the boundary line as previously fixed and described by boundary commissioners in 1880-81 and 1904-06.

Field work completed.—Field work was commenced at Gundia on the 5th January 1922. Owing to the serious illness of Mr. Donaghey, he was replaced by Mr. V. W. Morton, as Survey of India officer on the 13th February 1922.

About 61 miles (measured on the map) of boundary were finally settled during the season, making a total length of 85 miles settled up to date. The rains which set in on the 18th April eventually made conditions impossible for coolies in forest camps, so that field work had to be closed on the 23rd April, leaving about 115 miles of boundary still to be completed. The demarcation work was carried out by the erection of cairns serially numbered on stones placed on the top of the cairns or on rocks "*in situ*." The line was cleared where it passed through forest areas.

The survey establishment consisted of one surveyor, one forester, one clerk and 19 menials.

Records.—A survey record of the boundary was prepared on the sheets of the Madras forest survey on the scale of 4 inches=1 mile and a descriptive memorandum of the line was kept up. The records of the detachment are lodged in the Southern Circle Office.

Future programme.—It has been decided that the work will not be continued during season 1922-23, owing to financial reasons, but will in all probability be resumed in the 1923-24 season.

NOTES ON THE REVISION SURVEY IN THE NEIGHBOURHOOD OF POONA.

By LIEUT.-COLONEL M. O' C. TANDY, D. S. O., O. B. E., R. E.

1. The area surveyed varied considerably, on the west it included portions of the Western Ghâts and the fairly high spurs extending eastwards from them, while on the east it included considerable areas of undulating land.

2. The main details on the old 1-inch maps, dating from about 1880, were found on the whole quite accurate: these details consisted of the rivers and streams, the main village blocks and the main roads and railways.

3. The chief work of revision consisted in substituting 50 feet contours for the form lines of the old maps; the general shapes of the hills and the crest lines of spurs were accurately indicated by the old form lines, but they were, especially in the case of minor features, very much exaggerated; sometimes small features shown by 2 or even more form lines in the old maps proved to be too insignificant to be shown at all by our 50 feet contours. In the flat-topped hills, which form such a common and striking feature in parts of the area surveyed, the top form line of the old maps could generally be accepted as the accurate limit of the hill-top.

4. The chief deficiencies of the old maps, in addition to the absence of contours, were.—

- (a) They showed no cultivation limits.
- (b) Embankments, cuttings, burial grounds and telegraph lines were omitted.
- (c) Numerous hamlets and isolated huts, mile-stones and temples, and in some sheets wells, were omitted.
- (d) Many forest reserve boundaries were omitted.
- (e) The classification of all roads had to be revised.
- (f) In a few cases considerable discrepancies were found in the position of main metalled roads.

(g) Minor communications had altered very considerably, a very large proportion of the cart tracks and paths shown on the old maps had been abandoned and new ones had taken their places.

(h) Ornamentation was defective, some maps showed practically no trees and in the sheets where trees were shown no distinction was made between different classes of trees.

(i) Poona and Kirkee were very sketchily shown and have now been shown in much greater detail.

(j) The main line of the M. and S. M. Railway was very much out of position throughout 2 sheets.

(k) The Nira left bank canal in 2 sheets was very inaccurate.

(l) Important details which have developed since the time of the last survey and which had to be surveyed were:—the Nira Right bank canal in 2 sheets; the 2 construction railway lines to the sites of Mulshi dam and the Kundli valley in 3 sheets; the new Andhra lake in 1 sheet and the changes in the Bhatgar dam in 1 sheet.

Items (j) and (k) had evidently been added to the old maps from extra departmental sources, there was a foot-note on the old map saying "Railways and roads constructed since the date of survey have been added from extra departmental sources" but nothing was said about the canal. A foot-note of this sort is of no use to any one using the map as it is impossible to know the date at which roads and railways were constructed, and such a foot-note can only be a warning to the effect that *any* of the roads and railways on the map be found incorrect.

5. The number of omissions on the old maps and the large number of corrections and additions which had to be made and the fixings required for the contouring made it necessary for the surveyors to go over the ground almost as carefully as if original survey was being done. The average number of fixings per square mile was 7.2, the average in the hilly portions being of course much smaller than in the plains.

6. When all the detail on a map is complete and accurate and the map is contoured a revision survey might be carried out by an almost cursory examination of the map in the field to see where changes in the detail had occurred, and when a change or addition had to be made it might be sufficient to fix the new details by measurement or by fixings based on the old detail; but this is not the case when new contouring has to be done and when lots of new items of detail have to be shown and when the only reliable detail consists of the streams and the main village blocks (as well as main metalled roads and railways where they exist); in revision survey of this nature the surveyor is only saved the time and trouble of making such fixings as the original surveyor would have made *solely* to fix the streams and main detail and he still has to make all the fixings which an original surveyor would have had to make to do the contouring and to fix minor details. In very hilly areas the conditions are rather different, here there is little new detail of the kinds mentioned as deficient in the old maps, mountain tracks seldom change, cultivation only exists in the big valleys, new hamlets and huts etc. are not found in large numbers; with the streams and main villages correctly shown the revising surveyor has in the hills little else to do but the contouring and making checks to satisfy himself that the old streams are correctly shown; but in the hills a surveyor's camp is much further from his work than is the case in the plains, and a much larger proportion of the surveyor's time is spent in getting to his work and climbing between his fixings, and as the ground has to be completely covered to do the contouring the actual saving in time of revision as compared to original survey is not very great.

7. In reporting on the result of our first season of revision survey I have been asked to discuss the advisability or otherwise of using low grade surveyors for such work. In considering this question it must be remembered that the Rs. 50 or 60 representing the difference of pay between a superior and an inferior surveyor represents such a small proportion of the total costs of a surveyor's squad that it must *always* be more economical to employ a good surveyor for any survey in which the extra skill of the good surveyor results in a considerable increase in the outturn of work, and generally we may say that the easier the nature of a survey may be the less advantage will there be in employing highly skilled surveyors. This is shown in the simplest form of cadastral surveying where very large scale maps in the plains are based on accurate chaining and detail measurements, and where an inferior surveyor can do the work as accurately and nearly as quickly as a good one, and where in fact there is no scope for the skill of the superior surveyor.

8. In applying this argument to the revision now under discussion a distinction must be made between the revision in the plains and in the hills.

In the plains the survey is easy but the ground has to be fairly rigorously covered with fixings in order to do the contouring and to fix the new items on the maps, the work

is laborious rather than highly skilled and the proportionate gain in using superior surveyors will not be very great. In revising in the hills it is different, here the skilled surveyor assures himself more quickly that the old streams are correct (or if incorrect more quickly corrects them) and his extra skill enables him to do good contouring by making fewer fixings and using more intersected points than if he were doing an original survey, he should thus do a considerably larger outturn of revision than of original survey, while an inferior surveyor would probably require just as many fixings and take almost as long to do revision as to do original survey.

9. In the department we must always have and use a proportion of inferior surveyors and I think the general principle will always hold good that the easier a survey is the less advantage will there be in using only the best surveyors for it.

10. For the above reasons I think it will be found economical for revision in the very simple plains areas to use inferior surveyors, provided that work more suited to the skill of superior surveyors can be found for them elsewhere; the outturn of the party working under these conditions would be small but would be more than balanced departmentally by the better use made elsewhere of the superior surveyors. For revision in the hilly areas I feel sure that it would be economical to employ only superior surveyors, provided more simple work can be found elsewhere for the inferior surveyors, and except in so far as the training in contouring provided by such revision work is required as a means of training and improving the inferior surveyors.

THE TOPOGRAPHICAL RESULTS OF SIR H. H. HAYDEN'S
EXPEDITION TO TIBET IN 1922.

COMPILED FROM THE VERBAL NARRATIVE OF SURVEYOR GUJJAR SINGH

BY MAJOR H. T. MORSHEAD.

[Authority for spelling of place-names—Sir H. H. Hayden. The conventions employed in transliteration do not in some cases agree with those generally accepted by the Survey of India].

During the summer of 1922, Sir H. H. Hayden, Kt., C.S.I., C.I.E., F.R.S., late of the Geological Survey of India, made a tour at the request of the Tibetan Government, of certain mineral bearing areas in central and south-eastern Tibet, in order to report on their resources.

In addition to Sir H. H. Hayden and his Italian guide M. Cesar Cosson, it was arranged, with the full concurrence of the Tibetan authorities, that the party should include an Indian Surveyor; 1st Class Surveyor Gujjar Singh being selected for the purpose by the Surveyor General.

The districts visited had for the most part seldom been previously traversed by Europeans, and our knowledge of the "*Chang Thang*" portion of Tibet in the neighbourhood of the great lakes of Tang-ra, Kyā-ring, and Nam (Tengri Nor) has been derived from some half a dozen explorers of a generation ago, notably pandits Kishen Singh and Nain Singh of the Survey of India. It may therefore be of interest to place on record a short summary of the topographical exploration of this little-known area, as related by Surveyor Gujjar Singh on his return.

From Darjeeling Sir H. H. Hayden's party proceeded to Gangtok in Sikkim, where they were met on April 3rd by an English-speaking Tibetan official who had been deputed by the Tibetan Government to attend them throughout their journey. This official, K. K. Mondrong, had been one of a few Tibetan youths who had been sent ten years previously to Rugby to receive an English public school education, and had subsequently specialised in mining.

From Gangtok the party marched direct to Lhāsa, where they halted from 25th April till 9th May while instructions were being received regarding the areas to be visited.

Leaving Lhāsa on 9th May, the party first marched north-westwards to Shen-tsa Dzong, the headquarters of the district of Nak-tsang. The distance of 180 miles was traversed in 14 days, and planetabling on the $\frac{1}{4}$ -inch scale was kept up throughout the march. The Nyen-chen-thang-la range of mountains was crossed via the Go-ring pass (19,470 ft.) on 16th May, and for the next 40 miles peaks on this range triangulated by Major Ryder in 1904 continued to provide sufficient points for planetable interpolations. For the last 60 miles before reaching Shen-tsa the surveyor was compelled to make his own points by 'graphic triangulation' as he advanced. A check latitude was observed by Sir H. H. Hayden, at Lho-lam.

Advantage was taken of a 6 days' halt at Shen-tsa to measure a short base and to take a set of astronomical observations for latitude and azimuth. The latter observations were taken by Sir H. H. Hayden with a $4\frac{1}{4}$ -inch theodolite; a small piece of triangulation was also carried out to serve as a basis for further planetabling. A spell of broken weather interfered with the work at this period.

Ten days' marching in a westerly direction brought the party to their next objective, the village of Wom-po on the northern shore of the Tang-ra lake (the Dangra Yum lake of Nain Singh). After two days at Wom-po, the party returned to Shen-tsa, retracing their previous outward route as far as Ge-mār, and thence diverging slightly northwards to the south-western shore of the Kyā-ring lake. As a check to the plane-table, Sir H. H. Hayden took star observations for latitude on four nights between Shen-tsa and Wom-po. Leaving Shen-tsa once again on 18th June, a short trip was next made along the north-eastern shore of the Kyā-ring lake to Chu-sum-di and Kyā-tsoq respectively. Shen-tsa was again reached on 25th June.

Finally quitting Shen-tsa two days later, the party proceeded in a north-easterly direction to the district of Nāmru. The hills here flatten out considerably, and the level country on the eastern shore of the Tsozi-ling was found to be very marshy and treacherous. From this point the party temporarily diverged, Sir H. H. Hayden proceeding to Lum-po on the southern bank of the 'Tsa-khye Tsangpo river, while Gujjar Singh worked eastwards, eventually rejoining Sir H. H. Hayden on 7th July at Zi-ri-mār. The weather at this time was good and planetabling was carried on without difficulty; the surveyor, as usual, making his own points as the work progressed. Check-observations for latitude were made by Sir H. H. Hayden on 8th, 9th and 13th of the month.

From Zi-ri-mâr the party turned southwards towards Lhâsa. At Thak, near the eastern margin of the Nam lake (Tengri Nor), the triangulated peaks of the Nyen-chen-thang-la range once more came into view, and an accurate planetable fixing was obtained for the first time since 19th May, disclosing an accumulated easterly error of some 4·3 miles in the course of nearly two months' work. The Nyen-chen-thang-la range was crossed viâ the Lar-gen pass (the Dam Niargen La of A. K. 16,700 ft. approximately) on 15th July, and from this point the weather became so bad that the surveyor was unable to expose his planetable until Lhâsa was reached five days later. A rough route traverse by watch and prismatic compass was maintained until reaching the margin of Major Ryder's survey of 1904 at the Chak pass, two marches north of Lhâsa. This traverse was subsequently adjusted and transferred to the planetable section.

The party halted in Lhâsa from 20th July to 7th August, while Sir H. H. Hayden reported the results of his investigations. Gujjar Singh spent the time in making a large outline tracing of his surveys for the use of the Tibetan Government. This tracing was highly appreciated by the Tibetan Government, and was finally deposited in the new private house of the Dalai Lama which lies some two miles west of the Potala in the suburb of Norpu Lingka. The Tsârung Shâpe*, after inspecting the map and complimenting Gujjar Singh on his work, remarked that the Tibetan Government would be very glad to borrow the services of a surveyor from the Government of India, as the Tibetan Surveyor whom they had had trained at Roorkee College had been transferred to duty in the newly opened telegraph office in Lhâsa.

The party were next asked to visit the district of Thak Po. Quitting Lhâsa on 8th August, they crossed by skin boats to the south bank of the Kyi chu, which valley they ascended for three marches to the confluence of the Metu-mâ-chu—thence turning southwards over the Te-khar pass (17,050 ft.) to the Tsangpo valley. Crossing the latter river by boats at Sang-ri Dzong, the party ascended the Ri-go-sho valley from its confluence at Rong Dzong. The Pho-trang pass, at the head of the Ri-go-sho valley, forms the western boundary of the district of Thak Po whose head-quarters are situated at Lhap-so Dzong. This was reached on 21st August. Subsequently the party again joined the Tsangpo valley four miles below Lhap-so, marching 27 miles down the right bank of the river to the junction of a small stream flowing from the south. Eight miles up this side stream is situated the village and dzong of Ku-ru-nam, the seat of a considerable hand-made paper industry which supplies most of the requirements of Lhâsa and Southern Tibet. Pulp is manufactured from the scrub which grows plentifully in the lower valleys of south-eastern Tibet. Peach and apple trees are common in the lower Tsangpo valley, and the crops of barley, mustard and dwarf pea were being harvested at the end of August.

Turning westwards on 28th August, five days' marching over bleak and almost uninhabited country brought the party viâ the Ya-tö-tra pass into the head of the wide and fertile Ya-lung valley which descends to Tse-thang on the Tsangpo, whence Lhâsa was reached in four days viâ Sam-ye Monastery and the Gong pass. During the visit to Thak Po, the weather had been so bad as to preclude any attempt at planetabing from fixed points. The whole of this portion of the map consists therefore of route-traverse executed by watch and compass, and checked by Sir H. H. Hayden's latitude observations in four places.

On arrival in Lhâsa, the final reports and maps were completed and presented to the Dalai Lama, who distributed rolls of woollen cloth and pieces of silk among the party in token of his appreciation of the services they had rendered.

The party finally quitted Lhâsa on 20th September, travelling by boat down the Kyi chu to Chushul on the Tsangpo. Three days later the party broke up; the Tibetan official returned to his home in Lhâsa, while Gujjar Singh and his personal khalasi travelling ahead of Sir H. H. Hayden reached Gangtok on 7th October, and Darjeeling 7 days later.

Every possible assistance was rendered by the Tibetans to the party throughout their journeys in the country; free transport being provided, tents pitched wherever necessary; and supplies of flour, rice, sugar, and groceries sent out from Lhâsa.

Altogether 36,000 square miles of country were mapped on the $\frac{1}{4}$ -inch scale, out of which an area of 2,000 square miles in the neighbourhood of Lhâsa had been previously surveyed under Major Ryder during the Lhâsa Mission in 1904, while a tract of similar area south of the Tsangpo in the districts of Tsetang and Thak Po had been mapped on the $\frac{1}{4}$ -inch scale by Captains Bailey and Morshead in 1913. The remainder of the country was only known from the routes of sundry explorers, whose work can be but briefly referred to here.

Summary of results.
Previous explorations in
the area.

* Tibetan Commander-in-Chief.

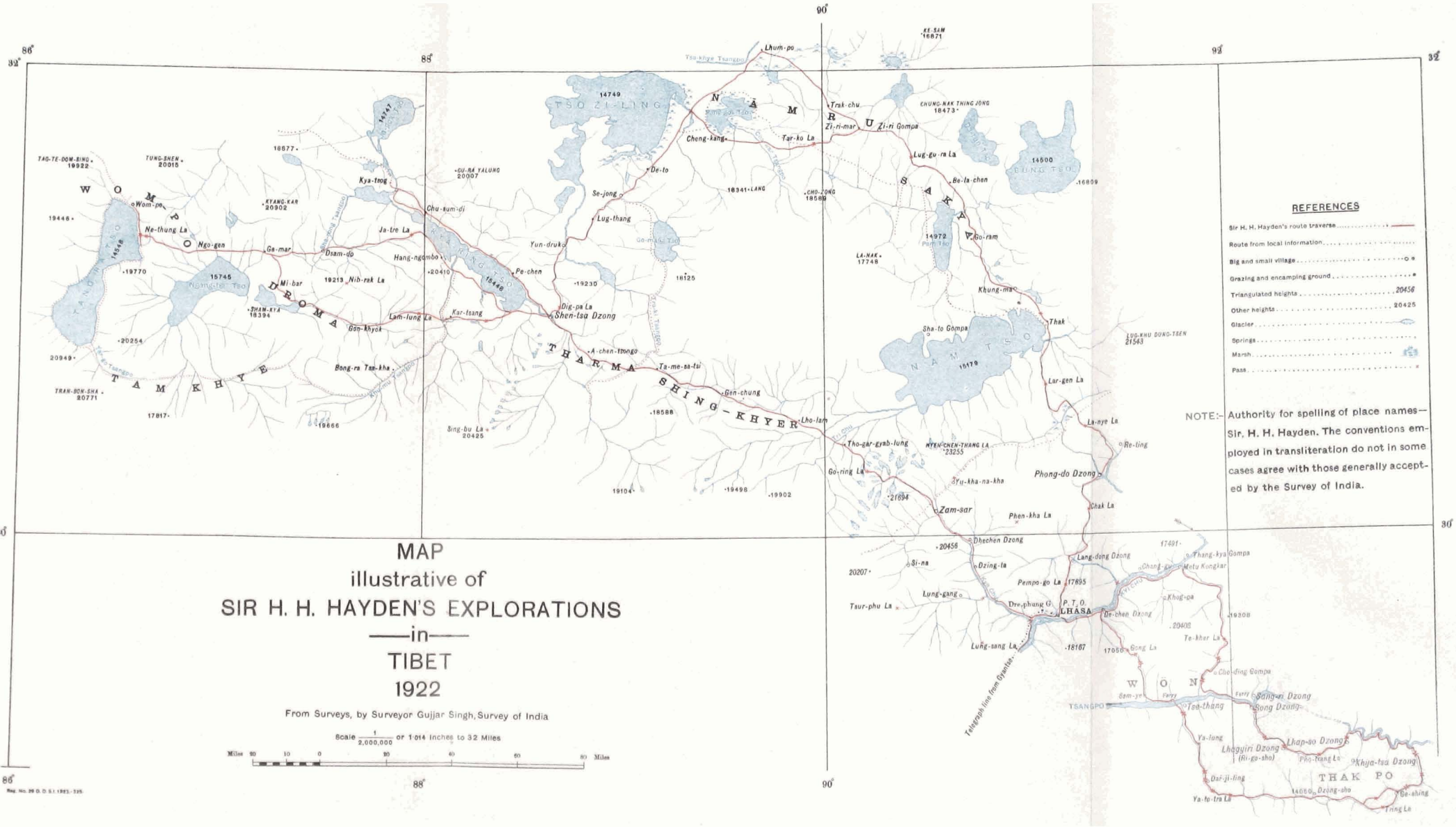
Early in 1872, explorer Kishen Singh ("Pandit A—k") travelling from Shigatse first discovered the Nam tso or Tengri Nor lake, of which he made a circuit in 15 days. The explorer had intended to make his way north-eastwards to the city of Sining in China, but had the misfortune on leaving the lake to fall among armed robbers who looted all his possessions, leaving him no alternative but to return direct to Lhāsa and India.

Two years later, explorer Nain Singh, in the course of his great Tibetan journey, reached Wom-po from Ladākh and discovered the lakes of Dangra and Kyā-ring, both of which are indicated on his map with remarkable accuracy. From Shen-tsa he continued around the northern shore of Tengri Nor, thence to Lhāsa and eventually to Odalguri in Assam viā Tsetang and Tawang.

The first Europeans to visit the Nam lake were Mm. G. Bonvalot and Prince Henri of Orleans who in February 1890 succeeded in reaching the Dam Chu some 65 miles north of Lhāsa before being turned back by the Tibetan authorities. Three years later, two countrymen of theirs, Mm. Dutreuil de Rhins and Grenard, endeavouring to reach Lhāsa from the north-east were detained fifty days at Zamna on the eastern edge of the Nam lake before being finally permitted to quit the country viā the Chinese frontier where Dutreuil de Rhins was murdered. Meantime, Namru had been reached by W. W. Rockhill from the north-east in July 1891, while in September of the same year Captain H. Bower and Surveyor Atma Ram succeeded in penetrating as far as Kyā-ring lake.

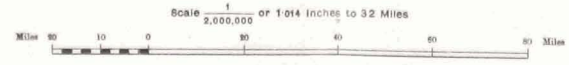
The Go-ring La was reached by Mr. and Mrs. St. G. R. Littledale in 1895. Finally, Sven Hedin in 1901, travelling from the north, crossed the Tsa-khye Tsangpo and reached a point one day's journey north of Tengri Nor before being, like his predecessors, turned back.

POSTSCRIPT.—Sir H. H. Hayden and his guide Cosson were killed in a mountaineering accident while climbing together in Switzerland in August 1923.



MAP
 illustrative of
SIR H. H. HAYDEN'S EXPLORATIONS
 —in—
TIBET
 1922

From Surveys, by Surveyor Gujjar Singh, Survey of India



REFERENCES

- Sir H. H. Hayden's route traverse.....
- Route from local information.....
- Big and small village.....
- Grazing and encamping ground.....
- Triangulated heights.....
- Other heights.....
- Glacier.....
- Springs.....
- Marsh.....
- Pass.....

NOTE: Authority for spelling of place names—Sir, H. H. Hayden. The conventions employed in transliteration do not in some cases agree with those generally accepted by the Survey of India.



89° D 90° E

86° 87° 88° 89° 90° 91° 92° 93°

31° 31°

2 2

30° 30°

3 3

86° E. of Greenwich A B C D E F G 29° 29° 93°

APPENDIX

List of Survey of India Publications

(Corrected up to 30th September 1924)

PUBLICATIONS
OF THE
SURVEY OF INDIA

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A—HISTORY AND GENERAL REPORTS.

(Obtainable from the Superintendent, Map Publication, 13, Wood Street, Calcutta).

MEMOIRS.

1. A Memoir on the Indian Surveys. By C. R. Markham, India Office, London, 1871. Price Rs. 5 or 10^s.
2. Ditto (second edition). By C. R. Markham, C.B., F.R.S., India Office, London, 1878. Price Rs. 5-8 or 11^s.
3. Abstract of the Reports of the Surveys and of other Geographical Operations in India, 1869-78. By C. R. Markham and C. E. D. Black, India Office, London. Published annually between 1871 and 1879. (Out of print).
4. A Memoir on the Indian Surveys, 1875-1890. By C. E. D. Black, India Office, London, 1891. Price Rs. 5-8 or 11^s.

ANNUAL REPORTS.

- Reports of the **Revenue Branch.** 1851-1877.—(1851-67 and 1869-70, out of print). Price Rs. 3 or 6^s.
- | | | |
|-------|--------------------------------|--|
| Ditto | Topographical Branch | 1860-1877.—(Out of print). |
| Ditto | Trigonometrical Branch. | 1861-1878.—(1861-71, out of print).
Price Rs. 2 or 4 ^s . |

In 1878 the three branches were amalgamated, and from that date onwards annual reports in single volumes for the whole department, are available as follows:—

- General Reports** { from 1877-1900 (1877-79, 1887-88, 1895-96 and 1897-98, out of print)
at Rs. 3 or 6^s per volume.
{ from 1900-1922 (1902-04 and 1906-08, out of print) at Rs. 2 or 4^s per volume.

From 1900 onwards the Report has been issued annually in the form of a condensed statement known as the "General Report" supplemented by fuller reports, which were called "Extracts from Narrative Reports" up to 1909, and since then have been styled "Records of the Survey of India." These fuller reports are available as follows:—

(a) "Extracts" Volumes at Rs. 1-8 or 3^s per volume.

1900-01—Recent Improvements in Photo-Zincography. G. T. Triangulation in Upper Burma. Latitude Operations. Experimental Base Measurement with Jäderin Apparatus. Magnetic Survey. Tidal and Levelling. Topography in Upper Burma. Calcutta, 1903. (Out of print).

1901-02—G. T. Triangulation in Upper Burma. Latitude Operations. Magnetic Survey. Tidal and Levelling. Topography in Upper Burma. Topography in Sind. Topography in the Punjab. Calcutta, 1904. (Out of print.)

1902-03—Principal Triangulation in Upper Burma. Topography in Upper Burma. Topography in Shan States. Survey of Sāmbar Lake. Latitude Operations. Tidal and Levelling. Magnetic Survey. Introduction of the Contract System of Payment in Traverse Surveys. Traversing with the Subtense Bar. Compilation and Reproduction of Thāna Maps. Calcutta, 1905.

1903-04—Magnetic Survey. Pendulum. Tidal and Levelling. Astronomical Azimuths. Utilization of old Traverse Data for Modern Surveys in the United Provinces. Identification of Snow Peaks in Nepāl. Topographical Surveys in Sind. Notes on town and Municipal Surveys. Notes on Riverain Surveys in the Punjab. Calcutta, 1906.

1904-05—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Triangulation in Baluchistān. Survey Operations with the Somāliland Field Force. Calcutta, 1907.

1905-06—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Topography in Shan States. Calcutta, 1908.

1906-07—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Triangulation in Baluchistān. Astronomical Latitudes. Topography in Shan States. Calcutta, 1909.

1907-08—Magnetic Survey. Tidal and Levelling. Astronomical Latitudes. Pendulum Operations. Topography in Shan States. Calcutta, 1910.

1908-09—Magnetic Survey. Tidal and Levelling. Pendulum Operations. Triangulation. Calcutta, 1911.

(b) "Records of the Survey of India" at Rs. 4 or 8^s per volume, except where otherwise stated.

Vol. I—**1909-10**—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey (Astronomical latitudes and pendulum observations).
Magnetic Survey. Calcutta, 1912.

ANNUAL REPORTS—(Continued).

- Vol. II—1910-11—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey. Magnetic Survey. Calcutta, 1912.
- III—1911-12—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey, Magnetic Survey. Calcutta, 1913.
- IV—1911-13—*Explorations on the North-East Frontier—North Burma, Mishmi, Abor and Miri Surveys* Calcutta, 1914.
- V—1912-13—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey. Magnetic Survey. Note on the relationship of the Himalayas to the Indo-Gangetic Plain. Calcutta, 1914.
- VI—1912-13—*Link connecting the Triangulations of India and Russia* Dehra Dün, 1914.
- VII—1913-14—Topographical Survey. Triangulation. Tidal and Levelling Operations. Geodetic Survey. Magnetic Survey (Annual report and Government Committee's report). Note on Scales and cost rates of Town plans. Calcutta, 1915.
- VIII—{ 1865-79—Part I } *Explorations in Tibet and* { Dehra Dün, 1915.
 { 1879-92—Part II } *neighbouring regions* { Price of each part Rs. 4 or 8.
- IX—1914-15—Topographical Survey. Triangulation. Tidal and Levelling Operations. Magnetic Survey. Criterion of strength of Indian Geodetic Triangulation. A traverse signal for City Surveys. The plains of Northern India and their relationship to the Himalaya Mountains by Colonel S. G. Burrard F. R. S. Report on Turco-Persian Frontier Commission. Calcutta, 1916.
- X—1915-16—Topographical Survey. Tidal and Levelling Operations. Magnetic Survey. Mechanical Integrator for calculating Attractions (illustrated). Traverse Survey of the boundary of Imperial Delhi ... Dehra Dün, 1917.
- XI—1916-17—Topographical Survey. Triangulation—use of high trestle for stations and 100-foot mast signals. Tidal and Levelling Operations. Magnetic Survey. Note on Basevi's Pendulum operations at Moré. Photo-Litho Office—New method of preparing Layer plates—Developments and Improvements in preparing Tint-plates. Dehra Dün, 1918.
- XII—Notes on Survey of India Maps and the modern development of } Calcutta, 1919.
 Indian Cartography, by Lt.-Col. W.M. Coldstream, R.E., } Price Rs. 3 or 6.
Superintendent, Map Publication.
- XIII—1917-18—Topographical Survey. Tidal and Levelling Operations. Magnetic Survey. Photo-Litho office—the Powder Process. Problem of the Himalayan and Gangetic Trough—Review by Dr. A. Morley Davies. Dehra Dün, 1919.
- XIV—1918-19—Topographical Survey. Tidal and Levelling Operations. Levelling in Mesopotamia. Magnetic Survey. Dehra Dün, 1920.
- XV—1919-20—Topographical Survey. Tidal work. Levelling—proposed new level net. Magnetic Survey. The Earth's Axes and Figure by Dr. J. de Graaff Hunter (a paper read at the R. A. S. Geophysical Meeting). Report on the expedition to Kamet. Note on the Topography of the Nun Kun Massif in Ladakh Dehra Dün, 1921.
- XVI—1920-21—Topographical Survey. Tidal work. Levelling and Magnetic Survey. High Climbs in the Himalaya prior to the Everest Expedition. Mt. Everest Survey Detachment Report, 1921. Traverse Survey of Allahābād city. Settlement of Boundary between Mysore and South Kanara. Dehra Dün, 1922.
- XVII—1923 — Memoir on Maps of Chinese Turkistān and Kansu from the Surveys made during Sir A. Stein's Explorations, 1900-01, 1906-08, 1913-15. Dehra Dün 1923
- XVIII—1921-22—Topographical Survey. Tidal work. Levelling and Magnetic Survey. Traverse Survey of Allahābād city. Settlement of Boundary between Mysore and South Kanara. Notes on Revision Survey in the neighbourhood of Poona Dehra Dün, 1923.

"Notes of the Survey of India" are issued monthly. Price As. 2 or 3d.

B—GEODETIC WORKS OF REFERENCE.

(Obtainable from the Superintendent of the Trigonometrical Survey, Dehra Dün, U.P.)

EVEREST'S GREAT ARC BOOK.

1. An account of the Measurement of an Arc of the Meridian between the parallels of 18° 3' and 24° 7', by Capt. George Everest. East India Company, London, 1830. (Out of print).
2. An account of the Measurement of two Sections of the Meridional Arc of India, bounded by the parallels of 18° 3' 15", 24° 7' 11" and 29° 30' 48", by Lt.-Col. G. Everest, F. R. S. East India Company, London, 1847. (Out of print).
3. Engravings to illustrate the above. London, 1847. (Out of print).

G.T.S. VOLUMES—describing the Operations of the Great Trigonometrical Survey,
Price Rs. 10-8 or 21^s per volume, except where otherwise stated.

Vol. I—Standards of Measure and Base-Lines, also an Introductory Account of
 the early Operations of the Survey, during the period of 1800-1830.

Dehra Dūn, 1870. (Out of print).

- Appendix No. 1. Description of the method of comparing, and the apparatus employed.
 Appendix No. 2. Comparisons of the Lengths of 10-feet Standards **A** and **B**, and determinations of the Difference of their Expansions.
 Appendix No. 3. Comparisons between the 10-feet Standards **I_B** **I_S** and **A**.
 Appendix No. 4. Comparisons of the 6-inch Brass Scales of the Compensated Microscopes.
 Appendix No. 5. Determination of the Length of the Inch [7.8] on Cary's 3-foot Brass Scale.
 Appendix No. 6. Comparisons between the 10-feet Standard Bars **I_S** and **A** for determining the Expansion of bar **A**.
 Appendix No. 7. Final determination of the Differences in Length between the 10-feet Standards **I_B** **I_S** and **A**.
 Appendix No. 8. On the Thermometers employed with the Standards of Length.
 Appendix No. 9. Determination of the Lengths of the Sub-divisions of the Inch [*a.b*].
 Appendix No. 10. Report on the Practical Errors of the Measurement of the Cape Comorin Base.

II—A History and General Description of the Reduction of the Principal Triangulation. ... Dehra Dūn, 1879. (Out of print).

- Appendix No. 1. Investigations applying to the Indian Geodesy.
 Appendix No. 2. The Micrometer Microscope Theodolites.
 Appendix No. 3. On Observations of Terrestrial Refraction at certain stations situated on the plains of the Punjab.
 Appendix No. 4. On the Periodic Errors of Graduated Circles, &c.
 Appendix No. 5. On certain Modifications of Colonel Everest's System of Observing introduced to meet the specialities of particular instruments.
 Appendix No. 6. On Tidal Observations at Karāchi in 1855.
 Appendix No. 7. An alternative Method of obtaining the Formulæ in Chapters VIII and XV employed in the Reduction of Triangulation.—Additional Formulæ and Demonstrations.
 Appendix No. 8. On the Dispersion of Circuit Errors of Triangulation after the Angles have been corrected for Figural conditions.
 Appendix No. 9. Corrections to azimuthal Observations for imperfect Instrumental Adjustments.
 Appendix No. 10. Reduction of the N.W. Quadrilateral—the Non-Circuit Triangles and their Final Figural Adjustments.
 Appendix No. 11. The Theoretical Errors of the Triangulation of the North-West Quadrilateral.
 Appendix No. 12. Simultaneous Reduction of the N.W. Quadrilateral—the Computations.

III—North-West Quadrilateral.—The Principal Triangulation, the Base-Line Figures, the Karāchi Longitudinal, N. W. Himālaya, and the Great Indus Series. ... Dehra Dūn, 1873. (Out of print.)

IV—North-West Quadrilateral.—The Principal Triangulation, the Great Arc—Section 24°-30°, Rahūn, Gurhāgarh and Jogi-Tila Meridional Series and the Sutlej Series. ... Dehra Dūn, 1876.

IVA—North-West Quadrilateral.—The Principal Triangulation, the Jodhpur and the Eastern Sind Meridional Series with the details of their Reduction and the Final Results. ... Dehra Dūn, 1886.

V—Pendulum Operations of Captains J. P. Basevi and W. J. Heaviside, and their Reduction. Dehra Dūn and Calcutta, 1879.

- Appendix No. 1. Account of the Remasurement of the Length of Kater's Pendulum at the Ordnance Survey Office, Southampton.
 Appendix No. 2. On the Relation between the Indian Pendulum Operations, and those which have been conducted elsewhere.
 Appendix No. 3. On the Theory, Use and History of the Convertible Pendulum.
 Appendix No. 4. On the Length of the Seconds Pendulum determinable from Materials now existing.
 Appendix No. 5. A Bibliographical List of Works relating to Pendulum Operations in connection with the Problem of the Figure of the Earth.

VI—South-East Quadrilateral.—The Principal Triangulation and Simultaneous Reduction of the following Series:—Great Arc—Section 16° to 24°, the East Coast, the Calcutta and the Bidar Longitudinal, the Jubbulpore and the Bilāspur Meridionals. ... Dehra Dūn, 1880. (Out of print.)

VII—North-East Quadrilateral.—General Description and Simultaneous Reduction. Also details of the following five series:—North-East Longitudinal, the Budhon Meridional, the Rangir Meridional, the Amua Meridional, and the Karāra Meridional. ... Dehra Dūn, 1882.

- Appendix No. 1. The Details of the Separate Reduction of the Budhon Meridional Series or Series J of the North-East Quadrilateral.

G.T.S. VOLUMES—(Continued).

- Appendix No. 2. Reduction of the North-East Quadrilateral. The Non-circuit Triangles and their Final Figural Adjustments.
- Appendix No. 3. On the Theoretical Errors generated respectively in Side, Azimuth, Latitude and Longitude in a Chain of Triangles.
- Appendix No. 4. On the Dispersion of the Residual Errors of a Simultaneous Reduction of several Chains of Triangles.
- Vol. VIII—**North-East Quadrilateral**—Details of the following eleven series:—
Gurwāni Meridional, Gora Meridional, Hurilāong Meridional, Chendwār Meridional, North Parasnāth Meridional, North Malūncha Meridional, Calcutta Meridional, East Calcutta Longitudinal, Brahmaputra Meridional, Eastern Frontier—Section 23°-26°, and Assam Longitudinal. ... Dehra Dūn, 1882.
- IX—Telegraphic Longitudes**—during the years 1875-77 and 1880-81. Dehra Dūn, 1883.
- Appendices to Part I. {
1. Determination of the Geodetic Elements of Longitude Stations.
2. Descriptions of Points used for Longitude Stations.
3. Comparison of Geodetic with Electro-Telegraphic Arcs of Longitude.
4. Circuit Errors of Observed Arcs of Longitude.
5. Results of Idiometer Observations made during Season 1880-81.
- Appendices to Part II. {
1. Situations of the Longitude Stations at Bombay, Aden and Suez.
2. Survey Operations at Aden.
3. Results of the Triangulation.
4. Right Ascensions of Clock Stars.
- X—Telegraphic Longitudes**—during the years 1881-82, 1882-83, and 1883-84. Dehra Dūn, 1887.
- Appendices to Part I. {
1. Determination of the Geodetic Elements of the Longitude Stations.
2. Descriptions of Stations of the Connecting Triangulation and of those at which the Longitude Observations were taken.
3. On the Errors in ΔL caused by Armature-time and the Retardation of the Electric Current.
4. On the Rejection of some doubtful Arcs of Season 1881-82.
5. On the probable Causes of the Errors of Arc-measurements, and on the Nature of the Defects in the Transit Instruments which might produce them.
- XI—Astronomical Latitudes**—during the period 1805-1885. Dehra Dūn, 1890.
- XII—Southern Trigon**—General Description and Simultaneous Reduction. Also details of the following two series:—Great Arc—Section 8°-18°, and Bombay Longitudinal. ... Dehra Dūn, 1890.
- XIII—Southern Trigon**—Details of the following five series:—South Konkan Coast, Mangalore Meridional, Madras Meridional and Coast, South-East Coast, and Madras Longitudinal. ... Dehra Dūn, 1890.
- XIV—South-West Quadrilateral**—Details of Principal Triangulation and Simultaneous Reduction of its component series. ... Dehra Dūn, 1890.
- XV—Telegraphic Longitudes**—from 1885 to 1892 and the Revised Results of Volumes IX and X: also the Simultaneous Reduction and Final Results of the whole Operations. ... Dehra Dūn, 1893.
- Appendix No. 1. Determination of the Geodetic Elements of the Longitude Stations.
- Appendix No. 2. On Retardation. (A numerical mistake was made in this appendix in the conversion of a formula from kilometres to miles: the conclusions drawn cannot therefore be upheld).
- XVI—Tidal observations**—from 1873 to 1892, and the Methods of Reduction. Dehra Dūn, 1901.
- XVII—Telegraphic Longitudes**—during the years 1894-95-96. The Indo-European Arcs from Karāchi to Greenwich. ... Dehra Dūn, 1901.
- Appendix No. 1. Descriptions of Points used for Longitude Stations.
- Appendix No. 2. The Longitude of Madras.
- XVIII—Astronomical Latitudes** from 1885 to 1905 and the Deduced Values of Plumb-line Deflections. ... Dehra Dūn, 1906.
- Appendix No. 1. On Deflections of the Plumb-line in India.
- Appendix No. 2. Determination of the Geodetic Elements of the Latitude Stations of Bajamara, Bahak, Lambatach and Kidarkanta.
- Appendix No. 3. On the (N-S) Difference exhibited by Zenith Sector No. 1.
- Appendix No. 4. On the Value of the Micrometer of the Zenith Telescope.
- Appendix No. 5. On the Azimuth Observations of the Great Trigonometrical Survey of India.
- Appendix No. 6. A Catalogue of the Publications of the Great Trigonometrical Survey of India.
- Appendix No. 7. On the combination weights employed.
- XIX—Levelling of Precision in India** from 1858 to 1909. Dehra Dūn, 1910.
- Appendix No. 1. Experiment to test the changes, due to Moisture and Temperature, in the Length of a Levelling Staff.

G.T.S. VOLUMES—(Continued).

- Appendix No. 2. On the erection of Standard Bench-Marks in India during the years 1904-1910.
 - Appendix No. 3. Memorandum on the steps taken in 1905-1910 to enable movements of the Earth's crust to be detected.
 - Appendix No. 4. Dynamic and Orthometric corrections to the Himālayan levelling lines and circuit; and a consideration of the order of magnitude of possible refraction errors.
 - Appendix No. 5. The passage of rivers by the Levelling Operations.
 - Appendix No. 6. The Errors of the Trigonometrical values of Heights of stations of the principal triangulation.
 - Appendix No. 7. The effect on the spheroidal correction of employing Theoretical instead of Observed values of Gravity and a discussion of different formulæ giving variation of Gravity with Latitude and Height.
 - Appendix No. 8. On the discrepancy between the Trigonometrical and spirit-level values of the difference of height between Dehra Dūn and Mussoorie.
- Vol. XIXA—**Bench-Marks** on the **Southern** Lines of Levelling. Dehra Dūn, 1910.
Price Rs. 5 or 10^s.
- XIXB—**Bench-Marks** on the **Northern** Lines of Levelling. Dehra Dūn, 1910.
Price Rs. 5 or 10^s.

TRIANGULATION PAMPHLETS with charts, are now being issued for every square degree, giving the results of all minor triangulation. *Price Re. 1 or 2^s per pamphlet except otherwise stated. Vide page 131.*

LEVELLING PAMPHLETS—giving heights and descriptions of all **Bench-marks**, fixed by levelling of Precisions in India and Burma. Each pamphlet embraces an area of 4° × 4° and the numbering is the same as that of the corresponding sheets of the 1/M map of India. Each is illustrated by a map of the area. *Price Rs. 2 or 4^s per pamphlet except where otherwise stated.*

Pamphlet Nos.	Latitude.	Longitude.	Published	Pamphlet Nos.	Latitude.	Longitude	Published.
India 34	28°-32°	64°-68°	Dehra Dūn, 1916.	India 57	12°-16°	76°-80°	Dehra Dūn, 1919. †
" 35	24°-28°	64°-68°	" 1911.	" 58	8°-12°	76°-80°	" 1914.
" 38	32°-36°	68°-72°	" 1912.	" 62	28°-32°	80°-84°	" 1922.
" 39	28°-32°	68°-72°	" 1913.	" 63	24°-28°	80°-84°	" 1923.**
" "	Addendum	"	" 1916.	" 64	20°-24°	80°-84°	" 1912.
" 40	24°-28°	68°-72°	" 1911.	" 65	16°-20°	80°-84°	" 1913.
" 41	20°-24°	68°-72°	" 1913.	" 66	12°-16°	80°-84°	" 1912.
" 43	32°-36°	72°-76°	" 1913.	" 72	24°-28°	84°-88°	" 1912.
" "	Addendum	"	" 1915.	" "	Addendum	"	" 1919.
" 44	28°-32°	72°-76°	" 1920†.	" 73	20°-24°	84°-88°	" 1913.
" "	Addendum	"	" 1921.	" "	Addendum	"	" 1920.
" 45	24°-28°	72°-76°	" 1911.	" 74	16°-20°	84°-88°	" 1913.
" 46	20°-24°	72°-76°	" 1912.	" 78	24°-28°	88°-92°	" 1923.**
" 47	16°-20°	72°-76°	" 1912.	" 79	20°-24°	88°-92°	" 1912.
" "	*Addendum	"	" 1915.	" "	Addendum	"	" 1916.
" 48	12°-16°	72°-76°	" 1912.	" 83	24°-28°	92°-96°	" 1912. §
" 49*	8°-12°	72°-76°	" 1911.	Burma 84	20°-24°	92°-96°	" 1918. ||
" 52	32°-36°	76°-80°	" 1912.	" 85	16°-20°	92°-96°	" 1917. ||
" 53	28°-32°	76°-80°	" 1920.	" 92	24°-28°	96°-100°	" 1918. ||
" 54	24°-28°	76°-80°	" 1921. ¶	" 93	20°-24°	96°-100°	" 1917. ||
" 55	20°-24°	76°-80°	" 1912.	" 94	16°-20°	96°-100°	" 1916. ||
" 56	16°-20°	76°-80°	" 1912.	" { 95	12°-16°	96°-100°	" 1916. ||
" "	*Addendum	"	" 1919.	" }			

Levelling of Precision in Mesopotamia—

Descriptions and heights of bench-marks, reprinted, Dehra Dūn, 1923. *Price Rs. 3 or 6^s.*

TIDE TABLES—

Since 1881 Tidal predictions based on the observations of the Survey of India have been published annually by the India Office, London up till the year 1922. From 1923 onwards the prediction and publication have been undertaken at Dehra Dūn by the Survey of India. The tables give the time and height of high and low water for every day in the year at each port, and are published early in the previous year. Current tables are available for the following 40 ports:—

Western Ports—

Suez (Egypt)—Perim—Aden—Maskat—Basrah—Bushire—Karāchi—Okha Point and Bet Harbour (Gulf of Cutch)—Porbandar—Port Albert Victor (Kāthiāwār)—Bhāvnagar—Bombay (Apollo Bandar)—Bombay (Prince's Dock)—Marmagao (Goa)—Kārwār—Beyporē (near Calicut)—Cochin—Tuticorin—Minicoy (Indian Ocean)—Pāmban Pass (Island of Rāmeswaram).

* Price Re. 1 or 2^s † 2nd Edition. ‡ 2nd Edition (revised and enlarged). § Heights on pages 45 & 46 revised in 1918. || Heights revised. ¶ 3rd Edition (revised with additions). ** Data up to 1923.

TIDE TABLES—(Continued).**Eastern Ports**—

Colombo (Ceylon)—Galle (Ceylon)—Trincomalee (Ceylon)—Negapatam—Madras—Cocanāda—Vizagapatam—False-Point—Dublat (Sāgar Island)—Diamond Harbour—Kidderpore (Calcutta)—Chittagong—Akyab—Diamond Island (Burma)—Bassein—Elephant Point (Burma)—Rangoon—Amherst—Moulmein—Mergui—Port Blair.

The Tide Tables are issued in the following forms up to those for 1924.

- (i) **Part I and Part II**—including Western and Eastern ports respectively—
Each part Rs. 8 or 16s.
- (ii) **Pamphlets**—giving separately the tables for individual ports or for small local groups of ports—Price varying from As. 12 or 1s 6d to Rs. 1-8 or 3s per pamphlet.
- (iii) **Sheets**—These are only published for Karāchi, Bombay, Madras, Hooghly River. Price varying from As. 12 or 1s 6d to Rs. 1-8 or 3s per sheet.

C—CATALOGUES AND INSTRUCTIONS.

(Obtainable from the Superintendent, Map Publication, 13, Wood Street, Calcutta).

DEPARTMENTAL ORDERS.—

From 1878 to 1885 the Surveyor General's orders were all issued as "Circular Orders." Since then they have been classified as follows:—

From 1885 to 1904 as $\left\{ \begin{array}{l} 1\text{—Government of India Orders (called "Circular Orders" up to 1898.)} \\ 2\text{—Departmental Orders (Administrative).} \\ 3\text{—Departmental Orders (Professional).} \end{array} \right.$

In 1904 the various orders issued since 1878 were reclassified as follows:—

	Number to date.
1.—Government of India Orders.—	786
2.—Circular Orders (Administrative).—	402
3.—Circular Orders (Professional).—	196
4.—Departmental Orders. (appointments, promotions, transfers, etc.)	

These are numbered serially and had reached the above numbers by September 1922. Government of India Orders and Circular Orders (Administrative) are bound up in volumes from time to time, as shown below, while Circular Orders (Professional) are gradually incorporated in the Survey Hand-books. Besides the above, temporary orders have been issued since 1910 in the form of "Circular Memos." These either lapse or become incorporated in some more permanent form, and are therefore only numbered serially for each year. Bound volumes of orders are available as follows:—

1. *Government of India Orders (Departmental) 1878-1903.—Calcutta, 1904.
Ditto ditto 1904-1908.—Calcutta, 1909. (Out of print).
Ditto ditto 1909-1913.—Calcutta, 1915.
Ditto ditto 1914-1918.—Calcutta, 1920.
2. *Circular Orders (Administrative) 1878-1903.—Calcutta, 1904.
Ditto ditto 1904-1908.—Calcutta, 1909.
Ditto ditto 1909-1913.—Calcutta, 1915.
Ditto ditto 1914-1918.—Calcutta, 1920.
3. *Regulations on the subject of Language Examinations for Officers of the Survey of India. Calcutta, 1914.
4. *Map Publication Orders 1908-1914 (Superintendent, Map Publication's Orders).—Calcutta, 1914.
5. Specimens of papers set at Examinations for the Provincial Service.—Dehra Dūn, 1903.—(Out of print).

CATALOGUES AND LISTS.

1. **Catalogue of Maps** published by the Survey of India. Corrected to 1st January 1923, Calcutta, 1923. Price Re. 1 or 2s.

NOTE.—Lists of new maps published during each month appear in the monthly NOTES OF THE SURVEY OF INDIA. These monthly lists are also issued separately.

2. **Catalogue of Maps** of the Bombay Presidency, Calcutta, 1913. Price As. 4 or 6d.
3. **List of the publications of the Survey of India** (published annually)—Dehra Dūn. *Gratis*.
4. **Price List of Mathematical Instrument Office.** Calcutta, 1921. *Gratis*.
5. **Catalogue of Books in the Head-Quarters Library, Calcutta, 1901.** (Out of print).

* For Departmental use only.

CATALOGUES AND LISTS—(Continued).

6. Catalogue of Scientific Books and Subjects in the Library of the Trigonometrical Survey Office. Dehra Dün, 1908. *Price Re. 1 or 2^s.*
7. Classified Catalogue of the Trigonometrical Survey Library. Dehra Dün, 1921. *Gratis.*
8. **Green Lists**—PART I—List of officers in the Survey (*annually to date 1st January*)—Calcutta. *Price As. 6 or 9^d.*
PART II—History of Services of Officers of the Survey of India (*annually to date 1st July*)—Calcutta. *Price As. 8 or 1^s.*
9. **Blue Lists**—Ministerial and Subordinate Establishments of the Survey of India.
PART I—Head-quarters and Dehra Dün offices (*published annually to date 1st April*)—Calcutta. *Price Re. 1 or 2^s.*
PART II—Circles and parties (*published annually to date 1st January*).—Calcutta. *Price Rs. 1-8 or 3^s.*

TABLES AND STAR CHARTS.

1. **Auxiliary Tables**—to facilitate the calculations of the Survey of India. Fourth Edition (Revised), Dehra Dün, 1906. *Price Rs. 4 or 8^s in cloth and calf, or Rs. 2 or 4^s in paper and boards.*
2. ***Auxiliary Tables**—of the Survey of India. Fifth Edition (Revised and Extended), *by J. de Graaff Hunter, M.A., Sc.D., F. Inst. P.* In parts—
PART I—Graticules of Maps (Reprinted). Dehra Dün, 1921. *Price Re. 1 or 2^s.*
PART II—Mathematical Tables (Reprinted with additions). Dehra Dün, 1924. *Price Rs. 2 or 4^s.*
PART III—Topographical Survey Tables. (Reprinted with additions). Dehra Dün, 1923. *Price Re. 1-8 or 3^s.*
3. Tables for Graticules of Maps. Extracts for the use of **Explorers**. Dehra Dün, 1918. *Price As. 4 or 6^d.*
4. † Metric Weights and Measures and other tables. Photo-Litho Office. Calcutta, 1889. (Out of print.)
5. Logarithmic Sines and Cosines to 5 places of decimals. Dehra Dün, 1886. (Out of print.)
6. Logarithmic Sines, Cosines, Tangents and Cotangents to 5 places of decimals. Dehra Dün, 1915. (Out of print.)
7. Common Logarithms to 5 places of decimals 1885. *Price As. 4 or 6^d.*
8. Table for determining Heights in Traversing. Dehra Dün, 1898. *Price As. 8 or 1^s.*
9. Tables of distances in Chains and Links corresponding to a subtense of 20 feet. Dehra Dün, 1889. *Price As. 4 or 6^d.*
10. † Ditto ditto 10 feet. Calcutta, 1915.
11. † Ditto ditto 8 feet. Ditto.
12. Star Charts for latitude 20° N., *by Colonel J. R. Hobday, I.S.C.* Calcutta, 1904. *Price Rs. 1-8 or 3^s.*
13. Star Charts for latitude 30° N., *by Lt.-Col. S. G. Burrard, R.E., F.R.S.* Dehra Dün, 1906. *Price Rs. 1-8 or 3^s.*
14. † Catalogue of 249 Stars for epoch Jan. 1, 1892, from observations by the Survey, Dehra Dün, 1893. *Price Rs. 2 or 4^s.*
15. † Rainfall, maximum and minimum temperatures from 1863 to 1920, recorded at the Survey Office Observatory, Dehra Dün. (Revised.)

OLD MANUALS.

1. A Manual of Surveying for India, detailing the mode of operations on the Revenue Surveys in Bengal and the North-Western Provinces. Compiled *by Captains R. Smyth and H. L. Thuillier*. Calcutta 1851. (Out of print.)
2. Ditto ditto ditto. Second Edition. London, 1855. (Out of print.)
3. A Manual of Surveying for India, detailing the mode of operations on the Trigonometrical, Topographical and Revenue Surveys of India. Compiled *by Colonel H. L. Thuillier, C.S.I., F.R.S., and Lieutenant-Colonel R. Smyth*. Third Edition, revised and enlarged. Calcutta, 1875. (Out of print.)
4. Hand-book Revenue Branch. Calcutta, 1893. *Price Rs. 2-8 or 5^s.*

SURVEY OF INDIA HAND-BOOKS.

1. **Hand-book of General Instructions**, Fourth Edition. Calcutta, 1914. *Price Rs. 3 or 6^s.*
2. **Hand-book, Trigonometrical Branch**, Second Edition. Calcutta 1902. (Out of print.)

* Obtainable from the Superintendent of the Trigonometrical Survey, Dehra Dün, U.P.

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SURVEY OF INDIA HAND-BOOKS—(Continued).

3. **Hand-book of Trigonometrical Instructions.**—Third Edition. Chapters, in pamphlet forms—

Chapter VI—Levelling of Precision. Dehra Dūn 1920. *Price Re. 1 or 2s.*

4. **Hand-book, Topographical Branch,** Third Edition. Calcutta, 1905. (Out of print.)

5. **Hand-book of Topography.**—Fourth Edition. Calcutta, 1911. Chapters, in pamphlet forms—

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| Chapter | I—Introductory.—reprinted with additions, 1921. <i>Price As. 8 or 1s.</i> |
| „ | II—Constitution and Organization of a Survey Party.—reprinted with additions, 1923. <i>Price As. 8 or 1s.</i> |
| „ | III—Triangulation and its Computation.—revised 1923. <i>Price Re. 1 or 2s.</i> |
| „ | IV—Theodolite Traversing.—reprinted, 1924. <i>Price Re. 1 or 2s.</i> |
| „ | V—Plane-tableing.—reprinted 1915. <i>Price Re. 1 or 2s.</i> |
| „ | VI—Fair Mapping.—reprinted with additions and revised, 1922. <i>Price Re. 1 or 2s.</i> |
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| „ | VIII—Surveys in time of war (not ready). |
| „ | IX—Forest Surveys and Maps.—revised 1924. (In the Press). |
| „ | X—Map Reproduction.—reprinted 1919. <i>Price As. 8 or 1s.</i> |
| „ | XI—Geographical maps.—1917. <i>Price As. 8 or 1s.</i> |

6. ***Photo-Litho Office,** Notes on Organization, Methods and Processes. *By Major W. C. Hedley, R. E.* Revised and amplified *by Capt. S. W. S. Hamilton, R. E.* Calcutta, 1914.

7. **The Reproduction (for the guidance of other Departments),** of Maps, Plans, Photographs, Diagrams, and Line Illustrations. Calcutta, 1914. *Price Rs. 3 or 6s.*

NOTES AND INSTRUCTIONS.**Drawing and Paper.**

1. ***Notes on Printing Papers** suitable for Maps, and on Whatman Drawing Paper. *By Major W. M. Coldstream, R. E.* Calcutta, 1911.

Printing and Field Litho processes.

2. ***Report on Rubber Offset Printing for Maps.** *By Major W. M. Coldstream, R. E.* Calcutta, 1911.

3. ***Notes on the "Vandyke" or Direct Zinc Printing Process,** with details of Apparatus and Chemicals required for a small section. Compiled in the Photo and Litho Office, Survey of India. Calcutta, 1913.

4. ***Report on the Working of the Light Field Litho Press (experimental)** in November and December 1910 with Appendices. *By Lieutenant A. A. Chase, R. E.,* Calcutta, 1911.

(1) Notes on some of the Methods of Reproduction suitable for the Field.

(2) Suggested Equipment Tables for the Light Field Litho Press (experimental).

5. ***Report on a trial of the equipment of the 1st (Prince of Wales' Own) Sappers and Miners** for reproducing maps in the field. *By Lieutenant A. A. Chase, R. E.* Calcutta, 1912. (Out of print).

Base Lines and Magnetic.

6. ***Notes on use of the Jäderin Base-line Apparatus.** Dehra Dūn. 1904. (Out of print).

7. ***Miscellaneous Papers** relating to the Measurement of Geodetic Bases by Jäderin Invar Apparatus. Dehra Dūn, 1912.

8. ***Instructions for taking Magnetic Observations.** *By J. Eccles, M. A.* Dehra Dūn, 1896. (Out of print).

9. **Rectangular Coordinates.**—On a Simplification of the Computations relating to—*By J. Eccles, M. A.* Dehra Dūn, 1911. *Price Re. 1 or 2s.*

10. ***For Explorers.**—Notes on the use of Thermometers, Barometers and Hypsometers with Tables for the Computation of Heights. *By J. de Graaff Hunter, M. A.* Dehra Dūn, 1911. (Out of print).

11. **Amended Instructions for the Survey and Mapping of Town Guide Maps.** August 1919.

* For Departmental use only.

D—MISCELLANEOUS PAPERS.

(Obtainable from the Superintendent, Map Publication, 13, Wood Street, Calcutta).

UNCLASSIFIED PAPERS.**Geography.**

1. A Sketch of the Geography and Geology of the Himālaya Mountains and Tibet (in four parts), by Colonel S. G. Burrard, R. E., F. R. S., Supdt., *Trigonometrical Surveys*, and H. H. Hayden, B. A., F. G. S., Supdt., *Geological Survey of India*. Calcutta, 1907-08.

Part I.—The High Peaks of Asia.

„ II.—The Principal Mountain Ranges of Asia.

„ III.—The Rivers of the Himālaya and Tibet.

„ IV.—The Geology of the Himālaya.

} Price Rs. 2 or 4* per part.

2. *Report on the Identification and Nomenclature of the Himālayan Peaks as seen from Kātmandu, Nepāl, by Capt. H. Wood, R. E. Calcutta, 1904.

3. Routes in the Western-Himālaya, Kashmīr, etc., by Lieut. Colonel T. G. Montgomerie, R. E., F. R. S., F. R. G. S. Third Edition, revised and corrected. Dehra Dūn, 1909. (Out of print.)

4. Routes in the Western-Himālaya, Kashmīr, etc. with which are included Montgomerie's Routes. Volume I. Pūnch, Kashmīr and Ladākh, by Major Mason, M.C., R.E., 1st edition, Dehra Dūn, 1923. Price Rs. 6.

Exploration.

1. *Account of the Survey Operations in connection with the Mission to Yārkanḍ and Kashgar in 1873-74, by Captain Henry Trotter, R.E. Calcutta, 1875. (Out of print.)

2. Report on the Trans-Himālayan Explorations during 1869. (Out of print.)

3. Report on the Trans-Himālayan Explorations during 1870. Dehra Dūn, 1871. (Out of print.)

4. Report on the Trans-Himālayan Explorations during 1878. Calcutta, 1880. (Out of print.)

5. Explorations in the Eastern Kara-koram and Upper Yārkanḍ Valley. (Narrative report of the work of the Survey of India Detachment with the De Filippi Scientific Expedition 1914), by Major H. Wood, R.E. Dehra Dūn, 1922. Price Rs. 3 or 6*.

Special Reports.

1. *Report on the Mussoorie and Landour, Kumaun and Garhwāl, Rānīkhet and Kosi Valley Surveys extended to Peshāwar and Kāghān Triangulation during 1869-70, by Major T. G. Montgomerie, R.E. (Out of print.)

2. Report on the Recent Determination of the Longitude of Madras, by Capt. S. G. Burrard, R. E. Calcutta, 1897. (Out of print.)

3. *Report on the Observations of the Total Solar Eclipse of 6th April, 1875 at Camorta, Nicobar Islands, by Colonel J. Waterhouse. Calcutta, 1875. (Out of print.)

4. *The Total Solar Eclipse, January 22, 1898. Dehra Dūn, 1898.

(1) Report on the observations at Dumraon.

(2) Report on the observations at Pulgaon.

(3) Report on the observations at Sahdol.

5. *Report on Local Attraction in India, 1893-94, by Captain S. G. Burrard, R.E. Calcutta, 1895. (Out of print.)

6. *Report on the Trigonometrical Results of the Earthquake in Assam, by Captain S. G. Burrard. Calcutta, 1898. (Out of print.)

7. *Notes on the Topographical Survey of the 1/50,000 Sheets of Algeria by the Topographical Section of the "Service Geographique de l'Armée", by Captain W. M. Coldstream, R.E. Calcutta, 1906.

8. *The Simla Estates Boundary Survey on the scale of 50 feet to 1 inch, by Captain E. A. Tandy, R.E. Calcutta, 1906.

9. *A note on the stage reached by the Geodetic Operations of the Survey of India in 1920, by Lieut. Col. H. M. Cowie, R.E.; the Magnetic Survey of India, by Major R. H. Thomas, D.S.O., R.E., and a note on the present Levelling Policy, by Major K. Mason, M.C., R.E. Dehra Dūn, 1922. (Out of Print.)

Geodesy.

1. Notes on the Theory of Errors of Observation, by J. Eccles, M.A. Dehra Dūn, 1903. Price As. 8 or 1*.

2. *Note on a Change of the Axes of the Terrestrial Spheroid in relation to the Triangulation of the G.T. Survey of India, by J. de Graaff Hunter, M.A. Dehra Dūn. (Out of print.) Now incorporated in Professional Paper No. 16.

3. Report on the Treatment and use of Invar in measuring Geodetic Bases, by Capt. H. H. Turner, R. E. London, 1907. Price As. 8 or 1*.

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UNCLASSIFIED PAPERS.—(Continued).**Projections.**

1. On the projection used for the General Maps of India. Dehra Dün, 1903. (Out of print).
2. *On the deformation resulting from the method of constructing the International Atlas of the World on the scale of one to one million. *By Ch. Lallemand. Translated by J. Eccles, M.A., together with tables for the projection of 1/M Maps on the International system.* Dehra Dün, 1912. (Out of print).

Mapping.

1. *A Note on the different methods by which hills can be represented upon maps. *By Colonel S. G. Burrard, C.S.I., R.E., F.R.S., Surveyor General of India.* Simla, 1912.
2. *A Note on the representation of hills. *By Major C. L. Robertson, C.M.G., R.E.* Dehra Dün, 1912.
3. *A Note on the representation of hills on the Maps of India. *By Major F. W. Pirrie, I.A.* Dehra Dün, 1912.
4. *A consideration of the Contour intervals and Colour Scales best suited to Indian 1/M maps. *By Captain M. O'C. Tandy, R.E.* Calcutta, 1913. (Out of print).

PROFESSIONAL PAPERS—Price Rupee 1 or 2* per volume, except where otherwise stated.

- No. 1—**Projection**—On the Projection for a Map of India and adjacent Countries on the scale of 1: 1,000,000. *By Colonel St. G. C. Gore, R.E.* Second Edition, Dehra Dün, 1903.
- No. 2 ***Base Lines**—Method of measuring Geodetic Bases by means of Metallic Wires. *By M. Jäderin. (Translated from Mémoires Présentés par Divers Savants à l'Académie des Sciences de l'Institut de France).* Dehra Dün, 1899. (Out of print.)
- No. 3—**Base Lines**—Method of measuring Geodetic Bases by means of Colby's Compensated Bars. Compiled by *Lieutenant H. McC. Cowie, R. E.* Dehra Dün, 1900. (Out of print.)
- No. 4—**Spirit-levels**—Notes on the Calibration of Levels. *By Lieutenant E. A. Tandy, R. E.* Dehra Dün, 1900. (Out of print.)
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- No. 6—**Base Lines**—Account of a Determination of the Co-efficients of Expansion of the Wires of the Jäderin Base-Line Apparatus. *By Captain G. P. Lenox-Conyngham, R. E.* Dehra Dün, 1902. (Out of print.)
- No. 7—***Miscellaneous.** Calcutta, 1903.
 - (1) On the values of Longitude employed in maps of the Survey of India.
 - (2) Levelling across the Ganges at Dāmukdia.
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- No. 9—**Geodesy**—An Account of the Scientific work of the Survey of India and a Comparison of its progress with that of Foreign Surveys. *Prepared for the use of the Survey Committee assembled in 1905. By Lieutenant-Colonel S. G. Burrard, R. E., F. R. S.* Calcutta, 1905.
- No. 10—**Pendulums**—The Pendulum Operations in India, 1903-1907. *By Major G. P. Lenox-Conyngham, R. E.* Dehra Dün, 1908. *Price Rs. 2-8 or 5*.*
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- No. 16—**Geodesy**—The Earth's Axes and Triangulation, by *J. de Graaff Hunter, M.A.* Dehra Dün, 1918. *Price Rs. 4 or 8.*
- No. 17—**Isostasy**—Investigations of Isostasy in Himälāyan and Neighbouring Regions, by *Colonel Sir S. G. Burrard, K. C. S. I., R. E., F. R. S.* Dehra Dün, 1918. *Price Re. 1 or 2.*
- No. 18—**Isostasy**—A criticism of Mr. R. D. Oldham's memoir "The structure of the Himälāyas and of the Gangetic Plain", by *Lieut.-Colonel H. McC. Cowie, R.E.* Dehra Dün, 1921. *Price Rs. 1-8 or 3.*
- No. 19—**Aerial Photography**—Experiments in Aeroplane Photo Surveying, by *Major C. G. Lewis, R.E.* and *Captain H. G. Salmond, (Late R.A.F.).* Dehra Dün, 1920. *Price Rs. 1-8 or 3.*

DEPARTMENTAL PAPERS SERIES. (For departmental use only.)

- No. 1—**Type**—A consideration of the most suitable forms of type for use on maps, by *Captain M. O'C. Tandy, R. E.* Dehra Dün, 1913.
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- No. 6—**Levelling**—Levelling of High Precision, by Ch. Lallemand. *Translated from the French by J. de Graaff Hunter, M.A.* Dehra Dün, 1914.
- No. 7—**Standard Bars**—Bar Comparisons of 1907-08, by *Major H. McC. Cowie, R. E.* Dehra Dün, 1915.
- No. 8—**Helio-zincography**—Report on Rubber Off-set Flat bed Machine Printing, by *Captain S. W. Sackville Hamilton, R.E.* Calcutta, 1915.
- No. 9—**Stereo-Auto-Plotting**—A translation of Paul Corbin's French Stéréo Autogrammétrie by *Lieutenant-Colonel H. M. Cowie, R.E.* Dehra Dün, 1922.

PROFESSIONAL FORMS.

A large number of forms for the record and reduction of Survey Operations are stocked at Dehra Dün. A list of these can be obtained from the Superintendent of the Trigonometrical Survey, Dehra Dün, U. P.

EXTRA-DEPARTMENTAL PUBLICATIONS.

1. *India's Contribution to Geodesy, by *General J. T. Walker, R.E., C.B., F.R.S., LL.D.* (Philosophical Transactions, Royal Society Series A, Volume 186, 1895).
2. *On the Intensity and Direction of the Force of Gravity in India, by *Lieutenant-Colonel S. G. Burrard, R.E., F.R.S.* (Philosophical Transactions, Royal Society Series A, Volume 205, pages 289-318, 1905).
3. *On the effect of the Gangetic Alluvium on the Plumb-Line in Northern India, by *R. D. Oldham, F.R.S.* (Proceedings Royal Society, Series A, Volume 90, pages 32-40, 1914).
4. *On the origin of the Indo-Gangetic trough, commonly called the Himälāyan Foredeep, by *Colonel Sir S. G. Burrard, K.C.S.I., R.E., F.R.S.* (Proceedings, Royal Society Series A, Volume 91, pages 220-238, 1915).
5. †Three comprehensive articles on "Comparators for the Indian Government" from a report by *Major H. M. Cowie, R. E.* (Engineering, Aug. 20, Aug. 27, Sep. 3, 1915).
6. §Identification of Peaks in the Himälāya with notes, by *Colonel Sir S. G. Burrard, K.C.S.I., R.E., F.R.S.* (Geographical Journal, September, 1918).

* Obtainable from Messrs. Dulau & Co., 37, Soho Square, London, W., or Messrs. Harrison & Sons, St. Martin's Lane, London, or the Royal Society at Burlington House, London.

† Obtainable from Charles Robert Johnson at the offices of "Engineering", 35 and 36, Bedford Street, Strand, London W. C.

§ Obtainable from the Royal Geographical Society Kensington Gore London, S.W. 7.

EXTRA-DEPARTMENTAL PUBLICATIONS—(Continued).

7. §Geological interpretations of Geodetic Results, by Colonel Sir S. G. Burrard K.C.S.I., R.E., F.R.S. (Geographical Journal, October 1918).
8. §War Surveys in Mesopotamia, by Colonel F. W. Pirrie, C.M.G., I.A. (Geographical Journal, December 1918).
9. §Air Photography in Archaeology, by Lieutenant-Colonel G.A. Beazeley, D.S.O., R.E., (Geographical Journal, May 1919).
10. §Mapping from Airphotographs, by Lieutenant-Colonel M.N. MacLeod, R.E. (Geographical Journal, June 1919).
11. §Reminiscences of the Map of Arabia and Persian Gulf, by Lieutenant-Colonel F. Hunter, D.S.O., I.A. (Geographical Journal, December 1919).
12. §Central Kurdistan, by Major K. Mason, M.C., R.E. (Geographical Journal December 1919).
13. §Surveys in Mesopotamia during the War, by Lieutenant-Colonel G.A. Beazeley, D.S.O., R.E. (Geographical Journal, February 1920).
14. ‡A lecture on the Earth's Axes and Figure, by J. de Graaff Hunter, M.A., (The Observatory, May 1920).
15. §A brief review of the evidence upon which the Theory of Isostasy has been based, by Colonel Sir S.G. Burrard, K.C.S.I., R.E., F.R.S. (Geographical Journal, July 1920).
16. §A note on the topography of the NunKun Massif in Ladakh, by Major K. Mason, M.C., R.E. (Geographical Journal, August 1920).
17. §Notes on the Canal System and Ancient Sites of Babylonia in the time of Xenophon, by Major K. Mason, M.C., R.E. (Geographical Journal, December 1920).
18. ¶Topographical Air Survey (with plates and maps), by Lieutenant-Colonel G.A. Beazeley, D.S.O., R.E. (Royal Engineers Journal, February 1921).
19. ¶Projection of Maps.—A review of some Investigations in the theory of Map Projection, by A. B. Young—by Colonel Sir S.G. Burrard, K.C.S.I., R.E., F.R.S. (Royal Engineers Journal, March 1921).
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24. ||The Survey of Mr. W.H. Johnson in the K'un Lun in 1865, by Major K. Mason, M.C., R.E. (Alpine Journal, November 1922).
25. ‡Gravity Survey, by J. de Graaff Hunter, M.A, Sc.D., F. Inst. P. (A Dictionary of Applied Physics, Vol. III).
26. ‡Trigonometrical Heights and Atmospheric Refraction, by J. de Graaff Hunter, M.A., Sc.D., F. Inst. P. (A Dictionary of Applied Physics, Vol. III).
27. Geodesy, by Colonel Sir G.P. Lenox-Conyngham, Kt., R.E., F.R.S. and J. de Graaff Hunter, M.A. Sc.D., F. Inst. P. (Enc. Brit. 12th Edition, Vol. XXXI, 1922).
28. §The proposed Determination of Primary Longitudes by International Cooperation, by Colonel Sir G.P. Lenox-Conyngham, Kt., R.E., F.R.S. (Geographical Journal, Feb. 1923).
29. §Recent Developments of Air photography.—(1) The adjustment of Air photographs to Survey points, by Lieutenant-Colonel M.N. MacLeod, D.S.O., R.E. (Geographical Journal, June 1923)
30. §Kishen Singh and the Indian Explorers, by Major K. Mason, M.C., R.E. (Geographical Journal, December 1923).
31. **Electrical Registration of Height of water at any time in Tidal Prediction, by J. de Graaff Hunter M.A., Sc.D., F. Inst. P. (Journal of Scientific Instruments, Vol. 1, No. 8, May 1924).

§ Obtainable from the Royal Geographical Society Kensington Gore London, S.W. 7.

¶ Obtainable from Messrs. Taylor & Francis, Red Lion Court, Fleet Street, London, W.C.

¶ Obtainable from The Institution of Royal Engineers, Chatham.

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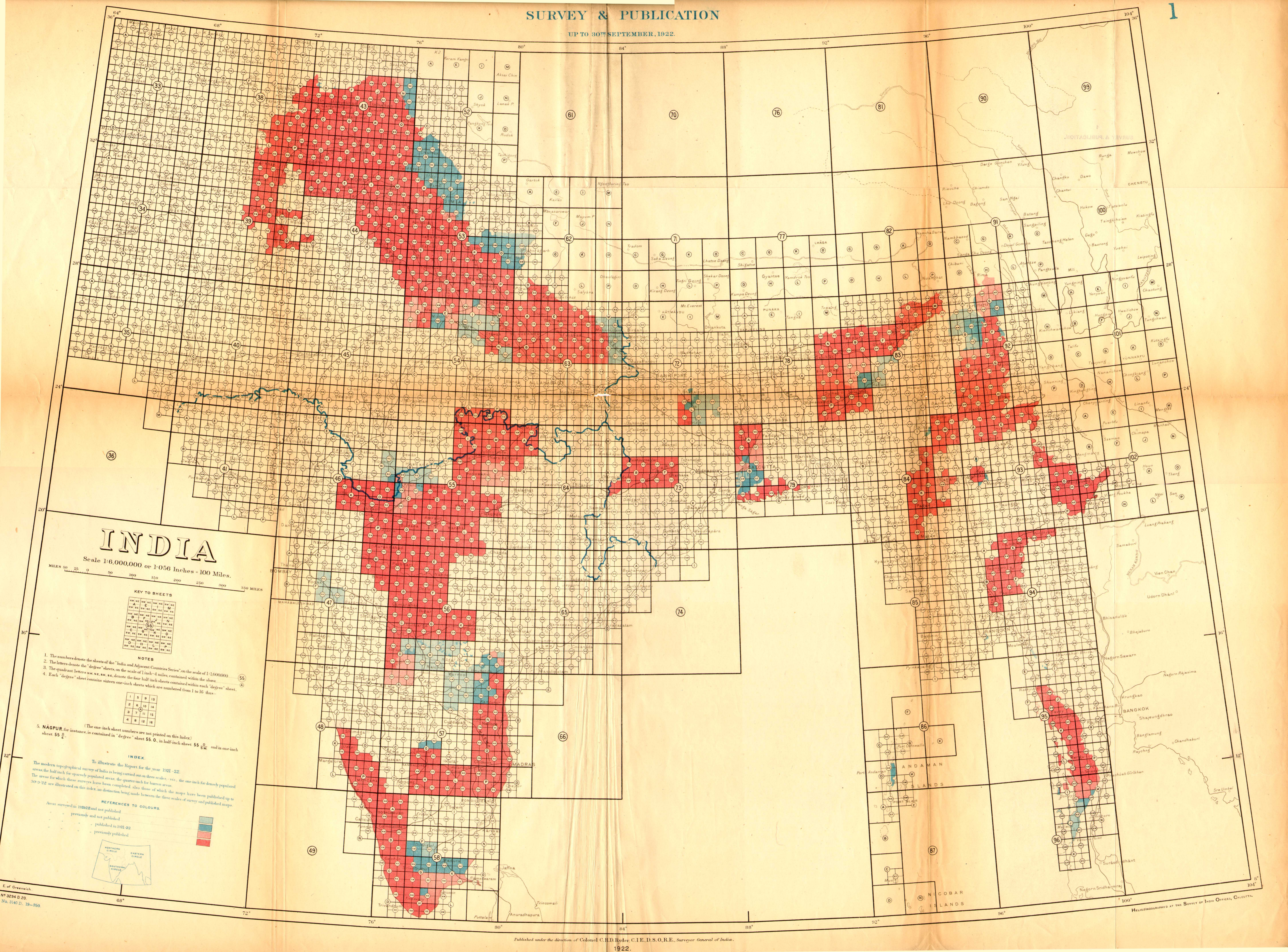
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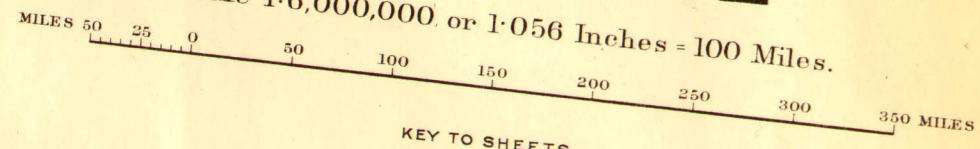
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INDIA

Scale 1:6,000,000 or 1:056 Inches = 100 Miles.



KEY TO SHEETS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P

NOTES

1. The numbers denote the sheets of the "India and Adjacent Countries Series" on the scale of 1:1,000,000.
2. The letters denote the "degree" sheets on the scale of 1 inch = 4 miles, contained within the above.
3. The quadrant letters N.W., N.E., S.W., S.E. denote the four half-inch sheets contained within each "degree" sheet.
4. Each "degree" sheet contains sixteen one-inch sheets which are numbered from 1 to 16 thus—

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
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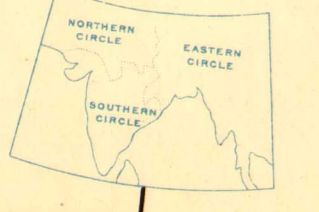
5. NAGPUR for instance, is contained in "degree" sheet 55 O., in half-inch sheet 55 O₉ and in one-inch sheet 55 9.

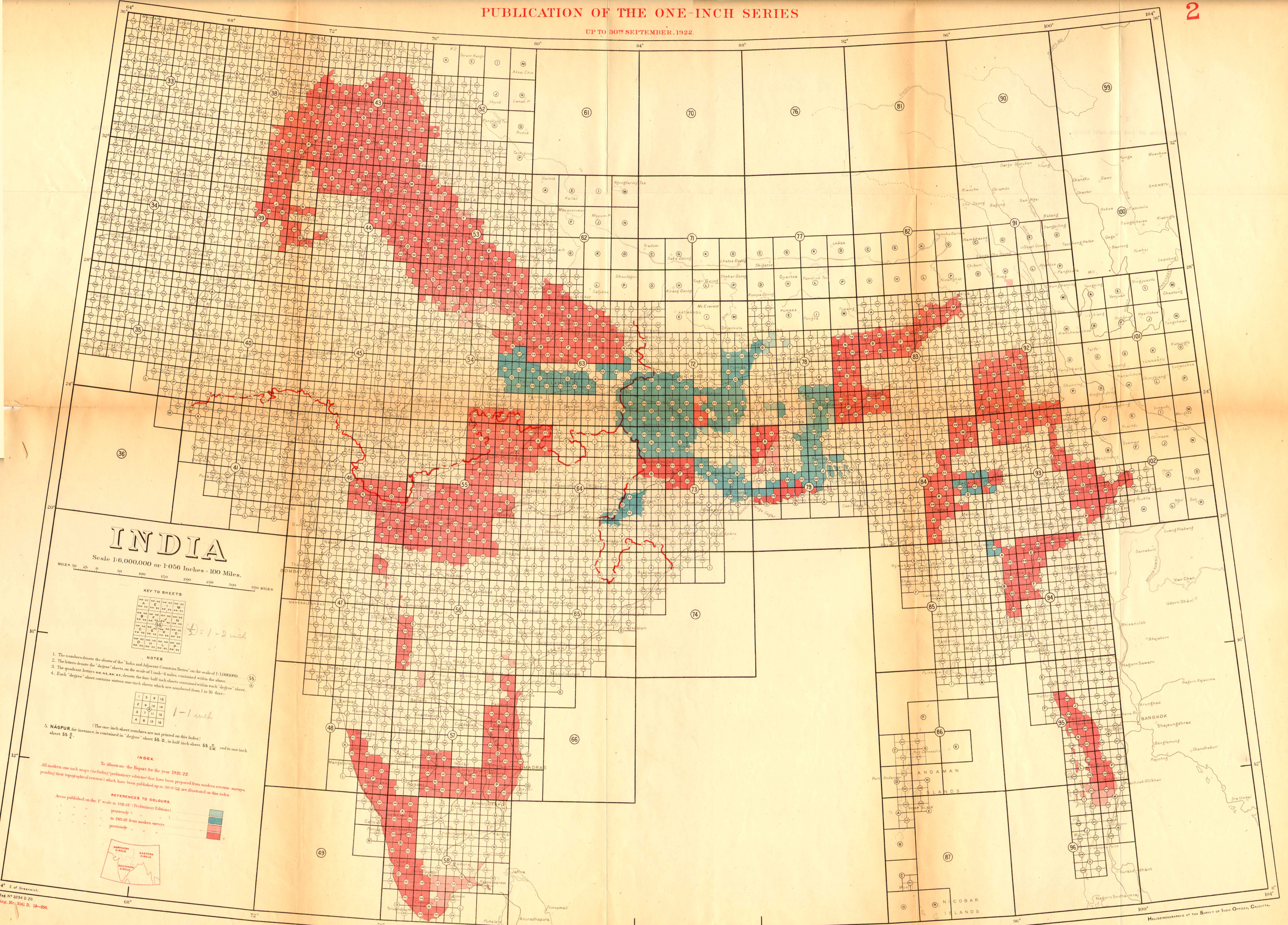
INDEX

To illustrate the Report for the year 1921-22, the modern topographical survey of India is being carried out on three scales, viz., the one inch for densely populated areas, the half-inch for sparsely populated areas, the quarter-inch for barren areas. The areas for which these surveys have been completed, also those of which the maps have been published up to 30-9-22 are illustrated on this index, no distinction being made between the three scales of survey and published maps.

REFERENCES TO COLOURS

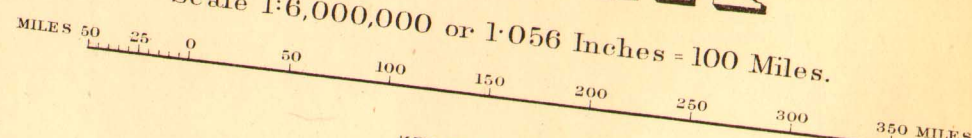
- Areas surveyed in 1921-22 and not published previously and not published
- published in 1921-22
- previously published





INDIA

Scale 1:6,000,000 or 1:056 inches = 100 Miles.



KEY TO SHEETS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100												

NOTES

- The numbers denote the sheets of the "India and Adjacent Countries Series" on the scale of 1:1,000,000.
- The letters denote the "degree" sheets on the scale of 1:4 miles, contained within the above.
- The quadrant letters *sw, se, nw, ne* denote the four half-inch sheets contained within each "degree" sheet.
- Each "degree" sheet contains sixteen one-inch sheets which are numbered from 1 to 16 thus:

1	5	9	13
2	6	10	14
3	7	11	15
4	8	12	16

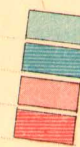
- NAGPUR** for instance is not printed on this index sheet 55 ^{sw}, in half-inch sheet 55 ^{sw} and in one-inch sheet 55 ^{sw}.

INDEX

To illustrate the Report for the year 1921-22. All modern one-inch maps (including preliminary editions) that have been prepared from modern revenue surveys, pending their topographical revision, which have been published up to 30-9-22, are illustrated on this index.

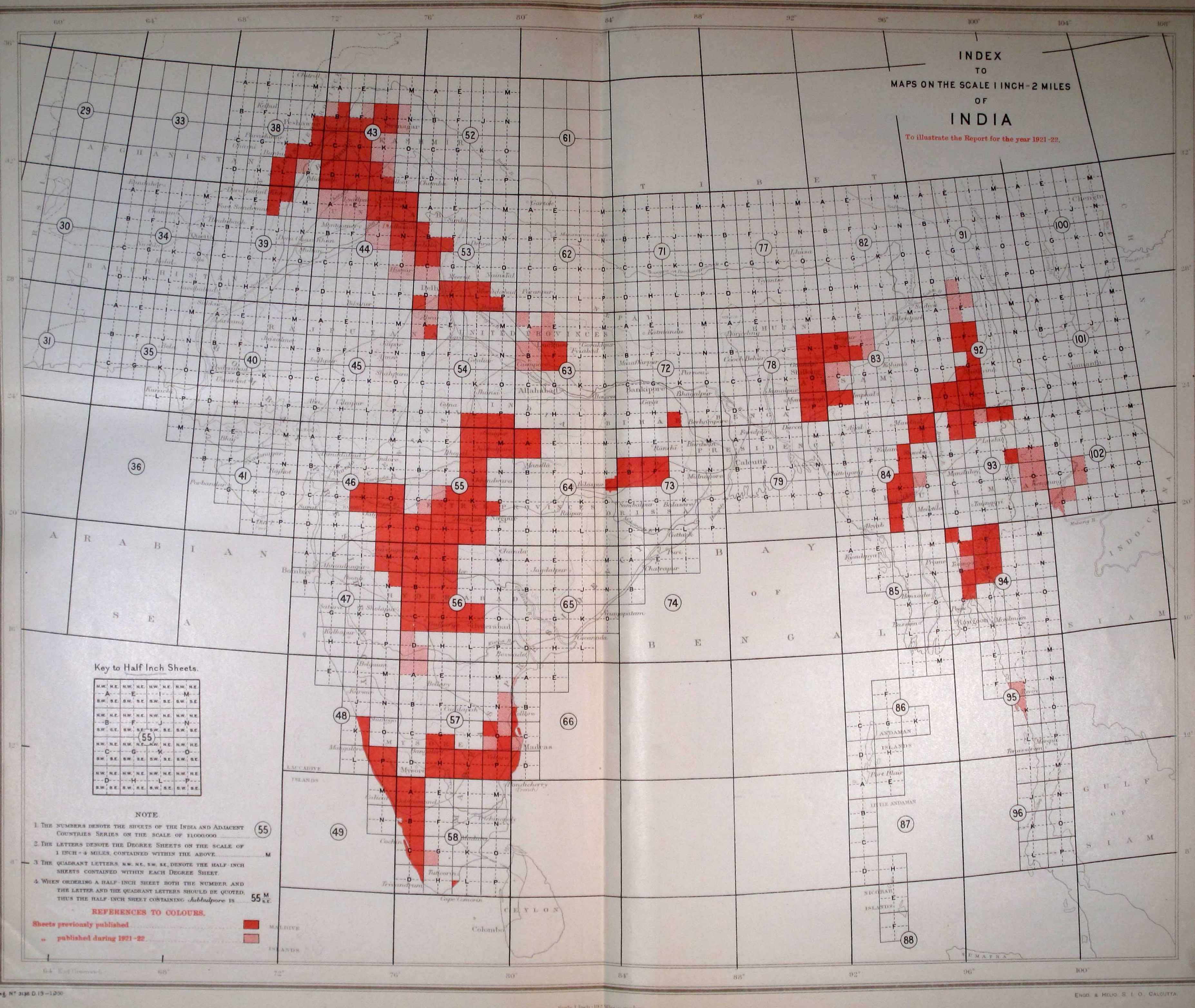
REFERENCES TO COLOURS

- Areas published on the 1" scale in 1921-22 (Preliminary Editions) previously 1
- in 1921-22 from modern surveys previously



INDEX
TO
MAPS ON THE SCALE 1 INCH = 2 MILES
OF
INDIA

To illustrate the Report for the year 1921-22.



Key to Half Inch Sheets.

NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE
A	E	M	
NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE
B	F	J	N
NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE
C	G	K	O
NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE
D	H	L	P
NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE	NW, NE, SW, SE
(55)			

NOTE

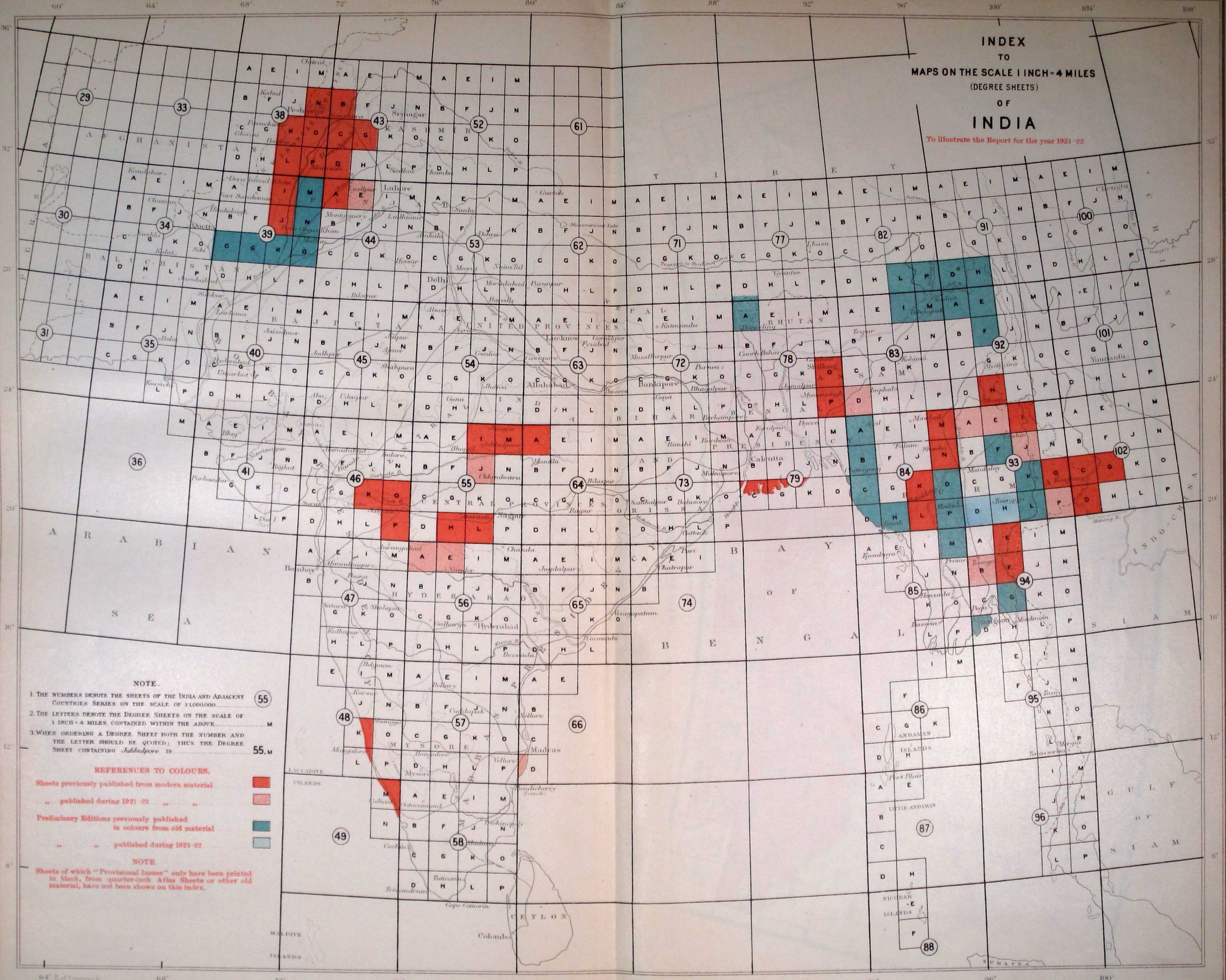
1. THE NUMBERS DENOTE THE SHEETS OF THE INDIA AND ADJACENT COUNTRIES SERIES ON THE SCALE OF 1:100,000
2. THE LETTERS DENOTE THE DEGREE SHEETS ON THE SCALE OF 1 INCH = 4 MILES, CONTAINED WITHIN THE ABOVE.
3. THE QUADRANT LETTERS, NW, NE, SW, SE, DENOTE THE HALF-INCH SHEETS CONTAINED WITHIN EACH DEGREE SHEET.
4. WHEN ORDERING A HALF-INCH SHEET BOTH THE NUMBER AND THE LETTER AND THE QUADRANT LETTERS SHOULD BE QUOTED, THUS THE HALF-INCH SHEET CONTAINING *Subalpur* IS

REFERENCES TO COLOURS.

- Sheets previously published ■ MALDIVE ISLANDS
- published during 1921-22 ■

INDEX
TO
MAPS ON THE SCALE 1 INCH=4 MILES
(DEGREE SHEETS)
OF
INDIA

To illustrate the Report for the year 1921-22



NOTE.

1. THE NUMBERS DENOTE THE SHEETS OF THE INDIA AND ADJACENT COUNTRIES SERIES ON THE SCALE OF 1:100,000.
2. THE LETTERS DENOTE THE DEGREE SHEETS ON THE SCALE OF 1 INCH=4 MILES, CONTAINED WITHIN THE ABOVE.
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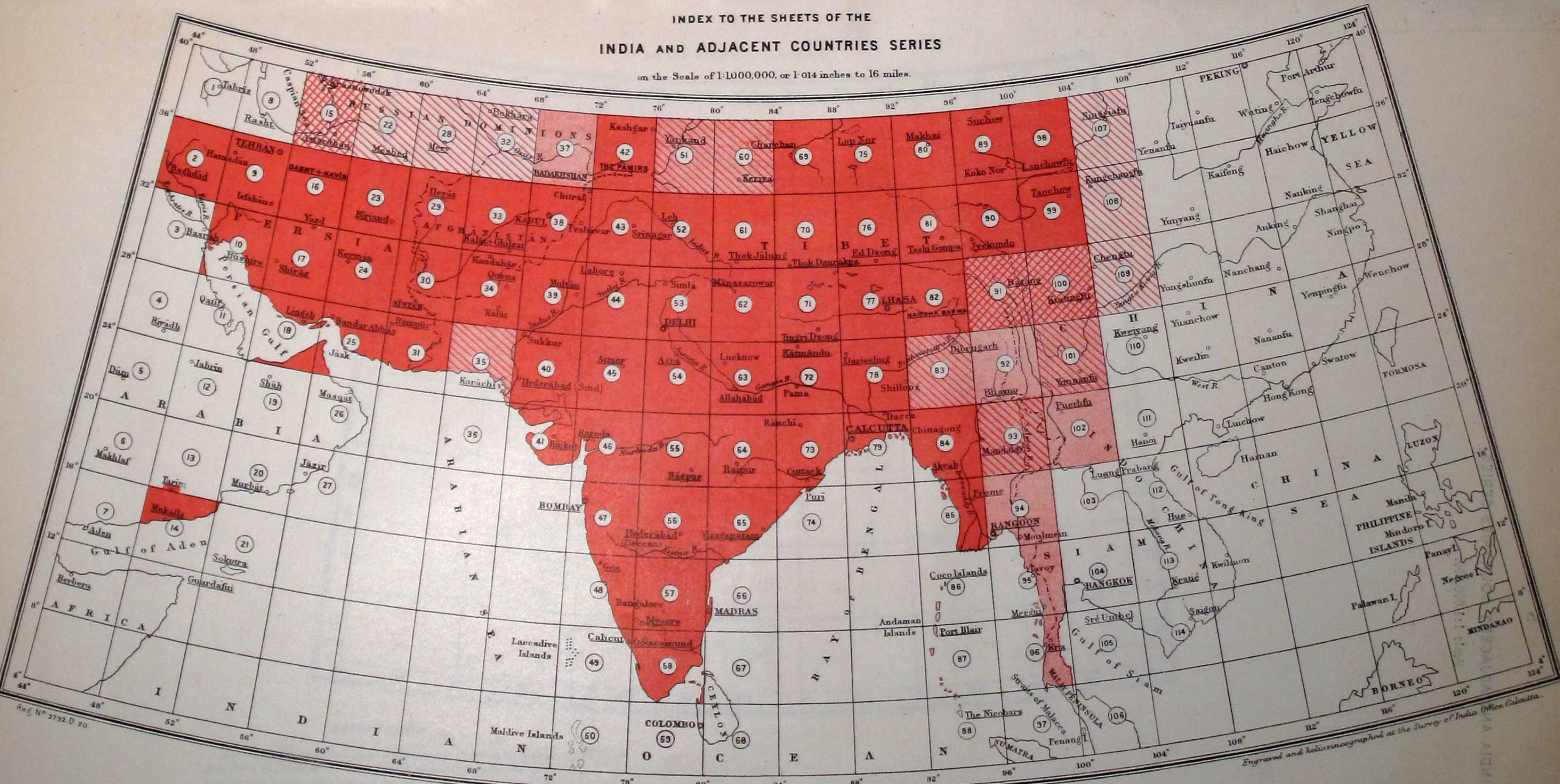
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- Preliminary Editions previously published in colours from old material
- published during 1921-22

NOTE.

Sheets of which "Provisional Issues" only have been printed in black, from quarter-inch Atlas Sheets or other old material, have not been shown on this index.

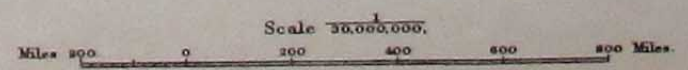
INDEX TO THE SHEETS OF THE INDIA AND ADJACENT COUNTRIES SERIES

on the Scale of 1:1,000,000, or 1/16 inch to 16 miles.



Reg. N° 3732.D. 20.

Engraved and heliogravured at the Survey of India Office Calcutta.



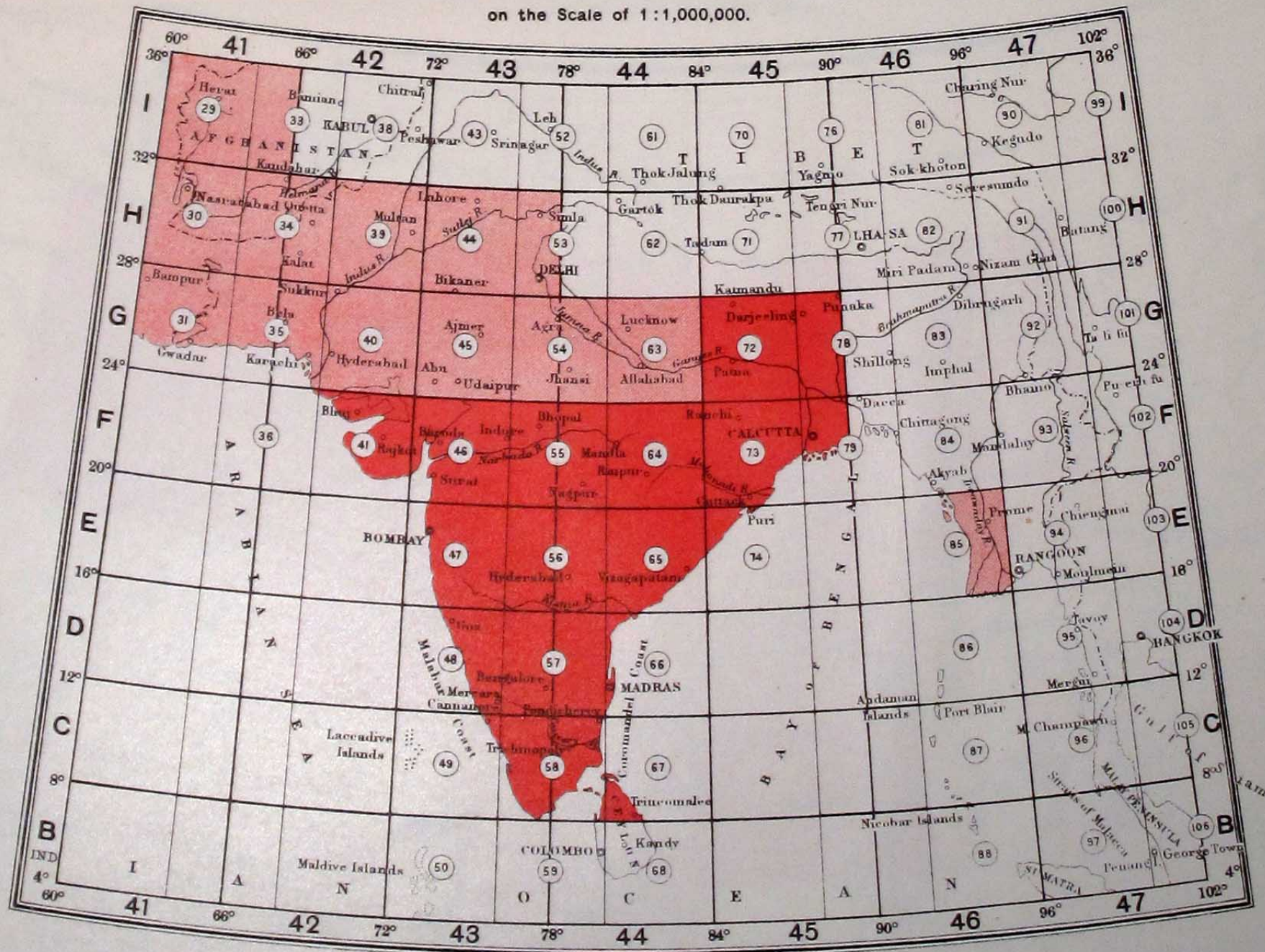
NOTE.

The names underlined on this Index are the title names of the sheets, and their numbers are shown in circles. Sheets 35 and 36, 57 and 66, are published respectively as combined sheets.

REFERENCE

- To illustrate the Report for the year 1921-22
- Sheets published without contours & layers
- “ “ with contours & layers
- “ “ under publication
- “ “ in hand

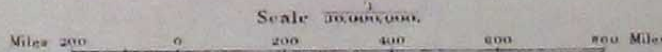
INDEX TO THE SHEETS OF THE
CARTE INTERNATIONALE DU MONDE
 on the Scale of 1:1,000,000.



EXPLANATION.

The thick lines show the margins of the sheets of the International Map of the World, Scale 1:1,000,000. Each sheet is designated by the letter N (Northern hemisphere), followed by the marginal letter and number corresponding to its position, e.g., the sheet which includes Bombay is N.E-43.

The figures in circles are the numbers of the sheets of the India and Adjacent Countries Series on the Scale of 1:1,000,000.



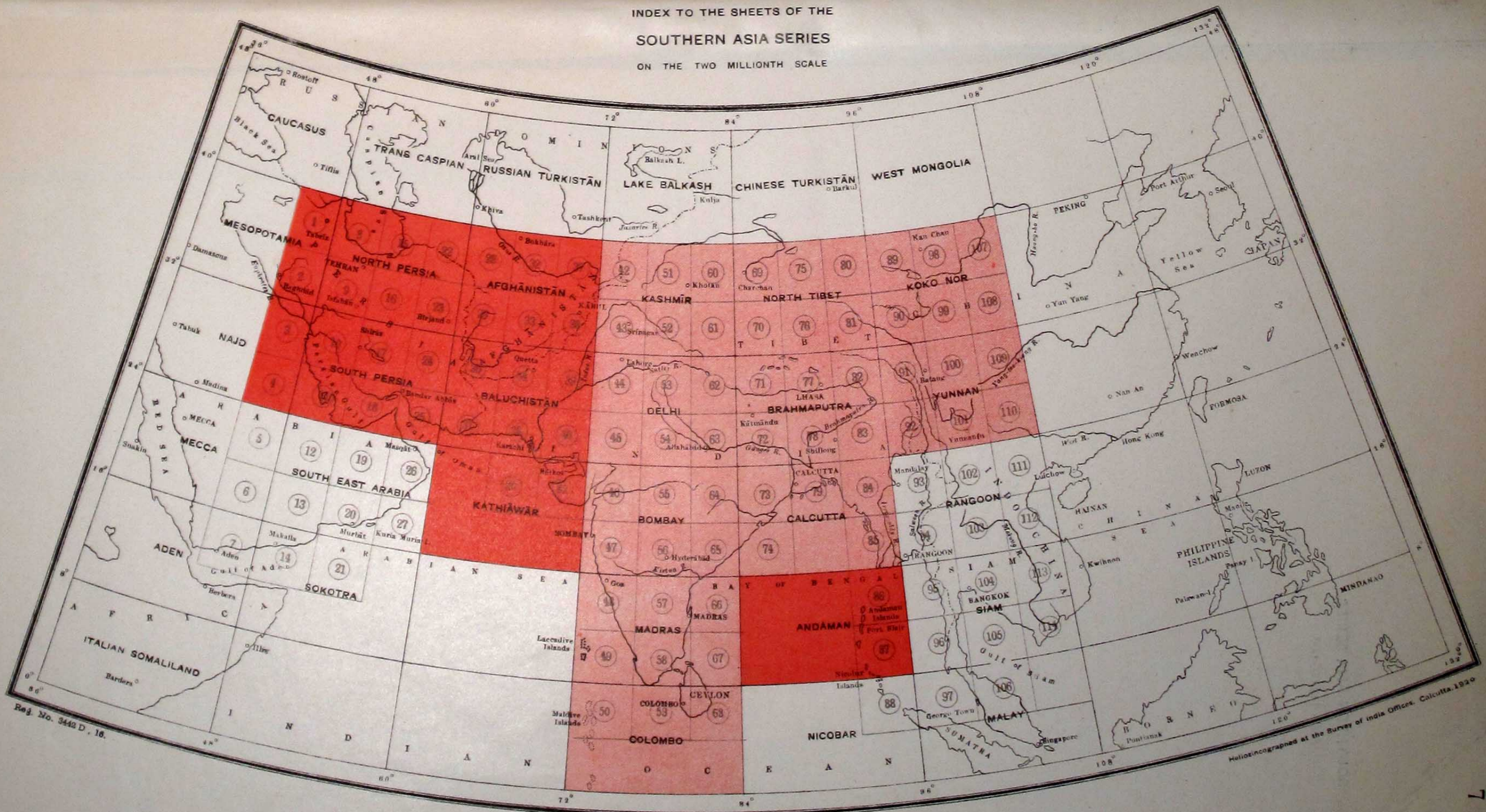
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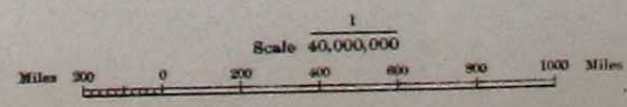


To illustrate the Report for the year 1921-22.

INDEX TO THE SHEETS OF THE
SOUTHERN ASIA SERIES
 ON THE TWO MILLIONTH SCALE



Reg. No. 3442 D. 16.



The E. portions of MESOPOTAMIA and NAJD sheets have been published for the present as outriggers to N. & S. PERSIA sheets respectively.

REFERENCE

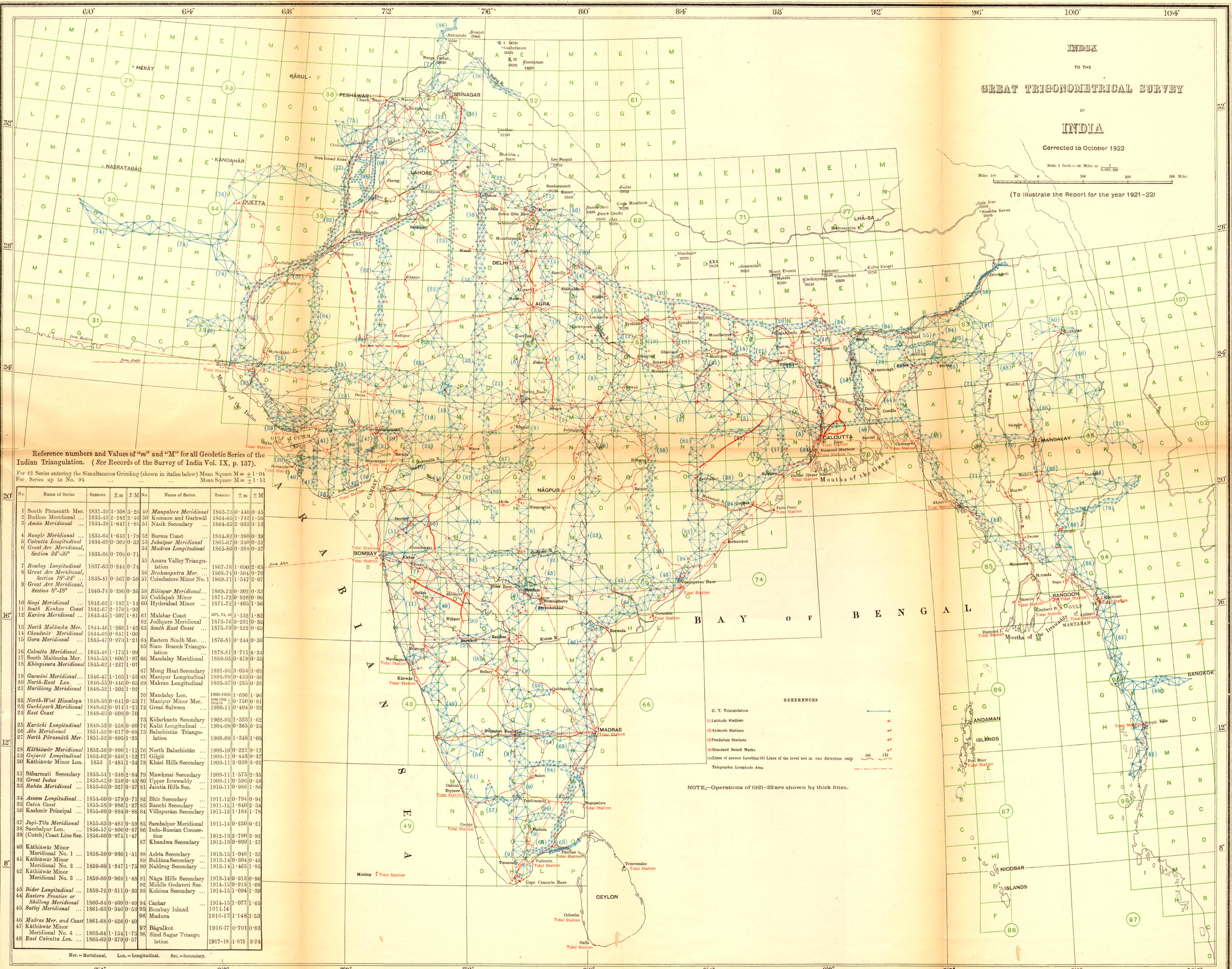
To illustrate the Report for the year 1921-22

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■	in hand

Heliozincographed at the Survey of India Office, Calcutta, 1920

INDEX
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA
Corrected to October 1922

Scale 1 Inch = 66 Miles or 105,600 Feet
Miles 100 0 100 200 300
(To illustrate the Report for the year 1921-22)



Reference numbers and Values of "m" and "M" for all Geodetic Series of the Indian Triangulation. (See Records of the Survey of India Vol. IX, p. 137).
For 42 Series entering the Simultaneous Gridding (shown in italics below) Mean Square M = ±1.04
For Series up to No. 94 ... Mean Square M = ±1.51

No.	Name of Series	Seasons	±m	±M	No.	Name of Series	Seasons	±m	±M
1	South Parasnath Mer.	1831-39	3.308	3.26	49	Mangalore Meridional	1863-73	0.440	0.45
2	Budion Meridional	1833-43	2.242	2.46	50	Kumam and Garhwal	1864-65	1.742	1.50
3	Amia Meridional	1834-38	1.647	1.85	51	Nasik Secondary	1864-65	2.033	3.12
4	Rangir Meridional	1834-64	1.643	1.79	52	Burma Coast	1864-82	0.380	0.39
5	Calcutta Longitudinal	1834-69	0.369	0.32	53	Jabalpur Meridional	1865-67	0.310	0.31
6	Great Arc Meridional, Section 24°-30°	1835-66	0.708	0.71	54	Madras Longitudinal	1865-80	0.384	0.37
7	Bombay Longitudinal, Great Arc Meridional, Section 15°-24°	1837-63	0.844	0.74	55	Assam Valley Triangulation	1867-78	1.690	2.65
8	Great Arc Meridional, Section 5°-15°	1838-41	0.507	0.59	56	Braknaputra Mer.	1868-74	0.564	0.70
9	Great Arc Meridional, Section 5°-15°	1840-71	0.390	0.36	57	Cumtalar Minor No. 1	1869-71	1.547	2.07
10	Singri Meridional	1842-62	1.187	1.14	58	Bilaspur Meridional	1869-73	0.302	0.33
11	North Konkani Coast	1842-67	2.176	1.93	59	Cuddapah Minor	1871-72	0.826	0.96
12	Karara Meridional	1843-45	1.507	1.81	60	Hyderabad Minor	1871-72	1.405	1.56
13	North Malancha Mer.	1844-46	1.266	1.42	61	Malabar Coast	1873-74	1.532	1.82
14	Chendur Meridional	1844-69	0.841	1.06	62	Jodhpore Meridional	1873-76	0.291	0.32
15	Gora Meridional	1845-47	0.973	1.21	63	South East Coast	1873-79	0.522	0.65
16	Calcutta Meridional	1845-48	1.173	1.99	64	Eastern Sindh Mer.	1876-81	0.244	0.30
17	South Malancha Mer.	1845-53	1.606	1.97	65	Siam Branch Triangulation	1878-81	3.711	4.34
18	Khampisura Meridional	1845-62	1.227	1.07	66	Mandalay Meridional	1889-95	0.418	0.35
19	Garsuni Meridional	1846-47	1.165	1.55	67	Mong Hsat Secondary	1891-93	3.034	3.01
20	North-East Lon.	1846-55	0.440	0.65	68	Manipur Longitudinal	1894-99	0.433	0.36
21	Huridong Meridional	1848-52	1.502	1.92	69	Makran Longitudinal	1895-97	0.285	0.26
22	North-West Himalaya	1848-53	0.641	0.55	70	Mandalay Lon.	1899-1900	1.696	1.96
23	Gurkhar Meridional	1848-62	0.914	1.21	71	Manipur Minor Mer.	1899-1903	0.750	0.81
24	East Coast	1848-63	0.608	0.76	72	Great Salween	1900-11	0.404	0.32
25	Karachi Longitudinal	1849-53	0.558	0.60	73	Kidaranta Secondary	1902-08	1.323	1.62
26	Abu Meridional	1851-52	0.617	0.68	74	Kalit Longitudinal	1904-08	0.365	0.25
27	North Parasnath Mer.	1851-52	0.895	1.25	75	Baluchistan Triangulation	1908-09	1.348	1.08
28	Kathiawar Meridional	1852-56	0.990	1.11	76	North Baluchistan	1908-10	0.221	0.17
29	Gujarat Longitudinal	1852-62	0.839	1.12	77	Gilgit	1909-11	0.443	0.37
30	Kathiawar Minor Lon.	1853	1.481	1.34	78	Khasi Hills Secondary	1909-11	2.035	3.01
31	Sabarmati Secondary	1853-54	1.348	2.84	79	Mawkiat Secondary	1909-11	1.575	3.35
32	Great Indus	1853-61	0.359	0.43	80	Upper Irrawaddy	1909-11	0.590	0.49
33	Rahia Meridional	1853-63	0.327	0.37	81	Jaintia Hills Sec.	1910-11	0.986	1.86
34	Assam Longitudinal	1854-60	0.579	0.71	82	Bhir Secondary	1911-12	0.794	0.94
35	Cutch Coast	1855-58	0.956	1.27	83	Ranchi Secondary	1911-12	1.840	2.34
36	Kashmir Principal	1855-60	0.854	0.86	84	Villupuram Secondary	1911-12	1.184	1.78
37	Jogi-Tila Meridional	1855-63	0.481	0.58	85	Sambalpur Meridional	1911-14	0.250	0.21
38	Sambalpur Lon.	1856-57	0.806	0.87	86	Indo-Russian Connection	1912-13	2.790	3.92
39	(Cutch) Coast Line Sec.	1856-60	0.975	1.47	87	Khandwa Secondary	1912-13	0.909	1.27
40	Kathiawar Minor Meridional No. 1	1858-59	0.930	1.51	88	Ashta Secondary	1913-15	1.046	1.33
41	Kathiawar Minor Meridional No. 2	1859-60	1.247	1.76	89	Buldana Secondary	1913-14	0.304	0.43
42	Kathiawar Minor Meridional No. 3	1859-60	0.969	1.48	90	Naldurg Secondary	1913-14	1.465	1.85
43	Bider Longitudinal	1859-72	0.311	0.30	91	Naga Hills Secondary	1913-14	0.918	0.96
44	Eastern Frontier or Shillong Meridional	1860-64	0.409	0.49	92	Middle Godavari Sec.	1914-15	0.913	1.08
45	Sutlej Meridional	1861-63	0.340	0.53	93	Kohima Secondary	1914-15	1.094	1.39
46	Madras Mer. and Coast	1861-68	0.426	0.46	94	Cachar	1914-15	1.077	1.65
47	Kathiawar Minor Meridional No. 4	1863-64	1.154	1.78	95	Bombay Island	1911-14		
48	East Calcutta Lon.	1863-69	0.379	0.57	96	Madura	1916-17	1.148	1.53
					97	Bagalkot	1916-17	0.701	0.83
					98	Sind Sagar Triangulation	1917-18	1.575	3.24

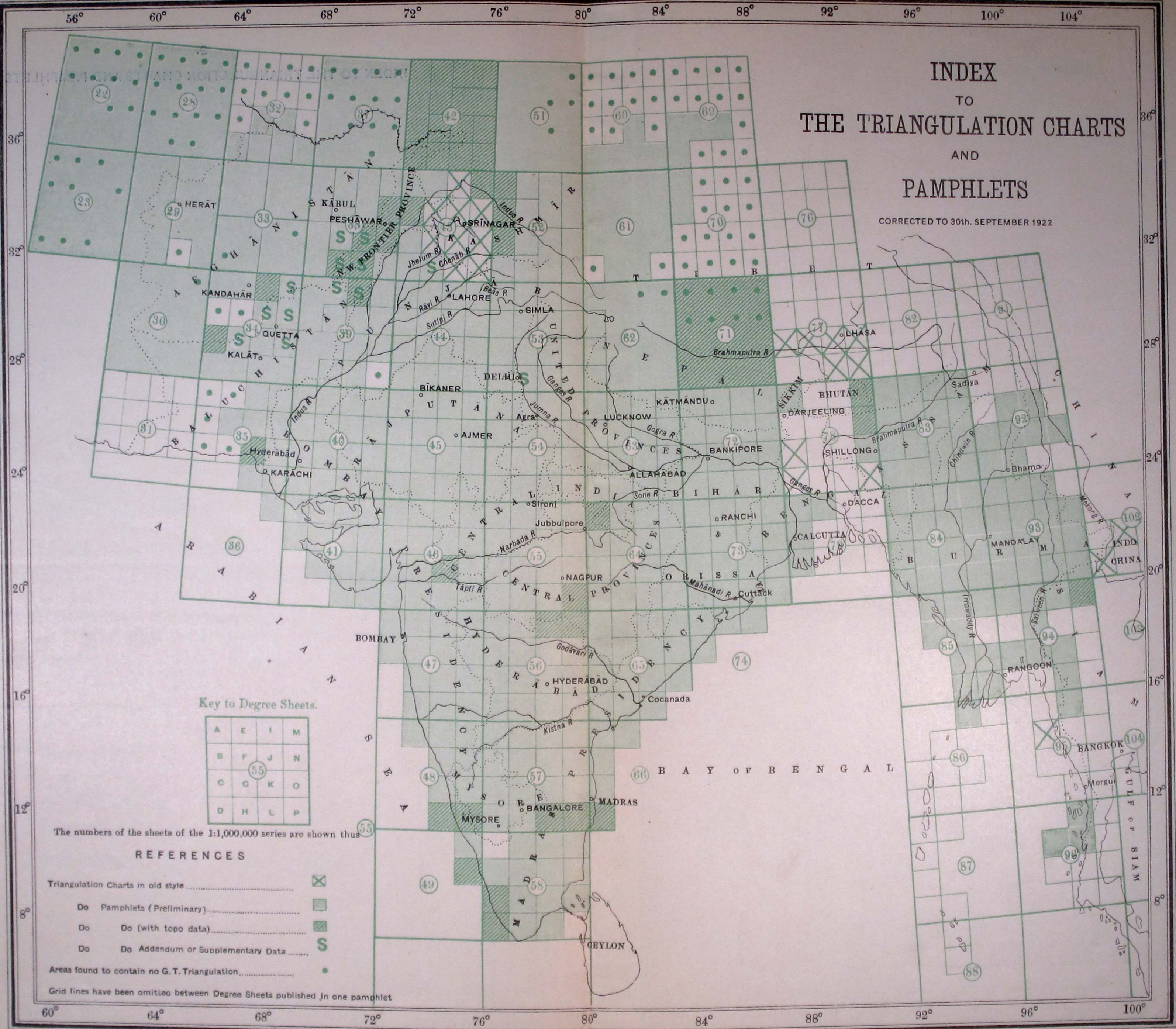
Mer. = Meridional. Lon. = Longitudinal. Sec. = Secondary.

REFERENCES
 G. T. Triangulation
 (1) Latitude Stations
 (2) Azimuth Stations
 (3) Pendulum Stations
 (4) Standard Bench Marks
 (5) Lines of precise Levelling (6) Lines of the level net in one direction only
 Telegraphic Longitude Area

NOTE.—Operations of 1921-22 are shown by thick lines.

INDEX TO THE TRIANGULATION CHARTS AND PAMPHLETS

CORRECTED TO 30th. SEPTEMBER 1922



Key to Degree Sheets.

A	E	I	M
B	F	J	N
C	G	K	O
D	H	L	P

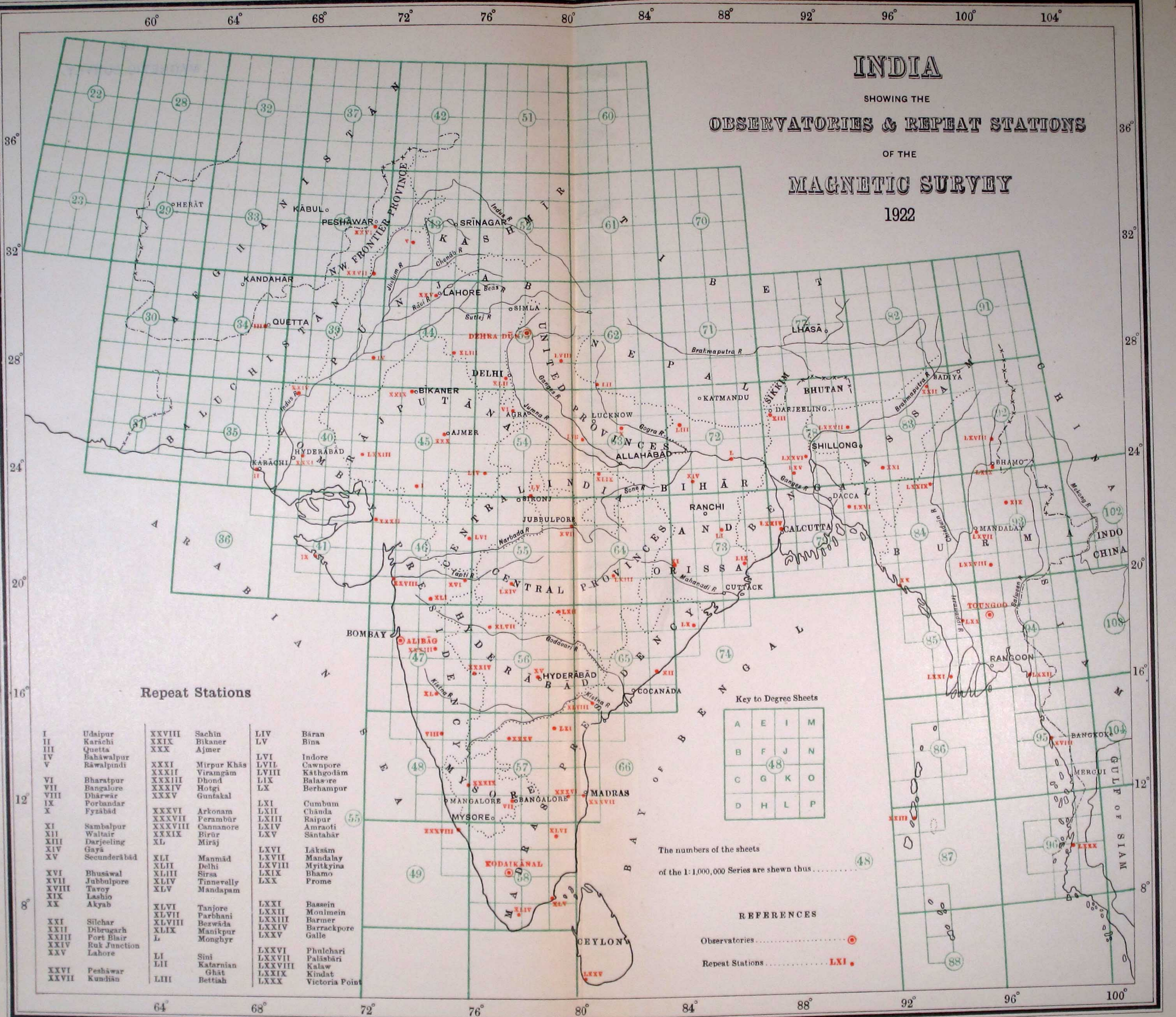
The numbers of the sheets of the 1:1,000,000 series are shown thus

REFERENCES

- Triangulation Charts in old style..... X
 - Do Pamphlets (Preliminary)..... □
 - Do Do (with topo data)..... ▨
 - Do Do Addendum or Supplementary Data..... S
 - Areas found to contain no G. T. Triangulation..... •
- Grid lines have been omitted between Degree Sheets published in one pamphlet

INDIA

SHOWING THE
OBSERVATORIES & REPEAT STATIONS
OF THE
MAGNETIC SURVEY
1922



Repeat Stations

I	Udaipur	XXVIII	Sachin	LIV	Bāran
II	Karachi	XXIX	Bikaner	LV	Bina
III	Quetta	XXX	Ajmer	LVI	Indore
IV	Bahawalpur	XXXI	Mirpur Khās	LVII	Cawnpore
V	Rawalpindi	XXXII	Virangām	LVIII	Kāthgodām
VI	Bharatpur	XXXIII	Dhond	LIX	Balasore
VII	Bangalore	XXXIV	Hotgi	LX	Berhampur
VIII	Dhārwar	XXXV	Guntakal	LXI	Cumbum
IX	Porbandar	XXXVI	Arkonam	LXII	Chānda
X	Fyzābād	XXXVII	Perambūr	LXIII	Raipur
XI	Sambalpur	XXXVIII	Cannanore	LXIV	Amraoti
XII	Waltair	XXXIX	Birūr	LXV	Sāntābār
XIII	Darjeeling	XL	Mirāj	LXVI	Lāksām
XIV	Gaya	XLI	Manmād	LXVII	Mandalay
XV	Secunderābād	XLII	Delhi	LXVIII	Myitkyina
XVI	Bhusawal	XLIII	Sirsa	LXIX	Bhāmo
XVII	Jubbulpore	XLIV	Tinnevely	LXX	Prome
XVIII	Tavoy	XLV	Mandapam	LXXI	Bassein
XIX	Lashio	XLVI	Tanjore	LXXII	Monlmein
XX	Akyab	XLVII	Parbhani	LXXIII	Barmer
XXI	Silchar	XLVIII	Bezwāda	LXXIV	Barrackpore
XXII	Dibrugarh	XLIX	Manikpur	LXXV	Galle
XXIII	Port Blair	L	Monghyr	LXXVI	Phulchāri
XXIV	Ruk Junction	LI	Sini	LXXVII	Palāsbari
XXV	Lahore	LII	Katarnian	LXXVIII	Kalaw
XXVI	Peshawar	LIII	Ghāt	LXXIX	Kindat
XXVII	Kundian		Bettiah	LXXX	Victoria Point

Key to Degree Sheets

A	E	I	M
B	F	J	N
C	G	K	O
D	H	L	P

The numbers of the sheets

of the 1:1,000,000 Series are shown thus 48

REFERENCES

- Observatories
- Repeat Stations