GENERAL REPORT

ON THE OPERATIONS

OF THE

GREAT TRIGONOMETRICAL SURVEY OF INDIA,

DURING

1874-75,

Prepared for submission to the Government of India.

BY

COLONEL J. T. WALKER, R.E., F.R.S., &C.,

SUPERINTENDENT OF THE SURVEY.

Dehra Dun:

PRINTED AT THE OFFICE OF THE SUPERINTENDENT G. T. SURVEY.

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IN 1874-75.

The following is a summary of the several operations of the present year, given in the order in which they will be found described in this report.

(2.) The operations carried on during the year under review have produced the following out-turn of work;—of Principal Triangulation, with the great theodolites of the Survey, 89 triangles, covering and area of 6,416 square miles, and disposed in chains which, if united, would extend over a direct length of 297 miles, and in connection with which 2 astronomical azimuths of verification have been measured;—of Secondary Triangulation, with smaller theodolites, an area of 4,049 square miles has been closely covered with points for the topographical surveys, and an area of about 6,000 square miles has been operated in *pari passu* with the principal triangulation;—of Topographical Surveying, an area of 2,176 square miles has been completed in the Himalayas, on the scale of one inch to the mile, and areas of 2,141 square miles, on the two-inch scale, and 1,208 square miles on the four-inch scale, in the course of which 2,026 linear miles of boundary and check lines have been traversed;—and of Geographical Explorations, much valuable work has been completed, on the Northern Frontier of Afghanistan, and on the lines from Ládákh to Lhása, and Lhása to Assam.

(3.) The principal triangulation has been executed with the great theodolites, whose azimuthal circles have a diameter of 24 inches, and are read by 5 equidistant microscopes. The average theoretical probable error of the angles, and the average geometrical error, of the triangles—the amount by which the sum of the three observed angles of each triangle differs from 180° + the spheroidal excess—are shown in the table given in the margin. The number of parties employed on the principal triangulation—which was originally fixed at six, but had by last year been reduced to four—has this year been reduced to three, the party employed on the Brahmaputra Meridional Series having been transferred, on the completion of that chain of triangles, to undertake secondary triangulation in Burmah.

Section.	Probable Errors of Observed Angles.		Geometrical Errors of Triangles.		Nature of country operated in.
	Number.	Amount.	Number.	Amount.	
I.	106	±0″·17	42	0″·55	Plains.
II.	56	·25	19	·48	Hills.
V.	84	·16	28	·47	„
Averages,...	...	±0″·18	...	0·51	

(4.) The financial administration of the Department during the present year has been exceedingly difficult and embarrassing. A large increase of expenditure had been occasioned by the introduction of the system of consolidated salaries, which was effected in 1874, under the anticipation that the increase might be met by 'savings in other quarters'; these savings have turned out to be illusive, and a further increase of expenditure has been incurred by the resumption of operations in Burmah, where almost every description of work is very much more expensive than it is in India proper. The orders and instructions for giving effect to the above measures were followed very speedily by orders for large reductions of expenditure; the latter could not be immediately carried out without keeping a large portion of the establishment of officers and surveyors unemployed; they are now to be gradually carried out within the next three years, by the stoppage of promotions, and a reduction of numbers as vacancies occur by death, retirement, or transfer to other Departments.

(5.) I now proceed, as usual, to report on and give an abstract of the operations of the several Survey Parties and Offices. Further details will be found in the Extracts from the Narrative Reports of the Executive Officers given in the first appendix; and a full account of the Trans-Himalayan Explorations will be met with in the second appendix.

NO. I.—TRIGONOMETRICAL.

THE RAMNAD LONGITUDINAL SERIES; PARALLEL 9¼°.

PERSONNEL.

Major B. R. Branfill, Dy. Supdt. 2nd Grade.
Mr. G. Belcham, Surveyor 4th Grade.
" C. D. Potter, Assistant Surveyor 1st Grade.
Mr. E. W. Loseron, Asst. Surveyor 2nd Grade.

(6.) The operations for the revision of the portion of the Great Arc which lies to the south of Bangalore having been completed, as stated in my last Report, the Madras party was deputed to commence the Rámnád Longitudinal Series, which is to trend east-wards from the Great Arc on the parallel of 9¼°, and had been approximately laid out during the previous year.

(7.) Several stations had to be built and the rays between them to be cleared, before the final observations could be commenced; the series had also to be extended along the coast to the Island of Rámesweram, with a view to the proposed connection of the Survey of India with that of Ceylon. Major Branfill himself took in hand the completion of the stations and rays of the first figure, and sent his assistants to build the stations and clear the rays further in advance. He commenced the final observations on the 29th December and completed six stations by the 20th January, when, finding that he was likely to overtake the station-building and ray-clearing operations—which would have brought his own work to a stand still—he left his assistant Mr. Belcham to continue the observations and proceeded in person to direct and accelerate the operations in advance. It was fortunate that he did so, for the belts of dense palmyra forest, intermixed with groves of cocoanut trees, made the selection of stations very difficult indeed. To carry a zigzag traverse in the vicinity of each ray through the forest was possible, but to clear the straight lines between the stations, down to the ground level, as usual, was found to be impracticable; thus to raise the stations to a sufficient elevation to overlook all intermediate obstacles was the only thing to be done, although the palms grew to a considerable height, and the ground was generally flat. By availing himself of sand hillocks, and constructing an ingenious portable braced stand for the theodolite, and lofty scaffolds for the signals, Major Branfill succeeded in overcoming all obstacles, so that by the end of the first week in March the work of station building and line clearing—to the extent of cutting down or lopping the branches of some of the most obnoxious palms—was complete, as far as Rámnád. The observations proceeded without interruption and were brought to a close by the 1st May.

(8.) Major Branfill's, next care was to extend the approximate series from Rámnád to Rámesweram, with a view to the Ceylon connection. After examining the country, he decided, on account of the increasing density of the palm forest and the rapid narrowing of the land, to utilize the islets of the coral reef which lies parallel to the mainland at the distance of 4 or 5 miles; he thus extended the series by a succession of quadrilaterals as far as the land's end. Next season the remaining portion of the triangulation to connect the Survey of India with that of Ceylon—a sketch map of which is given in my last annual report—will, it is to be hoped, be completed; the work however cannot be begun before the end of the month of January, when the violent winds of the north-east monsoon moderate, and open boats—the only craft this Department can afford to entertain—may ply between the islands in the Straits, to supply the signal and observing parties with water and food.

(9.) The out-turn of field work consists of 27 principal stations fixed by 42 triangles, forming 9 polygonal figures (6 quadrilaterals and 3 hexagons) which cover an area of 791 square miles, entirely in the plains, and extend for a direct distance of 90 miles from west to east. A set of star observations for azimuth was also taken, and 35 secondary points were fixed. I have every reason to be satisfied with the vigorous manner in which Major Branfill has carried on his operations, and with his judicious efforts to reduce their cost, by modifying the structure of the stations of observation, so as to utilize the advantages afforded by the timber

of the palmyra trees, as a set off against the serious difficulties presented by the superabundance of these trees, on the ground over which he was operating.

(10.) For some years past Major Branfill has been making a collection of the common place-names met with in Southern India, with their traditional root-meanings and local applications. A list of these will be found in the Appendix to this Report. Similar lists, collected from other parts of India, would doubtless be of much value to the ethnologist and philologer, as well as to the topographer, throwing some light on the language and history of the inhabitants, and even on the physical geography of the country.

NO. II—TRIGONOMETRICAL.

THE OPERATIONS IN THE ASSAM VALLEY.

PERSONNEL.

Lieutenant H. T. Harman, R.E., Officiating Asst. Supdt. 2nd Grade.
Mr. W. O'Sullivan, Sur. 4th Grade.
„ J. O. Hughes, Asst. Surveyor 3rd Grade.

(11.) Lieutenant Harman relieved Mr. W. Beverley of the charge of this party at Shillong, in October 1874, under instructions that he would be required to join the Survey Detachment accompanying the Field Force which was to be sent into the Daphla Hills in December. Thus it was a matter of great importance that he should take the field at the earliest date that it would be safe to do so, and mark out work for his European assistants and Native establishment to perform, during his absence with the military expedition. Starting from his Head Quarters at Shillong on the 3rd November, he was able to devote upwards of a month to the preliminary operations of the triangulation in the country between the Civil Stations of Jorhát and Dibrugarh, and to frame instructions regarding the work which was to be carried on in his absence.

(12.) On the 12th December he reached Borpathár, the second encampment of the Field Force, and reported himself to Major Godwin-Austen, of the Topographical Survey Department, who had been selected for the charge of the Survey Party which was attached to the expedition. He accompanied the Feld Force, as Assistant to Major Austen, until the 7th January, when he was deputed to make a reconnoissance of the Ranga Valley and the hill ranges to the east of the tracts occupied by the Force. Starting from the vicinity of North Lakhimpur, he marched for some distance along the course of the Páns river, taking the most direct and best line to the Daphla villages in the Ranga Valley, which line, though crossing the outer hill ranges, is more open and easily traversed than the route along the Ranga river. Even here however no roads or well trodden foot paths were found, the country was overgrown with dense forest and jungle, and the progress made in each day's march was very small. It was known that no food would be obtainable *en route*, and very little at the Daphla villages when they were reached; supplies of food had therefore to be carried with the party, by coolies, and their daily consumption rapidly decreased the general stock provided for all. Thus Lieutenant Harman was obliged to content himself with a guard of only 12 sepoys; and after reaching the Daphla villages he found that even these men were more than he could feed, and that he would either have to return at once with them, *re infectâ*, or to dismiss them and trust himself entirely to the people of the country. He chose the latter alternative, and succeeded in making good friends of the simple mountaineers; and, after completing his survey of their country, he eventually persuaded them to take him back to Lakhimpur by the Ranga Valley route, though at first they stoutly objected to doing so. They represented the track as very difficult, a mere hunting track, not passable for any man with a load, and certainly not for Assamese coolies, whom they appear to regard with great contempt. Lieutenant Harman found that their accounts of

the difficulties of the route were not much exaggerated, as there were places over which even his dog had to be carried; but latterly it appeared that the chief objections on the part of the Daphlas to taking him by this route were caused by apprehensions that they might thereby incur the enmity of their more powerful neighbours, the Abors, and be punished by them for so doing.

(13.) Lieutenant Harman worked right well, and showed much patience and tact in his transactions with the semi-barbarous inhabitants of a country which no European had ever before entered. He underwent much roughing and exposure, and incurred many risks, but these have been repaid by the success which has crowned his exertions. He has drawn up a very interesting account of his own operations and of the country and people, which will be published by the Surveyor General as an appendix to the Daphla Military Expedition Survey Report, by Major Godwin-Austen.

(14.) Lieutenant Harman had expected that his services with the Expedition would not be required for a longer period than six weeks. But it was not until the month of March, after an absence of nearly three months, that he was able to rejoin his own party and resume the trigonometrical operations. He then found that the amount of progress which had been made during his absence was not as great as he had anticipated; several lines had still to be cleared before the observations of the angles could be commenced. He laboured very vigorously to push the work forward, but found the difficulties too great to be surmounted in the short time remaining before the setting in of the rains and the consequent termination of the field season. In many places the forest was very heavy and dense; and worse than all were the occasional patches of jheel-canes "terribly armed with crooked thorns on every surface," through which the native line-cutters, with their wooden sandals and naked legs, could scarcely creep without suffering severely, and it was found impossible to clear the lines more rapidly than at a rate of little more than 100 yards in a day. Thus the rains had commenced before Lieutenant Harman was able to begin final observations at the stations between which the lines were clear; and very soon the country was flooded to such an extent as to become impassable. Lieutenant Harman had therefore no alternative but to quit the field and return with his party to his head quarters, at Shillong; he completed only two triangles, after expending an amount of labour and exertion on his work, which would have sufficed for a long line of triangulation in almost any other part of India; much of what was done will however be of future value, and tend to expedite the operations of the next field season.

NO. III.—TRIGONOMETRICAL.

THE SECONDARY TRIANGULATION IN BURMAH.

PERSONNEL.

W. Beverley, Esq., Offg. Assistant Superintendent 1st Grade.
Mr. J. W. Mitchell, Surveyor 4th Grade.
Mr. D. J. Collins, Asst. Surveyor 4th Grade.

(16.) In May 1874, I received an intimation from the Secretary to the Government of India, in the Department of Revenue Agriculture and Commerce, that the want of proper topographical maps had necessitated the suspension of the Geological Survey in Burmah, that isolated town surveys were being carried out; that Marine Surveys of the coast were shortly to be commenced; and that the government wished me to take early steps for the vigorous prosecution of the triangulation in Burmah.

(17.) Accordingly the party which had recently completed the Brahmaputra Series, as reported last year, was re-organized and transferred to Burma—under the charge of Mr. W. Beverley,—with instructions to carry chains of se-

condary triangles, from the nearest principal sides of the Eastern Frontier Series, in order to fix all large towns, prominent and permanent objects, peaks, &c., for Topographical and Geological Surveys, and the light-houses, &c., along the coast, for the Marine Survey.

(18.) The establishment was formed into two detachments; one was immediately under Mr. Beverley himself; the other was under his senior assistant Mr. Mitchell, who was now transferred from the Eastern Frontier Series, in connection with which, he had, during the previous season, laid out the design of a secondary triangulation to Pegu and Rangoon. This he was now to finish, while Mr. Beverley worked in continuation, in the country to the south of Rangoon.

(19.) Before commencing his own work, Mr. Beverley examined Mr. Mitchell's selections and found that they required to be modified to some extent. He then reconnoitered the country to the south, and laid out a triangulation down to the coast line near the mouth of the Rangoon river. He took observations to fix the positions of Elephant Point Column and Eastern Grove Light, and various points in the town of Rangoon for the Seaport Towns Survey. He then commenced the observations at the stations, north of Rangoon, connecting his stations to the south with the Eastern Frontier Series, but was unable to observe because of the unfavorable condition of the atmosphere. Two more attempts were made subsequently, on the commencement of the rainy season, but both without success; and the same result attended the resumption of the triangulation along the coast towards China Bakir Light.

(20.) Mr. Mitchell spent much time in reconnoitering the ground and laying out the triangulation to the north of Rangoon, and he took observations from seven stations; but owing to very bad weather, frequent attacks of illness, and other causes, he failed to carry out his share of the operations, and thus Mr. Beverley's work still remains unconnected with the principal triangulation, and consequently does not give any but roughly approximate results. It is expected however that the requisite connection will be made early next season, when the atmosphere will probably be clear and favorable for the observations.

NO. IV.—TRIGONOMETRICAL.

THE EASTERN FRONTIER SERIES, BURMAH.

(21.) In previous years the triangulation of this series had been brought down from Prome to the northern portion of the Shoay-Gheen Districts, the terminal side spanning the Sittang Valley at a distance of about 30 miles above the town which gives its name to the District. During the present year the series has been extended in a south-easterly direction, to within 40 miles of the town of Moulmein, the stations on the eastern flank resting on the hill ranges which separate the British territories from the Shan States tributary to Siam, while those on the west flank are near the coast of the Gulf of Martaban. Stations have also been selected in advance, through the Province of Tennaserim, to a short distance below the town of Amherst.

PERSONNEL.

W. C. Rossenrode, Esq., Deputy Superintendent 3rd Grade.
Mr. H. Beverley, Surv. 1st Grade.
" J. C. Clancey, Assistant Surveyor 3rd Grade.

(22.) In Section V of my last Report I have given a very full account of the great difficulties which are met with in conducting the operations of this Survey in Burmah, in consequence of the dense forest and growth of tropical vegetation which is usually met with everywhere, the sparse population, the reluctance of the Burmese to work for hire, and the practice in which they indulge of firing the grass jungles during the field season, and thus obscuring the atmosphere to an extent which renders all observations to distant points im-

possible. I need not repeat what has been said on this subject, but allusion to it is necessary, because similar difficulties have attended the operations of the present field season. Moreover some of the stations had to be placed on obligatory peaks of the hill ranges, so far away from the nearest human habitations, and so thickly fringed with forest, that no one was known to have ever reached them; the surveyors had to pioneer themselves with their compasses, and to cut their way onwards through the jungle, scaling great rocks and precipices, without any guide to lead them.

(23.) The out-turn of work comprises a quadrilateral, a double polygon and part of a hexagon, covering an area of about 3,150 square miles and advancing the series a direct distance of about 100 miles. Numerous secondary points were fixed both within and external to the principal triangulation. The preliminary operations for future triangulation were carried over a distance of about 100 miles, and have reached the parallel of Kálégouk Island, on which a station-site has been selected. The principal towns wherein points have been fixed are Shoay-Gheen, Pegu, Sittang and Bhiling; a secondary triangulation has been commenced towards the new Civil Station of Paphoon. The out-turn of work would be considered very good in any part of India, under far more favorable conditions for its achievement; under the actual circumstances of the operations it is all the more creditable to Mr. Rossenrode, and to Mr. H. Beverley, by whom the preliminary operations were conducted.

NO. V.—TRIGONOMETRICAL.

THE JODHPUR SERIES; MERIDIAN 72½°.

(24.) Captain Rogers returned from furlough and relieved Captain Hill of the charge of the party on the 20th November 1874.

PERSONNEL.

Captain M. W. Rogers, R.E., Officiating Deputy Superintendent 3rd Grade.
Mr. W. C. Price, Surveyor 4th Grade.
„ C. P. Torrens, Assistant Surveyor 3rd Grade.
Mr. P. F. Prunty, Assistant Surveyor 4th Grade.

(25.) The triangulation was extended northwards, through the Deserts of Jaisalmir and Bikanir. These tracts are apparently so called because, though inhabited by a comparatively large population during the rainy season and the early portion of the cold weather—when there is still a supply of water in the tanks—they are deserted in the hot season, when the tanks are all dry, and drinkable water is in many parts only to be obtained by being sent for to great distances. The water in the wells is usually brackish and unfit for human consumption; thus water for the survey camps had to be brought from distances averaging 10 to 20 miles, throughout the greater portion of the season.

(26.) The out-turn of work has been very good and creditable to Captain Rogers and his assistants. The principal triangulation was advanced 104 miles along the meridian by a series of polygonal figures, consisting of a pentagon, two hexagons and one double polygon, which cover an area of 2472 square miles. An astronomical azimuth of verification was measured at one of the principal stations. The preliminary operations, for the selection of the sites of stations in advance, were carried over a distance of 64 miles, towards the Sutlej Series. The positions of the towns of Bikanir and Pugal, and other points, were fixed by secondary chains of triangles.

NO. VI.—TOPOGRAPHICAL.

THE SURVEY OF KATTYWAR.

(27.) The operations of this topographical survey have been carried on under the executive charge of Captain Pullan, owing to the continued absence of Captain Trotter on duties connected with the Geographical Explorations in Eastern Turkestan and other regions beyond the British Frontier. The year has been uneventful in the history of the survey, but good progress has been made, both in the field work and the mapping.

PERSONNEL.

Captain A. Pullan, S.C., Offg. Deputy Superintendent 3rd Grade.
J. McGill, Esq., Offg. Assistant Superintendent 1st Grade.
Mr. F. Bell, Surveyor 3rd Grade.
„ N. C. Gwynne, Sur. 4th Grade.
„ W. A. Fielding, Assistant Surveyor 2nd Grade.
Mr. W. Oldham, Asst. Surveyor 3rd Grade.
„ G. T. Hall, Ditto 3rd „
„ H. Corkery, Ditto 4th „
Visaji Ragonath and 11 Native Surveyors and Apprentices.

(28.) The out-turn of final topographical work, on the scale of 2 inches to the mile, by this party embraces an area of 1749 square miles, comprising parts of Prants Hállár and Machhu Kánthá in Kattywar and a portion of the southern sea-board of Cutch. The area is less than what was covered last year, but this is satisfactorily accounted for by Captain Pullan, in his report. The triangulation executed in advance for the operations of next year covers an area of 2,200 miles, 200 of which are intended for the Survey of the Cutch Coast. In addition to the above, 1,117 linear miles of traversing were executed in order to demarcate the boundaries of Native States, and to check the details of the plane table survey.

(29.) In my Report for 1872-73, para. 47, I stated that when the operations of this survey should reach the shores of the Gulf of Cutch, every effort would be made to connect them with the survey of that Gulf which was made by Lieutenant Taylor, I.N. This has now been done, and the agreement between the two surveys is reported by Captain Pullan to be very satisfactory.

(30.) As regards the mapping, four new sheets, Nos. 32, 33, 34 and 35, have been drawn in such a manner as to be suited either for reproduction on the full scale of 2 inches to the mile, or for reduction by photography to the 1-inch scale.

NO. VII.—TOPOGRAPHICAL.

THE SURVEY OF GUZERAT.

(31.) During the present year Major Haig has been carrying on the system of operation which has been very fully described in Section VIII of my report for last year, whereby all surveys of British lands, which had been previously made in detail for fiscal purposes, by the Bombay Revenue Surveyors, are combined together, supplemented by topography wherever necessary, and mapped on the scale of 4 inches = 1 mile,—while the remaining portions of the British Districts, and the whole of the Native States, are surveyed and mapped on the 2-inch scale, as in Kattywar.

PERSONNEL.

Major C. T. Haig, R.E., Deputy Superintendent 2nd Grade.
Lieut. J. E. Gibbs, R.E., Assistant Superintendent 2nd Grade.
Mr. J. Peyton, Surveyor 1st Grade.
„ A. D'Souza, „ 1st „
„ A. D. L. Christie, „ 4th „
„ C. H. McAFee, „ 4th „
„ E. J. Connor, Asst. Sur. 1st „
„ J. Hickie, „ 2nd „
„ G. D. Cusson, „ 2nd „
„ G. Hall, „ 3rd „
„ S. Norman, „ 4th „
„ C. Norman, „ 4th „
Gopal Vishnu and 11 Native Surveyors and Apprentices.

REVENUE SURVEYORS.

Mr. T. A. LeMesurier.
7 Native Surveyors.

(32.) An area of 1,375 square miles has been topographically surveyed, of which 983 square miles was on the scale of 4 inches to a mile and 392 square miles on the 2-inch scale. Thus the out-turn of work, as measured by the area completed, is almost exactly double what it was last year, when the operations were of a tentative nature, and the best method of utilizing the Revenue

Survey details had still to be ascertained, by careful trial and investigation.

(33.) In the Dang Forests an area of about 550 square miles was triangulated. A small area in Sheet 79 was also completed with data points, by traversing, and a further area of about 300 square miles of British territory previously triangulated was prepared for survey on the 4-inch scale, by effecting the necessary connection between the fiscal details of the Revenue Survey and the stations, of the triangulation by means of traversing.

(34.) The country topographically surveyed includes portions of the Dholka, Viramgám and Dhandhuka talukas of the Ahmedabad Collectorate and of the Limri, Lakhtar, Wadhwán and Cambay States, all which have now been completely surveyed, and appertain to Sheets 81 and 82 of the general maps; also portions of the Ankleswar taluka of the Broach Collectorate and of the Olpád taluka of the Surat Collectorate, appertaining to Sheet 14.

(35.) The mapping has progressed very satisfactorily. Major Haig has introduced a valuable printed form, called the "Section Register", in which all the different stages through which each map has to pass are tabulated, so that it progresses regularly, and passes from one class of draftsman to another, according as the stages are divided among the different classes.

(36.) An interesting report by Lieutenant Gibbs of the country in the Dangs, in continuation of the one which was published in my report for last year, will be found at page 36—a of the Appendix.

(37.) The Surveyor General has expressed very decided opinions against the desirability of making any use whatever of the Bombay Revenue Survey details; he has represented to the Government that, in his opinion, the Guzerat maps, on the 4-inch scale, in which full use is made of those details, are not as essential for the requirements of the country as maps on half that scale, obtained from more speedily executed surveys, made without reference to the Revenue Survey work; and he has particularly advocated the early procuring of materials for the completion of the sheets of the Indian Atlas, which are engraved on a scale of somewhat less than ½-inch to the mile. A Committee of Survey and Engineer Officers was therefore appointed by the Government of India to report on the subject. The Committee were not able to agree upon any report; no definite conclusion was arrived at with reference to the utilization of the work of Bombay Revenue Surveys for topographical purposes; and irreconcileable differences of opinion existed regarding the relative cost and utility of surveys on the 4-inch and the 2-inch scales. Under the circumstances the Government had adopted a medium course, and directed that the 2-inch scale is to be employed in future, but that the Revenue Survey maps are to be utilized in the operations.

NO. VIII.—TOPOGRAPHICAL.

THE SURVEYS IN DEHRA DŪN AND THE SIWALIKS.

Personnel of the portion of the Kumaun and Garhwál Survey Party employed in the Dún.

Captain H. R. Thuillier, R.E., Offg. Deputy Superintendent 1st Grade.
Lt. St. G. C. Gore, R.E., Offg. Asst. Superintendent 2nd Grade.
Mr. C. J. Neuville, Surveyor 2nd Grade.
Mr. J. Low, Surveyor 3rd Grade.
" L. J. Pocock, Surv. 4th Grade.
" H. Todd, Asst. Sur. 1st Grade.
" T. Kinney, " "
" E. P. Wrixon, " 2nd Grade.
11 Native Surveyors.

(38.) These surveys are being made conjointly by a portion of the Kumaun and Garhwál Party under Captain Thuillier, and by the survey branch of the Forest Department which has been lately created and placed under Captain Bailey—with a view to executing special surveys for the requirements of forestry—and, while under formation, has been temporarily affiliated to this Survey.

(39.) The survey of the non-forest tracts of the Dehra Dún District, by Captain Thuillier and his party, has made good progress during the year, and Captain Thuillier hopes to be able to complete it, as well as the survey of Jaunsár Báwar, in the next field season.

(40.) The field operations were commenced early in October and continued to the end of April. 225 square miles of country were topographically surveyed on the scale of 4-inches to the mile in the Dún. The whole of Jaunsár Báwar was covered with a net-work of triangles, comprising an area of 470 square miles; 398 linear miles of boundary traverses were executed, and 63 miles of check lines were run over the topographical work of the surveyors.

(41.) The country surveyed presents ground of very varied descriptions, from the flat cultivated lands in the vicinity of the River Asan—a tributary of the Jumna, and the main drainage channel of the Western Dún—to the crest of the Mussooree range, which rises to a height of 5,000 feet above the level of the Dún. The low spurs and broken tracts about the foot of the hills gave an infinity of trouble, both in delineating the features of the ground, and in chaining the boundary traverses; in the latter operation very heavy corrections were required for the reduction of hypothenusal to horizontal values.

(42.) Captain Thuillier reports favorably of the progress of his Native Surveyors, who are said to be improving in the art of delineating ground with the plane table; their traversing work was all reduced in the field and found to stand the usual tests in a satisfactory manner. As the survey advances and the Native Surveyors become better trained, the introduction of this cheap agency may be expected to have a very appreciable effect in expediting the completion and reducing the cost of the work.

(43.) The Index Map of the Dehra Dún and Siwalik Survey, which is attached to this report, shows very clearly the extent of work completed and remaining for execution by Captain Thuillier's party. The uncoloured portions of the map represent the forest tracts which have been or are being surveyed by Captain Bailey.

(44.) Captain Bailey's Annual Report has already been submitted to Government through his own Department, together with my review of his operations. It is here therefore unnecessary for me to say more than that the out-turn of topography is about 288 square miles, which has been done on the same scale as the non-forest tracts by Captain Thuillier; the amount of the boundary and interior traversing was 326 miles. The ground operated over was very broken and difficult, more particularly in the interior of the Siwalik Hills, the intricacy and ruggedness of which are probably unsurpassed by hill ranges of the same altitudes in any part of the world.

(45.) The out-turn of topography executed by these two parties may be considered small, as compared with that of other topographical parties working on the standard scale of 1-inch to the mile, in Native States and in Districts where minute delineation of the features of the ground is not required; or even with that of Revenue Survey parties, working on the same scale and with much attention to detail, but in flat and open country, which requires little or no topographical delineation. In Captain Thuillier's operations the average monthly out-turn of topographical area, during the field season, by a party of plane table surveyors, consisting of 1 European and 2 Natives, was 10 square miles; in Captain Bailey's with two more natives in each party, it was 7¼ square miles; in both cases the native surveyors were new hands under training, but the Europeans in the former were, as a rule, older surveyors and better skilled than in the latter. I am satisfied that there was no want of exertion and painstaking in the execution of the operations, and that a larger out-turn could only have been secured by a sacrifice of fidelity and exactness, in the delineation of the ground.

(46). The conjoint survey will form a map in 42 sheets; of these 18 have been completed and deposited in this office, and 15 have been reproduced to full scale and published by photo-zincography.

NO. IX.—TOPOGRAPHICAL.

HIMALAYAN SURVEYS IN KUMAUN AND GARHWAL.

(47.) During the rainy season of 1874, a detachment from Captain Thuillier's Party, under Mr. Ryall, was located at Almora, the nearest point to the scene of the future field operations at which the recess quarters of the party could be established. Before the rains were well over, Mr. Ryall and his assistants had to take the field, in order that they might reach the lofty ground they had to survey, and make the most of the short interval during which the snow line is at its highest and the atmosphere is bright and clear; this occurs between the cessation of the autumnal rains and the setting in of winter weather.

PERSONNEL.

E. C. Ryall, Esq. Officiating Assistant Superintendent 1st Grade.
Mr. C. H. McAFee, Assistant Surveyor 1st Grade.
Mr. E. F. Litchfield, Assistant Surveyor 3rd Grade.
Mr. I. S. Pocock, Assistant Surveyor 4th Grade.
Mr. J. F. McCarthy, Assistant Surveyor 4th Grade.

(48.) Mr. Ryall conducted a series of triangles through a stupendous gorge overhung by the lofty mountains of Chirkhana and Husaling; an undertaking which, he says, required all his skill and nerve. He also supervised the operations of his assistants who were employed in plane tabling on the scale of one inch to the mile. The difficulties this little detachment had to contend with in the lofty region in which they were employed, and which were successfully overcome, are fully detailed in the Appendix and they reflect credit on all concerned. Captain Thuillier draws particular attention to Mr. I. Pocock's work in the upper part of the Mána Valley, where the average height of the ground surveyed was over 21,000 feet and the maximum height reached was 22,040 feet above sea level.

(49.) The area topographically surveyed comprises 2,176 square miles, and the portion of country triangulated in advance covers 800 square miles. There now remains only about 1,200 square miles in the Mulla Jower, Dharma and Báyáns Valleys to survey, which will complete the unfinished portion of Garhwál. But as the operations in these desolate regions—to which supplies of food and fuel have to be transported from great distances—are necessarily of a somewhat costly nature, their completion has been postponed for the present, and it will not be undertaken until the expenditure can be met by savings in other quarters.

NO. X.

SPIRIT LEVELING OPERATIONS IN THE MADRAS PRESIDENCY.

(50.) Captain McCullagh, on his return from furlough, succeeded to the charge of these operations, *vice* Lieutenant Harman who had been transferred to Assam. He commenced work at the S.W. end of the Bangalore Base, the height of which had been provisionally ascertained by triangulation which rests on a determination of the mean sea-level at Madras, by Colonel De Haviland. He then carried a line of levels, *viâ* Túmkúr, Sira, Hiriyur Tallak and Rámpur, to to Honur H.S. and into Bellary, from which station the work was continued, *viâ* Alúr, Adoni, and Máduwáram to Raichore Railway station, where it was closed on the 3rd April 1875. The operations were carried on in a very satisfactory manner, and the aggregate length of the lines completed is 297 miles.

PERSONNEL.

Captain J. R. McCullagh, R.E., Officiating Assistant Superintendent 1st Grade.
Mr. A. H. Bryson, Assistant Surveyor 3rd Grade.
Two native recorders.

(51.) At Bellary a junction was effected with the line of levels which had been carried from there to the Port of Karwar—on the western coast—by Lieutenant Harman, in the preceding field season. Captain McCullagh's height of

the point of junction is 4·5 feet greater than Lieutenant Harman's; but the discrepancy is believed to be in great measure due to inaccuracies in the determinations of the datum points of the respective lines, both of which are provisional only; final results will not be obtained until the mean sea-level has been exactly determined at Karwar, and probably at Madras also; the difference of level between Madras and Bangalore also needs to be more exactly determined than at present.

NO. XI.—TIDAL OBSERVATIONS.

DETERMINATIONS OF MEAN SEA-LEVEL IN THE GULF OF CUTCH.

(52.) The primary object of these operations is to determine the existing relations between the level of the land and the sea at certain points on the coasts of the Gulf of Cutch, as a first step towards investigating the question whether progressive changes are taking place in the level of the land at the head of the gulf, as has long been supposed to be the case. It is under contemplation to repeat the operations a few years hence, at the same points, with a view to ascertaining the relations which will then obtain between the land and sea; a comparison between the results of the two series of determinations will show whether any sensible variation of level has occurred in the interim.

PERSONNEL.

Captain Baird, R.E., Offg. Deputy Superintendent 3rd Grade.
Mr. T. Rendell, Asst. Sur. 1st Grade.
Narsing Dass, and other Sub-Surveyors.

(53.) The operations were commenced in 1873; their annual progress, and the several instruments employed, have been very fully described in my reports for 1872-73, and 1873-74. I may here however repeat that the tidal stations are three in number, and are situated respectively at Hanstal Point, near the head of the gulf; at Nawanár Point, half way up on the northern coast; and at Okhá Point, on the southern coast and near the entrance to the gulf. At each station a self-registering tide gauge was set up, and it was a part of the programme of the operations that the relative levels of the three stations should be determined by running lines of very carefully executed spirit levels between them. No harbour walls or piers being available, at either place, for the tide gauges to be erected on—over deep water—it was found necessary to set up the instruments on shore, at the nearest points to deep water, and to connect them with the sea by a system of piping, of which the land portion was rigid and the sea portion flexible. The flexible piping terminated in a 'rose', which was suspended from a buoy in deep water, while the rigid piping was conducted to the bottom of an iron cylinder, which was sunk vertically—its lower end being closed by an iron plate—into a masonry well over which the tide gauge was erected. The sea water passed freely through the piping into the cylinder when the tide was rising, and back again when the tide fell, the level of the water in the cylinder being always identical with that of the sea at the same moment, when there was no air in the piping; by means of a stop-cock which was attached to the highest bend of the piping, any air, which might have accumulated internally—as occasionally happened—could be readily expelled whenever the level of the sea rose above that of the stop-cock, which occurred twice daily. The float of the tide gauge rested on the surface of the water in the cylinder, and its rise and fall was duly registered on the barrel of the gauge. Each station was furnished with self-registering instruments for recording the direction and velocity of the wind and the barometric pressure. A native surveyor with a few assistants was placed in charge, and located in a hut in the immediate vicinity of the station. Periodical inspections were made by Captain Baird, and by his assistant Mr. Rendell, and on these occasions the clock errors were determined, the cylinders and pipes cleared of any silt which had been deposited in them, and the instruments thoroughly overhauled.

(54.) Much time was necessarily occupied in the construction of the stations and in getting the instruments into good working order. The regular tidal registrations were commenced, at Okhá in December 1873, at Hanstal in March 1874, and at Nawanár in April 1874. It was hoped that they might be carried on continuously for at least a year, if not longer, at each station, a shorter period being inadequate to furnish the requisite data for an investigation of each of the principal tidal constituents. Considerable anxiety was however felt as to what might happen during the season of the monsoons, when heavy gales are prevalent; but every precaution was taken to strengthen the wooden observatories in which the instruments were set up, and to anticipate and provide for all possible contingencies.

(55.) The monsoon of 1874 set in with great severity and lasted long; but the observatories all stood firm, and the tide gauges and the other self-registering intruments remained in good working order, at all the stations, throughout the season. Unfortunately however at Nawanár the entire configuration of the fore-shore became altered, and an extensive sand spit was formed, below the low water level, on the line of piping, which became completely buried. This occurred in the month of July, and necessitated the suspension of the registrations at Nawanár, until such time as the piping could be extracted and again put into communication with deep water. It was expected that the original configuration of the fore-shore would probably be restored by natural causes, when the wind veered round to its usual direction, which would occur soon after the commencement of the cold weather months; but this expectation was disappointed, and, as the cold season wore on, it became only too certain that the piping which lay beyond the low water line would never be recovered. A supply of new piping was therefore obtained from Bombay and attached by Mr. Rendell to the land portion of the original pipe, and by the commencement of the month of March 1875, after a break of nine months duration, the tide gauge was once more in free communication with the sea, and there appeared to be every probability that it would so remain, at least until the setting in of the next monsoon.

(56.) But the station of Nawanár appears to have been fated to be a trouble and a vexation. Within a fortnight after Mr. Rendell had re-started the tide gauge, he returned, from an inspection of Hanstal station, to see how matters were progressing, and found that during his absence considerable changes had again taken place; the fore-shore had been rapidly shallowing, and the new piping was being fast covered with a deposit of silt and mud, which had nearly reached up to the level of the rose at its outer extremity. He cut it away at once, and substituted several lengths of iron piping, which were held in suspension above the surface of the shore, by being attached—at a level a little below that of the lowest spring tides—to stakes driven vertically into the ground for the purpose. Mr. Rendell remained on the spot for the next two months, taking steps to prevent the rose from being reached by the constantly rising mud and silt; he thus succeeded in getting satisfactory and continuous registrations for the whole of the time, and he checked them by a series of hourly readings taken *pari passu* on a graduated staff, which had been set up in the sea, in deep water, in order to afford a means of verifying the indications of the self-registering gauge.

(57.) At Okhá station all went on most satisfactorily throughout the monsoon of 1874 and the following field season; there were very few breaks of continuity in the registrations, and they were very short and of no importance. At Hanstal the breaks were more numerous and longer; here the water was very muddy, and not pure and clear as at Okhá; consequently there was a tendency for a sediment of mud to be deposited in the cylinder of the gauge and in the piping; this sediment had to be cleared out occasionally and then the registrations were necessarily interrupted; but the breaks in the curves are of no material importance, and they can be filled in by hand from the outlines of the collateral curves, without any risk of significant error.

(58.) The most trying and difficult portion of the operations was the

carrying out of the periodical inspections during the monsoon of 1874. This had proved to be so arduous, and to entail so much exertion and exposure on the officer on whom the duty devolved, that I felt I should not be justified in requesting Captain Baird to carry on the operations through the monsoon of 1875. I therefore directed him to continue the registrations up to within a few days of the commencement of the monsoon, and then to dismantle all the stations, and remove the instruments. These instructions were duly carried out in the month of May.

(59.) Thus the periods during which the tidal heights have been continuously registered at the three stations, are 16½ months at Okhá, 14 months at Hanstal, 2 months at Nawanár in 1874 and 2 months more in 1875. Simultaneous registrations of the direction and velocity of the wind, and of the barometric pressure, were made by the anemograph and the barograph, which were set up at each station.

(60.) The long break in the registrations at Nawanár is to be regretted. But as the station lies nearly midway up the gulf, it is probable that the values of the difference between the mean level for the periods of actual observation and the mean level for the entire year, which are given by the registrations at Okhá and Hanstal, may be safely applied to the results at Nawanár, to obtain the mean level for the year there. Captain Baird has already done this, and obtained very accordant and promising results.

(61.) During the field season of 1874-75, the work of inspecting the observatories, rating the clocks, and maintaining every thing in satisfactory working order, devolved chiefly on Mr. Rendell. Captain Baird was principally employed in conducting spirit leveling operations, for determining the relative levels of the datum points of the three tidal stations, and of the stone bench-marks which had been laid down, a year previously, along the lines to be leveled over. The length of the main lines connecting the three tidal stations was 275 miles, which was leveled over independently by Captain Baird and Narsing Dass, in accordance with the rigorous system of operation which has been followed for several years past in this Department; 29 miles of branch lines were also executed, in order to connect the stations of the Kattywar triangulation with the tidal stations.

(62.) In working between Nawanár and Hanstal, Captain Baird had to make a considerable detour round the head of the gulf, crossing the Runn between Shikarpúr and Malliá. Several bench-marks were fixed on the Runn, and they will be important points of reference when the operations are repeated some years hence. The existing surface level of the Runn has been obtained at a number of points, for Captain Baird took the precaution of having all the pins on which the leveling staves were set up, driven downwards until their heads were exactly flush with the surface of the ground.

(63.) At the close of the field season, the instruments were taken down and the observatories were dismantled. At each station the vertical iron cylinder, in which the float of the gauge had acted, was left *in statu quo*, together with a length of about 50 feet of the iron piping extending sea-wards from the cylinder. The cylinder was filled with clean dry sand, and closed above with a thick planking, after which a massive pile of stones was raised over the ground around it to serve the double object of a protection, and an indication of the position for future reference. The three bench-marks in the immediate vicinity of the cylinder, with each of which the datum of the gauge had been connected, were similarly covered over. Finally the several cairns were placed under the protection of the local officials; and it is to be hoped that the cylinders and bench-marks will be readily discovered whenever the second series of operations are commenced, and that they will be found to have remained undisturbed meanwhile.

(64.) Thus the first series of operations, to determine whether the relations of land and sea are constant or changing, is now an accomplished fact. Great credit is due to Captain Baird for the manner in which he has conducted the task entrusted to him. The difficulties he had to contend with, in obtaining exact re-

gistrations continuously for such long periods, were very serious and formidable; all the stations were situated at points on the coast line which were very far from the nearest habited localities; and the inspections during the season of monsoons, which work was done entirely by himself, necessitated constant travelling during the most inclement time of the year, and entailed an amount of risk and exposure which would tell on a constitution of iron.

(65.) The final reduction of the registrations at each station has been commenced, but it will still take some time to complete. The following preliminary results have however been obtained from the combined tidal and leveling operations—*viz.*, that the mean sea-level is higher, by 7 inches, at the head of the gulf, and by 4 inches, midway up, than it is at the mouth of the gulf.

(66.) During the present year the tidal observations which were taken at the Port of Tuticorin, in the year 1871-72,—with a self-registering tide gauge, similar in all respects to those employed by Captain Baird—have been reduced by the harmonic method, by Mr. Roberts of the Nautical Almanac Office, who has long been employed in reducing tidal observations for the British Association, and whose good services, in aiding Captain Baird in the preparation of his Notes on the Harmonic Analysis of tidal observations, I have already acknowledged in my report for 1872-73. Mathematical expressions have been deduced for each of the several tidal constituents, by means of which the height of the tide, at any moment, may be computed with great exactitude.

NO. XII.—GEODETIC.

ELECTRO-TELEGRAPHIC DETERMINATIONS OF LONGITUDE.

(67.) In consequence of Captain Herschel's absence from this country, on leave to Europe, and of the services of Captain Campbell having been placed at the disposal of Colonel Tennant for an entire year—to assist in the operations connected with the observations of the Transit of Venus at Roorkee—the differential determinations of longitude by the electro-telegraphic method, which were commenced in 1872-73, have been suspended, and the two assistant surveyors and small native establishments employed on them were transferred temporarily to the parties under Major Branfill and Captain McCullagh.

(68.) Captain Campbell's services were replaced at my disposal at the end of April, when the field season of 1874-75 was so nearly ended that it would not have been practicable to resume the electro-telegraphic operations. Captain Campbell came up from Roorkee to Mussooree to frame with me a programme of operations for the following field season, to be undertaken by himself and Captain Heaviside, whose services would be shortly available, for the purpose.

(69.) The first part of the programme was to endeavour, during the approaching season of recess, to ascertain the cause of the imperfect performances of one of the Transit Instruments, while employed in the operations on the line Madras-Bangalore-Mangalore, and to dispense with the induction coils—involving troublesome batteries and frictional electricity—which had hitherto been a constantly recurring source of failure and disappointment in the manipulation of the electric chronographs; *vide* paras 79 and 85 of my report for 1872-73. Both these duties have now been successfully accomplished, as will be seen on reference to Captain Campbell's report in the Appendix. The reduction of a portion of the previous observations—which remained in hand when the party had to be broken up, and has been held in abeyance ever since—has now been completed by Captain Campbell; the final results from the whole of the observations have been found to differ by only ·03 of a second of time, from the preliminary results by a portion of them which have been already published.

NO. XIII.—GEOGRAPHICAL.

YARKAND MISSION. TRANS-HIMALAYAN EXPLORATIONS.

(70.) In my report for last year I stated that, on the return of Sir Douglas Forsyth's Mission to Eastern Turkestan, Captain Trotter—who had been attached to the Mission on my recommendation, in order to utilize any opportunities which might occur for prosecuting geographical investigations—had returned to the Head Quarters of this Survey, and was supervising the reduction of his astronomical observations and the compilation of a map of the country, which were being done for him in this Office.

(71.) The map and his Narrative of the Geographical Operations, with full details of the results, have already been submitted to the Government, and are published in the Official "Report of a Mission to Yárkand in 1873, under the command of Sir T. D. Forsyth, K.C.S.I., C.B.", which was printed at the Foreign Department Press in 1875. It is now therefore only necessary for me to give a brief capitulation of the geographical acquisitions which were the fruits of the labours of himself, and of the Pandits and other natives especially trained for Himalayan Explorations, who were sent to assist him.

1st. The positions of Káshghar, Yárkand, Tashkurghán and Kila Panjah (on the River Oxus, in Wákhán) have been very exactly determined, by astronomical observations; they have been used as the basis of the mapping, and the positions of all other places have been laid down differentially from them.

2nd. The routes from Káshghar to the Chadirkul Lake, on the north, to the Belowti Pass, on the north-east, and to Marálbáshi, on the east, have been surveyed, the two first by Captain Trotter and the third by Captain Biddulph. The one to the Chadirkul Lake had been previously surveyed by Russian Officers, and it serves as the first connecting link between the British and the Russian Surveys in Central Asia.

3rd. The routes from Káshghar to the south-west, to Badakshán and Kabul, *viâ* Tashkurghán and the Pámir Lands, have been surveyed up to Kila Panjah and to points in Wákhán and near the sources of the River Oxus, some of which had been previously fixed in 1837 by Lieutenant Wood of the Indian Navy, and others by the Native Explorer who is known as the Mirza.

4th. The course of the Panjah Branch of the River Oxus has been surveyed from Wákhán through Shighnán, and down to Kila Wámar and Pigish in Roshán, whereby a considerable portion of the remarkable bend in the river, along the northern border of Badakshán, of which nothing was known previously, has now been clearly defined.

5th. The routes from Yárkand to Khotan, and from Khotan to Kiria and the Sorghák gold fields, on the road to China, and from Kiria southwards, across the Kuen Luen range and the Thibet plateau to the vicinity of Gartokh and Rudokh, have been surveyed.

6th. Various routes between Ladákh and Eastern Turkestan over the Karakoram and the Kuen Luen ranges have been surveyed, some for the first time, though of others we were already in possession of maps of varying degrees of accuracy, which had been constructed by Messrs. Johnson, Hayward and Shaw.

(72.) All these, and more particularly the surveys of the routes over the Pámir Lands and of the course of the Oxus, are very valuable additions to the geography of Eastern Turkestan; and they are especially gratifying to myself as having been obtained, almost entirely, through the instrumentality of an Officer of this Department who was attached to the Yárkand Mission on my recommendation, in order to make the most of the opportunities which would be afforded for surveying these interesting, but hitherto badly mapped, regions.

(73.) On the completion of his map and report, Captain Trotter was about to proceed to Europe, when the Havildar who had been deputed to make a survey of the unknown portions of the course of the River Oxus, and the Pandit who

had been deputed to survey the direct road from Ladákh to Lhása and then to make further explorations, returned to Head Quarters, almost simultaneously, though from such opposite directions. Each of them brought with him numerous journals and records of astronomical observations and route surveys, from which maps had to be constructed and the information extracted and put into a suitable form for publication, as has been done by Major, now Lieut. Colonel, Montgomerie in his reports of the Trans-Himalayan Explorations. Believing that this work could not be performed by any one better than by Captain Trotter, I asked him to postpone his return to Europe, and to undertake it; and he cordially assented to my proposal, though he was thereby disappointed of the gratification of an early return to Europe, which he had been looking forward to. It is to him therefore that I am indebted for the "Report on the Trans-Himalayan Explorations during 1873-74-75", which accompanies this report, and of which I now proceed to give a brief epitome.

(74.) Starting from Kabul, the Havildar struck at once to the north, instead of taking the usual circuitous route to the west, by the Bámian pass. He crossed the Hindú Kúsh range by the Sarolang pass, and, descending to Khinjan, took the direct route by Nárin and Ishkamish to Faizabad in Badakshán, the greater portion of which had never before been surveyed. Thence he proceeded *viâ* Rusták to Koláb, crossing the Oxus at Samti. His instructions were to follow the course of the Oxus upwards, as closely as possible; but he found that this would have led him away from the main lines of communication and rendered him open to suspicion, and that to advance at all into this *terra incognita*, it would be necessary for him to preserve his assumed character of a travelling merchant, and to keep to the most frequented roads. He proceeded in a north-easterly direction, *viâ* Khawáling and Ságri-dasht, to Kila Khumb (the capital of Darwáz) where he again struck the river – here called the Panjah—at the northernmost point of the bend in its course through the mountains, between its rise in the Pámir plateau, and its downward plunge into the plains of Koláb and Badakshán. From Kila Khumb the Havildar advanced for a distance of about 50 miles in a south-easterly direction, along the right bank of the river, making a detour to Kila Wanj *en route*; and finally he reached Yazghúlám, the frontier village of the principality of Darwáz. Most unfortunately he was turned back at this point, under orders from the Khan of Darwáz, who happened at the time to be at enmity with the Khan of Shighnán. Thus his exploration of the river was stopped at a distance of about one long day's journey from Pigish, the lowest point reached by Captain Trotter's native surveyor from the opposite direction. Being ignorant of what this man had already done, and most anxious to complete his survey of the bend of the river, the Havildar eventually returned to Faizabad, and went on to Ishkashim, the well known village on the river, at the eastern end of the bend; he then followed the river downwards, but was again stopped and turned back, this time by the Khan of Shighnán. There is therefore a gap, probably of about 20 miles, between the work of the Havildar from the west, and that of Captain Trotter's agent from the east, which is to be much regretted; but on the other hand it is a matter of congratulation that so large a portion of the course of the Oxus, which was unknown when that river was adopted as the Northern Boundary of Afghanistán, by the British and the Russian Governments, has now become clearly defined.

(75.) Compelled to return from Yazghúlám to Koláb, the Havildar, instead of directly retracing his steps to Faizabad, struck westwards, through regions, on the north bank of the Oxus, of the geography of which very little was known. His route determines the position of the important town of Kabádián, and proves that the Surkháb River—which rises in the Alai plateau to the south of Khokand, and passes through the principality of Karátigin—joins the Oxus, not near Koláb, as has long been supposed, but at a point about 80 miles lower down. His route survey was carried southwards from Kabádián,—crossing the Oxus at the Iwachik ferry—down to the well known town of Khulm, and thence eastwards, *viâ* Kunduz and Talikhán, back to Faizabad.

(76.) While the Havildar's observations were being worked out and mapped in this Office, information was received of the Russian expedition to Hissár, in the summer of 1875. As yet no full accounts or maps, which may have been published by the members of the expedition, have reached this country; but from the "Glance at the Results" by Herr. P. Lerch, which is translated from the *Russische Revue*, and published with notes by Colonel Yule in the Geographical Magazine for November 1875, it appears that Koláb and Kabádián are two of the points which were visited and fixed by the Russian Officers. Thus a second connecting link has been obtained between the British and the Russian surveys in Central Asia.*

(77.) A Mullah, who had been recently trained by the Havildar, was deputed to explore the course of the Kunar River, from its junction with the Kabul River near Jalálabad, to Chitrál, and then on to its source in the Hindú Kúsh range. This man ascended the river as far as Asmár, where he found any further direct advance impossible at the time, because the people of Asmár were at war with the neighbouring Káffir tribes. He therefore made his way over the range of hills on the left bank of the river to Janbatai, a place on the Havildar's route in 1870 from the Punjab to Badakshán, which route the Mullah followed as far as Chitrál. Thence he struck into new ground, ascending the course of the river, *viâ* Mastuj, up to the Baroghil pass; and after crossing the pass he worked up to Sarhadd Wákhán, the position of which had been fixed by Captain Trotter. His work was very carefully executed, and it has shown that the positions for Dir and Chitrál, which were determined by the Havildar, require to be altered by a few miles. It gives the entire course of the Kunar river with the exception of a length of about 25 miles through the Káffir hills immediately above Asmár.

(78.) Pandit Nain Singh—the Pandit *par excellence* of Major Montgomerie's Trans-Himalayan Explorations, whose name it is no longer necessary to suppress as he has recently retired from active employment—was one of the explorers who were attached to Sir Douglas Forsyth's Mission, with a view to being sent into the countries lying either to the north or the south of the Gobi Desert, should an opportunity present itself. As this was not found to be feasible, he was sent, on his return from Yárkand to Leh, on an exploration to Lhása, by a route lying considerably to the north of the one which he had previously taken, and which is described in my report for 1866-67. His instructions were to return to India from Lhása *viâ* China, if possible, otherwise by some hitherto unexplored route through the Bhotan Hills.

(79.) He left Leh in July 1874, and succeeded in crossing the Thibetan frontier, in the disguise of a Láma, or Buddhist priest. Passing about 15 miles to the north of Rudokh, he travelled nearly due east for a distance of more than 800 miles, over a new line of country, separated from the valley of the Tsanpo—or Great River of Thibet—by an almost continuous range of snow mountains, which trends eastwards from the Alang Gángri peaks, in longitude 81°, up to the Ninjin Thangla peaks, south of the great Tengri Nur Lake, in longitude 90½°. His road lay, throughout, over an extensive table land ranging in height from 13,900 to nearly 16,000 feet above the sea level, a region containing a few gold

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* While these pages were being passed through the press I received a copy of the table of "the Latitude, Longitude and Altitude of certain points in Hissár by M. Schwartz, a member of the Scientific Expedition of 1875 to that country", which is published in the Russian Turkestan Gazette No. 49 dated $\frac{9}{21}$ December 1875. The positions it gives for Koláb and Kabádián are very fairly accordant with those deduced from the Havildar's work as will be seen from the following values.

By M. Schwartz					By the Havildar	
Latitude.	*Longitude.*			*Latitude.*	*Longitude.*	
° ′ ″	° ′ ″			° ′	° ′	
37 54 33	69 46 24		Koláb,	37 50	69 48	
37 24 23	68 12 15		Kabádián,	37 22	68 11	

The longitudes are referred to the meridian of Greenwich.

fields, and numerous lakes and streams, and almost covered with rich pastures; the inhabitants are bands of nomads, who dwell in tents and regulate their movements by the supply of grass and water available for their flocks and herds. The Pandit struck the Tengri Nur Lake at its north-west corner, and travelled along the northern coast of the lake—a distance of nearly 50 miles—to the opposite corner, whence he turned southwards to Lhása.

(80.) He had spent three months at Lhása on the occasion of his first visit, without being discovered to be a British employé. On the present occasion, one of the first men he met was a Muhammadan merchant whose acquaintance he had made at Leh. Fearing that he might be betrayed, he hurried away at once, without waiting for the arrival of a caravan from Leh which was bringing him ample funds for further explorations. It was thus necessary for him to abandon all idea of working his way back through Western China, as his remaining funds would barely suffice to carry him back at once to India.

(81.) The most direct route for him to take was happily one which lay considerably to the east of any that had been previously explored. He followed the Tsanpo (or Brahmaputra) River for a distance of 30 miles, in a portion of its course through Thibet about 50 miles lower down than the lowest which had been reached by previous explorers, and his observations have enabled the course of the river to be laid down approximately for a further distance of about 100 miles, so that the part which still remains unknown is now materially reduced. He crossed the Bhotan Hills by the route from Chetang *viâ* Tawang into Assam, which lies nearly north and south on the meridian of 92°. And finally he brought his work to a close at the town of Odálguri in British territory, and, going down the Brahmaputra river by steamer, reached Calcutta on the 11th March 1875. His astronomical and boiling point observations were very numerous and satisfactory, and his work has been excellent throughout.

(82.) Thus a rich harvest of geographical results—now published in detail for the first time—has been obtained from the labours of the Pandit, the Havildar, and the Mullah; and happily it has been acquired without loss of life or serious misadventure, such as have too frequently been met with in these arduous and hazardous explorations.

NO. XIV.—THE COMPUTING OFFICE.

EXAMINATION, FINAL REDUCTION AND PUBLICATION OF THE OBSERVATIONS.

(83.) Mr. Hennessey—who has for so many years been in charge of this Office, and to whom its present state of efficiency is so greatly due—has been absent on furlough to Europe since the 1st January 1875. The honours have been recently conferred on him of being elected a Fellow of the Royal Society of London, and an M.A., *Honoris causâ*, of the University of Cambridge. During his absence the charge of the Office has devolved on Mr. Cole, by whom its varied and responsible duties have been carried on to my entire satisfaction.

PERSONNEL.

J. B. N. Hennessey, Esq., F.R.S., M.A., &c., Deputy Supdt. 1st Grade.
W. H. Cole, Esq., M.A., F.R.A.S., Offg. Dy. Superintendent 3rd Grade.

Computing Branch.

Mr. W. Todd, Surveyor 2nd Grade.
" C. Wood, " 3rd "
" H. W. Peychers, Surveyor 4th Grade.
Mr. J. Keating, Assistant Surveyor 4th Grade.
Mr. J. Kennedy, Assistant Surveyor 4th Grade.
Baboo Gunga Pershad Computer.
" Cally Mohun Ghose, "
" Kally Coomar Chatterjee and 11 other Computers.

Printing Branch.

Mr. M. J. O'Connor, Printer.
19 Compositors and 3 Pressmen.

Photozincograpic Branch.

Mr. C. G. Ollenbach, Zincographer.
" C. Dyson, Photographer.
2 Apprentices, 1 Map Keeper and 3 Pressmen.

Drawing Branch.

Mr. G. W. E. Atkinson, Surveyor 3rd Grade.
5 Draftsmen, 4 Asst. Draftsmen, and 12 Apprentices and map Colorists.

(84.) The Office has been employed in its usual duties of carefully examining and reducing the observations, and publishing the ultimate results of such portions as have been finally treated, and preliminary results of the portions which await the completion of further triangulations before they can be finally disposed of. The 3rd and 4th Volumes of the "*Account of the Operations, &c.*", have been completed and are now in the hands of the binders. They contain full details of the principal triangulation which is contained in the Sectional Figure known as the North-West Quadrilateral, the limits of which are,—on the east, the middle Indian meridian, 78°,—on the south, the western half of the line from Calcutta to Kurrachee,—on the west, the British Frontier line from Kurrachee to Pesháwar,—and on the north, the western half of the Himalayan Range. Of the Synoptical Volumes—which give the results of the principal and secondary triangulation for each series included within these limits, in a condensed form, for the use of geographers and surveyors—three had been published by the date of my last report; in the present year two more, *viz.*, No. 4, the Gurhágarh Meridional Series, and No. 5, the Rahún Meridional Series, have been published: No. 6, containing both the Jogí-Tílá Meridional and the Sutlej River Series, has been completed and is now in the hands of the binders; and No. 7, containing the North-West Himalaya Series and the Kashmir Triangulation has been got ready for the press.

(85.) Another Sectional Figure of the principal triangulation is known as the South-East Quadrilateral; its limits are,—on the north, the eastern half of the line from Calcutta to Kurrachee,—on the west, the central meridian of 78°,—on the south, the eastern half of the line from Vizagapatam to Bombay,—and on the east, the coast line from Calcutta to Vizagapatam. This section I had fixed on to be taken up, for final reduction, on the completion of the North-West Quadrilateral; and it has now been disposed of in a most satisfactory manner, under the supervision of Mr. Cole, to whose interesting report on the subject (in the first appendix), I must invite attention. The third Figure, known as the North-East Quadrilateral, comprises the whole of the country between the one now completed and the eastern half of the Himalayan range (up to the meridian of 89°); its reduction is now in hand.

(86.) Though Volumes III and IV of the *Account of the Operations, &c.*, are now in the book-binders' hands and might be shortly issued to the public, I propose to postpone their publication until the completion of Volume II, which should be issued simultaneously with them. That volume is intended to give an historical account of the triangulation, and descriptions of the methods of procedure and of the instruments which have been employed; to set forth the mathematical formulæ which have been adopted for the several calculations, and to give full details of the final steps in the reduction of the North-West Quadrilateral, when the several chains of triangles are regarded, no longer as separate series, but as a single triangulation, which has to be made consistent *inter se*, and with the four base-lines at its corners. A considerable portion of the volume has been completed and passed through the press, but the part appertaining to the North-West Quadrilateral is still in hand. The preparation of the volume has necessarily fallen in great measure on myself, and it has frequently had to be laid aside, when other matters of more immediate interest required my attention. Of these one of the most important has been the final reduction of the Pendulum Observations, and the preparation of the results for publication. Happening from my long personal as well as official acquaintance with the late Captain Basevi, to be more familiar than any one else with the work he had done, and with his ideas regarding the reduction of his observations, I felt it incumbent on me to set aside Volume II—which is on subjects that are familiar to several of the Officers of this Department, who might complete it in case of mishap to myself—and take up the volume which is to be devoted to the pendulum operations.

(87.) A great mass of experimental observations which Captain Basevi had made—for the determination of the reduction of the given vibration-numbers of the pendulums at the actual temperatures and atmospheric pressures under which the swings were observed, to the corresponding vibration-numbers in a standard temperature and in a vacuum—were still awaiting investigation and discussion at the time of his death; and until this work was completed the final reduction of the observations at the several pendulum stations could not be performed. I took it in hand about the time of Captain Heaviside's return from England, after completing the swings at the stations in the original programme of operations which Captain Basevi did not live to visit. It proved to be a very formidable task; for, excellent as were the experimental observations and great the care which had been bestowed on them, they presented many perplexing anomalies for examination, and these had to be patiently investigated *seriatim*, before any final decision, as to the inferences to be drawn from them, could be formed. All these investigations have now been completed, and the whole of the observations at the several stations visited by Captain Basevi and by Captain Heaviside have been reduced accordingly. A descriptive account of the general operations from first to last, of the several investigations just mentioned, and of the methods adopted in reducing the observations, and full details of the observations themselves—with the results obtained after the reductions—have now been completed and printed for publication; they fill 379 closely printed quarto pages, which will probably form part of Volume V of the *Account of the Operations &c.*, of this Survey.

(88.) It is intended to devote the remainder of the volume to papers by Captains Herschel and Heaviside. Captain Herschel is engaged in investigating the reduction of the pendulum vibration-numbers, from the values deduced for the respective levels of the several stations, to the corresponding values at the sea-level. In previous operations of this nature the reduction to sea-level, which is a question of attraction, has never occupied much time or been of much importance, owing to the fact of the stations having been usually situated at places near and very slightly above the sea. Here on the contrary the selection has, in some cases, been made expressly for the purpose of experiment in the direction of attraction. The stations on the table land of Southern India, and on the skirts of the Himalayas, and more particularly the station of Moré, at an altitude of 15,100 feet in the interior of the Himalayas, are of this kind; and a considerable majority of the stations, on the meridional axis of the Indian continent, are situated at elevations of upwards of 500 feet. There are also several stations which are either at or very little above the sea-level; for one of the objects of the operations was to investigate the relations of sub-oceanic to sub-continental attraction.

Captain J. Herschel, R.E., F.R.S. &c., Deputy Superintendent 2nd Grade.

Captain W. J. Heaviside, R.E., Deputy Superintendent 3rd Grade.

(89.) But enquiries of this nature are far from easy. The calculation of the attraction of a mass of known simple form is often troublesome; but where the mass is a mountainous district, it is absolutely necessary to make a variety of assumptions, of a more or less precarious character, on the legitimacy of which the result must depend. The principal of these has reference to the configuration of the surface. The effective attraction is separable into two parts of which the chief requires an accurate knowledge of the contours immediately round the station; while the other, depending on the curvature of the earth, does not become sensible for some distance, and then continually increases in importance—or more correctly, would do so, but for the general tendency of increased area to present a lower average height,—so that it is hardly too much to say that the effect of distant continents must not be entirely overlooked. Thus a knowledge is required in detail of the masses standing on given areas, and Captain Herschel has necessarily devoted much time to their estimation. The mean height of about 500 half degree squares have thus been obtained for Northern India, Kashmir, Turkestan and Thibet, by a close study of the best available maps. It is probable that the area to be dealt with will have to be extended so as to include a great

part of the Indian continent, should it appear worth the labour. Under the circumstances, there is still much work to be done, before the results of the pendulum operations can be satisfactorily elucidated and prepared for publication.

(90.) On his return from England, Captain Heaviside was employed in this Office, for nearly a year, in completing the reduction of his own observations with the Royal Society's pendulums and in supervising the printing of them and of the greater portion of Captain Basevi's observations. He also completed the reduction of his observations with the Russian pendulums—which had been sent to India to be swung at some of the Royal Society's pendulum stations, with a view to establishing a connection between the operations in India and in Russia—and with Kater's convertible pendulum, which had originally been employed in determining the relations between the length of the seconds' pendulum, and the British Standard Yard, and was re-employed by Captain Heaviside for the conversion of the differential results by the Royal Society's pendulums into absolute values. Full accounts of these operations, and details of the observations and reductions, have been printed in readiness for publication, either in Volume V or in a supplemental volume; they occupy 181 pages of closely printed quarto. The results have been provisionally reduced to the sea-level, but corrections may have to be applied to this portion of the reductions, after the completion of Captain Herschel's investigations. The result of the determination of the present relations of Kater's convertible pendulum to the Standard Yard, which is now being made in the Ordnance Survey Office, Southampton, by Colonel Andrew Clarke, R.E., C.B., is also awaited, to complete the subject, before publication.

(91.) I have every reason to be much obliged to Captain Heaviside for the assistance which he has rendered to myself, and the pains he has taken in completing his own share of the pendulum work. He is now employed with Captain Campbell in the determination of electro-telegraphic longitudes in the Madras and Bombay Presidencies.

NO. XV.—CARTOGRAPHY.

(92.) The preparation of a 3rd Edition of the Map of "Turkestan, and the Countries between the British and the Russian Dominions in Asia," was commenced last year. Each of the four sheets comprising the map had been entirely redrawn, on the same scale as that of the two first editions, *viz.* 1 inch=32 miles, and a large amount of valuable and newly acquired information of Khiva and the regions on the eastern borders of the Caspian Sea—obtained directly from the Topographical branch of the Russian War Office—and of the Northern Frontier of Persia, from British sources, had been inserted. But the completion of the map was postponed until the results of Captain Trotter's surveys, in connection with Sir Douglas Forsyth's Mission, and of the explorations of the Pandit, the Havildar and the Mullah—which I have described in the Geographical Section of this Report—could be introduced into the map. It was then finished and published.

(93.) A new map of Northern Afghanistán, and the Countries to the north of the Trans Indus Frontier—on twice the scale of the Turkestan Map—has been prepared under Captain Trotter's supervision, to indicate the results of the explorations of the Havildar and the Mullah; it is appended to this report. It is exceedingly interesting, its larger scale permitting of much detail being shown which had to be omitted from the Turkestan Map. Two maps, compiled from the Pandit's surveys of the routes from Ladákh to Lhása and thence to Assam, also accompany this report, and contain much new and valuable geography.

(94.) Of other work done in this office I may specify the preparation of Captain Trotter's Preliminary Map of Eastern Turkestan, which has been published with Sir Douglas Forsyth's Report; the completion of the Gazetteer Maps of Kumaun and Garhwál, of 23 Final Charts of the triangulation, in illustration of the Synoptical Volumes, and of 5 Preliminary Charts of triangulation which as yet has not been finally reduced; and the revision of the Map of Routes in Northern India. A tabular statement of the work is given at the end of the first appendix.

(95.) It now only remains for me to acknowledge the valuable services which have been rendered by my Personal Assistant, Mr. H. Duhan, who has relieved me of a considerable amount of official routine work, that would otherwise have taken up much of my time. Mr. L. H. Clarke, has rendered good service by the careful and punctual performance of his duties in the corresponding office and as general store-keeper; and he also acted for three months as Personal Assistant, during Mr. Duhan's absence on leave.

(96.) An abstract of the out-turn of work executed by each of the Survey Parties, whose operations can be exhibited in a tabular form, is given on the following page.

J. T. WALKER, COLONEL, R.E.,

Supdt. Great Trigonometrical Survey.

DEHRA DUN;
Dated 3rd March 1876.

Post-script. 27th March 1876.

Circumstances, which I am not at present in a position to explain, have disappointed me in the expectation of being able to append Captain Trotter's account of the Trans-Himalayan Explorations, during 1873-74-75, to this Report. An account will I trust be published hereafter, and at no very distant date.

J. T. W.

Abstract of the out-turn of work executed by the Great Trigonometrical Survey Parties, during the Official year 1874-75.

Description of Details.	1 Ramnád Longitudinal Series 24-inch Theodolite.	2 Assam Valley Triangulation 12-inch Theodolite.	3 Eastern Frontier Series 24-inch Theodolite.	4 Burmah Secondary Triangulation 12-inch Theodolite.	5 Jodhpúr Meridional Series 24-inch Theodolite.	6 Kattywar Topographical Survey.	7 Guzerat Topographical Survey.	8 Dehra Dún Topographical Survey.	9 Kumaun and Garhwál Survey.	Total.
Number of Principal Stations, newly fixed, ...	27	...	13	...	23	...	...	...	...	63
Number of Principal Triangles, completed, ...	42	...	19	...	28	...	...	...	...	89
Area of Principal Triangulation, in square miles,	791	...	3,153	...	2,472	...	...	...	...	6,416
Lengths of Principal Series, in miles, ...	93	...	100	...	104	...	...	...	...	297
Average Triangular Error, in seconds, ...	0·55	...	0·48	...	0·47	...	...	..	...	...
Average Probable Errors of Angles, in seconds, ±	0·17	...	0·25	...	0·16	...	...	...	...	...
Astronomical Azimuths of verification, ...	1	...	...	...	1	...	...	...	...	2
Number of Secondary Stations whose positions and heights have been fixed, ...	34	..	24	5	12	135?	24	98?	26?	358?
Number of Secondary Stations whose positions only have been fixed, ...	1	...	...	14	...	...	3	...	...	18
Number of Secondary Triangles of which all 3 angles have been observed, ...	10	...	24	11	22	211	35	119	23	455
Length of Secondary Series, in miles, ...	...	...	...	28	55	...	...	...	...	83
Area of Secondary and Minor Triangulation, in square miles, ...	1,096	...	2,249	2,000	681	2,200	559	490	800	10,075
Number of Points fixed by intersection, but not visited, ...	35	30	40	41	14	666?	92	596	56	1,570?
Length of boundary lines and check lines traversed, in miles, ...	...	...	...	...	...	1,117	448	461	...	2,026
Area topographically surveyed on scale of 1 inch = 1 mile, in square miles, ...	...	...	...	...	...	..	...	...	2,176	2,176
„ topographically surveyed on scale of 2 inches = 1 mile, in square miles, ...	...	..	...	...	...	1,749	392	...	...	2,141
„ topographically surveyed on scale of 4 inches = 1 mile, in square miles, ...	...	...	...	...	...	...	983	225	...	1,208
Number of Revenue Survey Stations and boundary junction pillars, fixed by triangulation, ...	...	...	...	...	1	...	...	22	...	23
Do. of Principal Stations selected in advance, ...	20	...	10	...	7	...	...	...	...	37
Lengths of Approximate Series, Principal, in miles, ...	59	...	100	...	64	...	...	...	...	223
Do. of Approximate Series, Secondary, in miles, ...	...	38	...	94	55	...	...	...	...	187
Number of Towers constructed, ...	5	...	1	...	...	...	...	...	...	6
Do. of Pillars and Platforms constructed for Principal Stations, ...	19	...	13	...	17	...	...	...	...	49
Do. of Pillars constructed for Secondary Stations, ...	...	6	3	7	26	...	...	...	...	42
Do. of miles of Rays cleared, ...	118	106	...	29	15	...	...	...	...	268
Do. do. Path-way made, ...	2½	...	190	5?	1	...	...	...	...	198½?
Do. Hill-tops cleared of forest and jungle,	4	...	28	7	...	...	...	5	...	44
Do. Principal Stations whose elements were computed, ...	27	...	10	...	42	...	...	...	...	79
Do. Secondary and Traverse Stations whose elements were computed, ...	35	...	50	71	101	...	...	6,871	...	7,128
Do. Preliminary Charts of Triangulation, ...	1	...	1	...	1	...	...	...	...	3
Do. Topographical Maps completed, ...	...	...	...	...	...	16	14	7	13	50
Do. Principal Stations placed under official protection, ...	35	...	...	...	17	...	...	...	...	52
Do. Stations protected and closed, ...	12	...	...	...	24	...	...	...	...	36
Do. Points fixed by traverse, ...	...	...	...	...	...	?	1,133	6,005	...	7,138?
Do. Aneroid Determinations of Height, ...	...	...	...	...	...	...	...	236	148	384
Do. Azimuths computed, ...	1	...	...	...	3	...	...	...	...	4

APPENDIX.

EXTRACTS FROM THE NARRATIVE REPORTS

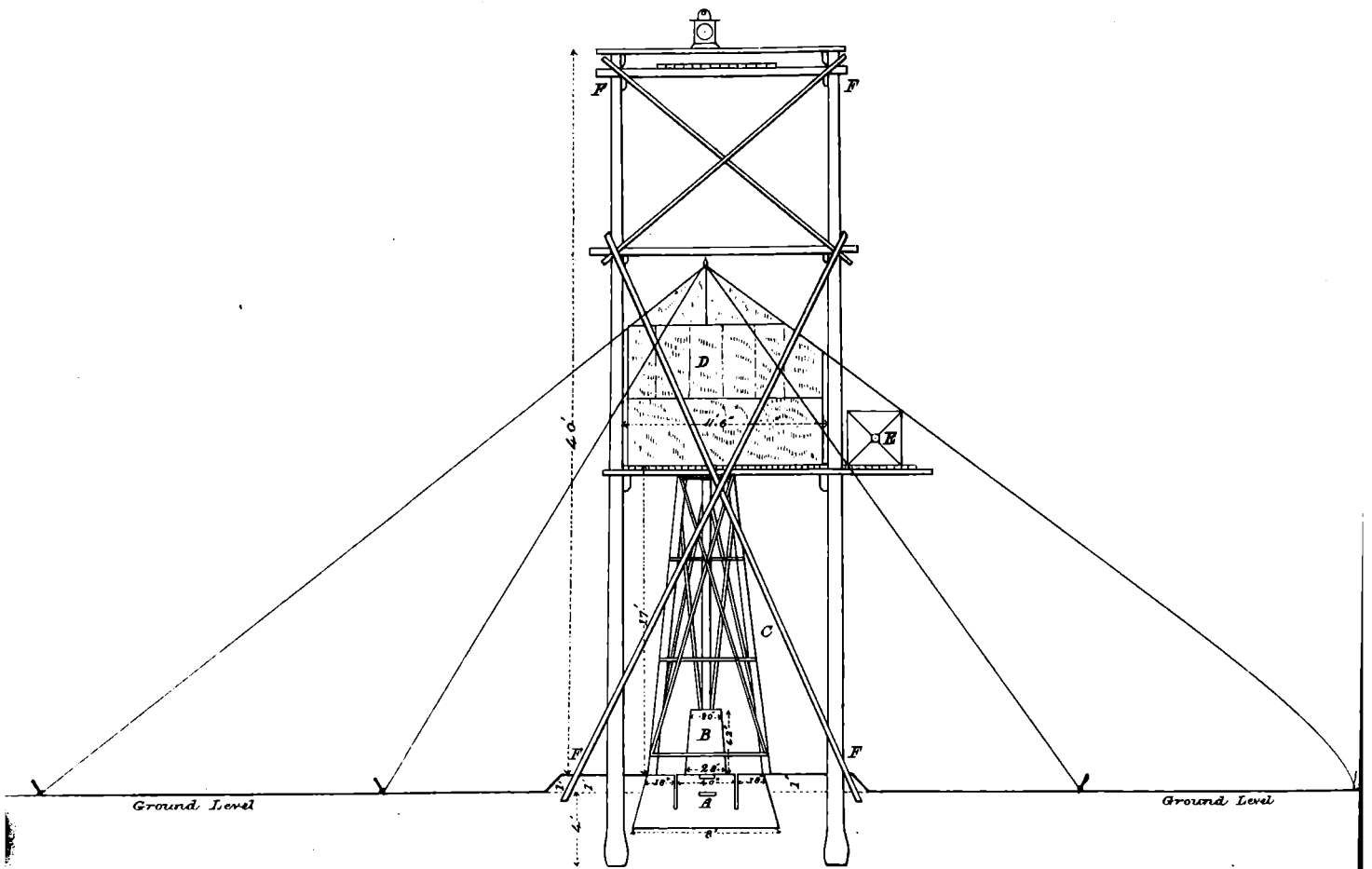
OF THE

EXECUTIVE OFFICERS IN CHARGE

OF THE

SURVEY PARTIES AND OPERATIONS.

PLAN of a G. T. SURVEY STATION with OBSERVATORY and SIGNAL PLATFORMS shewing BRACED STAND for the GREAT THEODOLITE, designed by MAJOR B. R. BRANFILL, Dupy. Supdt. G. T. Survey, for the RAMNAD LONGITUDINAL and MADRAS COAST SERIES (S. Section).



REFERENCE.

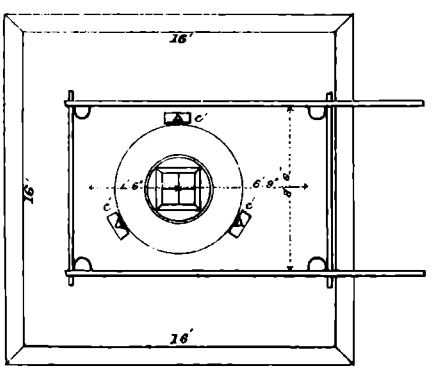
A Masonry pillar and annulus, section and plan.

B Closing pillar in section.

C Wooden braced stand, elevation.

c'c' Masonry support for ditto, in plan.

D Observatory tent,
E Theodolite box,
FF Palmyra platform,
} in elevation and plan.



Scale 1 inch = 8 feet.

Photozincographed at the Office of the Superintendent, Great Trigonometrical Survey, Dehra Dún, November 1875.

C. DYSON, PHOTO. C. G. OLLENBACH, SURVEYOR.

Extract from the Narrative Report—dated 30th September 1875—of MAJOR B. R. BRANFILL, Deputy Superintendent 2nd Grade, in charge Madras Party.

(2.) The party took the field at Bangalore on the 9th of November, reached Trichinopoly on the 6th of December, Madura on the 12th and the scene of operations on the 20th of the same.

The Season's work to be done.

(3.) The Rámnád Longitudinal Series had been approximately laid out the previous season as stated in my last Annual Report (para. 15). There remained to build most of the stations and clear the rays between them, to select a few of the station sites which had not been precisely determined on, to observe the final angles, and to close and deliver the stations. Besides this the Series had to be extended along the coast to Rámesweram with a view to the Ceylon connection.

Disposition of Party.

(4.) I myself took in hand the completion of the stations and rays of the first figure, a quadrilateral. I sent Mr. Belcham to complete the next figure in advance, also a quadrilateral, and the other two Assistants to build the stations and clear the rays further in advance; one on the northern flank and centre, and the other on the southern flank along the coast.

Final observations after three weeks entrusted to Mr. Belcham.

(5.) I commenced observing on the 29th December at the stations of Kulayanallúr and Kovilpatti, forming a side on the east flank of the Great Arc (Lat. 9°) and completed final observations at the six stations forming the first two figures (quadrilaterals) by the 20th January, when I was joined by Mr. Belcham, whom I had recalled to take up the observations, a mere mechanical process requiring only the skill and care which I felt sure Mr. Belcham possessed and would use.

I was impelled chiefly to take this step in consequence of the great probability of the observing overtaking the approximate series (which eventually it actually did) and because I felt that the most important duty in such difficult country (wooded plains) is the laying out the series in advance to the best advantage, and directing the "Approximate Series" operations generally. I remained instructing and assisting Mr. Belcham for a week, when after seeing him through the observations at two stations I felt confident that I might leave him to pursue the duty successfully.

The Executive Officer in charge proceeds to the front.

(6.) I then proceeded to inspect Mr. Potter's work on the north flank and centre, and, after selecting a station in advance and tracing and clearing the ray to it, visited Mr. Laseron, and gave him a little practical and personal instruction in the art of ray tracing, &c. I next proceeded to build the stations and clear the rays on the south flank, leaving Mr. Laseron to combine his efforts with Mr. Potter in pushing on the building and ray-clearing of the centre and north flank, where the most masonry work was required to be done.

Stations of the north flank and centre, hollow masonry pillars with timber scaffolds.

(7.) The stations of the north flank and centre of the Series were hollow masonry pillars 15 to 25 feet in height, banked up with earth and gravel as high as practicable to prevent vibration, with a timber scaffolding to support the observatory, run up to a much greater height for the signal.

Temporary stations of timber provided on the south flank.

(8.) The south flank lay along the series of sand hillocks and ridges that skirt the coast enveloped for the most part in dense palm forest. The shifting hillocks of drift-sand were not suitable for permanent principal stations, but by their means, temporarily occupied by stations composed of wooden piles, all the permanent buildings on the coast which could be observed, were fixed, and the series rendered a double one throughout. A large mark-stone was buried deeply in the sand, and should the sand hillocks remain, may be found for many years to come. I propose having a pile of (coral) stones placed over each such station more permanently to mark the site in case the sand does shift.

Completion of Approximate Series.

(9.) By the end of the first week in March the Approximate Series on the south flank and centre was complete as far as Rámnád.

Difficulty of the palm forest.

(10.) The south coast of Rámnád, from the lands-end (Toni Turei="*boat ferry*") opposite Pámban, for 50 miles to the westward, is fringed with a belt of dense palmyra forest, intermixed with groves of cocoanut trees, through which it was very difficult indeed to carry on the series, but there was no alternative feasible. To traverse or "*trace*" each ray through the forest was possible, but to "clear" it quite impracticable; to overlook it was the only thing to be done, although the palms grow to a height of 60 feet

and the ground is generally quite flat. At a distance of a mile or so inland from the sea shore there is a ridge or series of hillocks, rising from 10 to 50 feet above their base, formed probably by the constant action of the sea breezes blowing the dry surface sand of the beach inland, and depositing it in the palm forest where it is sheltered from farther action of the wind. After selecting and erecting high flags on the most promising of these sand hillocks for stations, the line between them had to be traversed and the height of the intervening hillocks and of the palms carefully noted. The latter has to be done by climbing the highest palms and examining the height of the forest in the direction of the ray. About midway the most prominent palm in or near the line is sought for and marked with a flag, whence the flags of the two station sites at the ends of the line can be seen; a sextant here may be used to measure the angle contained by the rays to the station flags, which, with the traversed (perambulated) distances gives the approximate position of the true ray, and one is able to judge by examining the top of the forest whether the ray is likely to prove practicable or not, and where most clearing is necessary. Having found the direction of the ray, (and if it still seems practicable) a trial line has to be carried, from one or both ends, *over the palm tops*, the leaves of which have to be cut off leaving a clear gap of 10 or 12 feet in the forest. If the trial line proves all right it has to be widened some scores of trees have to be cut down and their price, (from one to four shillings each), settled and paid to the owners.

Means for raising eye of observer and signals.

(11.) As the sand hillocks do not attain the height of the palms, within 15 or 20 feet probably, the eye and signals have still to be raised, and for this purpose I prepared a portable braced stand of wood 17 feet in height, or else in its place set up palmyra logs steadied by piles of sand, and found they both answered well, and thus the eye of the observer was raised more than 20 feet above the top of the sand hillocks. A much greater height was necessary for the signal, and this was obtained by means of lofty scaffolds, for which as regards length, the palmyra is well suited. The longest, straightest and most convenient trees cut down on the line were selected and split up into halves for the four uprights, and into quarters and eighths for the beams, braces, ties, &c. The stalks of the palmyra leaves furnish the rope by which the scaffold is put together and made fast. Such a scaffold takes two or three days to erect under ordinary circumstances and costs about Rupees 30 (thirty).

The brahmans refuse permission to occupy as a station the Tirupallâni temple tower.

(12.) In one instance I met with a great disappointment and the loss of several days. The lofty gopuram, or entrance-tower, of the Tirupullâni Temple, (a sacred Vishnu fane,) offered a tempting site for a station, eighty (80) feet above the ground, by which five rays to adjacent stations over the palm forest were well commanded. I visited the place and was allowed to mount and observe with a small theodolite from the summit of the tower without demur, and was informed that I might use it as a station, engaging to do no damage that I would not make good. When however I came subsequently to prepare the station, and had been allowed free access a second time, and had taken the necessary measurements, for the platform, &c., the brahmans and others attached to the temple, and a large portion of the inhabitants of the village that profits by the temple funds, turned out to the number of some hundreds, and surrounded my tents in a state of much excitement, protesting against my again entering the tower, unless I was prepared to pay many thousands of rupees for its purification, whilst some of them demanded money for the pollution that had already occurred through my presence. I tried for sometime to conciliate them but without effect: they refused me farther access, locked the door, and kept a watch to prevent by force any attempt on my part to effect an entrance, which of course I did not make, though it was with much reluctance that I felt obliged to abandon so advantageous a site. I afterwards learnt that on the day of my first visit a subscription was made and a sum of one or two rupees collected to enable the priests to perform certain purification ceremonies on account of my visit. On hearing this I sent word to the temple manager that I was ready to pay a rent equal to the amount of any such expiatory sacrifices as they deemed absolutely necessary, for as long as we occupied the tower, but they refused. They added that they had already caused the unhallowed government telegraph wire to be removed from passing too near their holy building to a distance of some hundreds of yards, and that they could not let me use their tower at any price. No anger or ill will was displayed on either side, but I was not prepared for such persistent obstructiveness, considering I had already established a station on the unfinished gopuram at Uttara Koshamangei, a celebrated Shiva temple only a few miles distant, without any difficulty. The gopuram, or entrance-tower, of any Indian temple is perhaps of less use, from a religious point of view, than the ordinary tower of an old English Church; and in this instance, as is common in Hindu temples, the tower being the sole resort of monkeys and bats, and seldom or never cleaned, was in a most filthy state, and so disgustingly loathsome as to be almost unendurable to any

one passing through it. That my presence should be thought a greater pollution to the temple than that of these unclean beasts and birds, reveals a state of mind that is somewhat remarkable. I lost no time in searching for another point, but the delay caused by the abandonment of this cost me about a week in the busiest time of the season.

Eastern extension for the Ceylon connection by an island series.

(13.) My next care was to extend the series to Rámesweram with a view to the Ceylon connection. After a careful examination of the country to the south-east of Rámnád, I found that the increasing density of the palm forest and the rapid narrowing of the land, obliged me to attempt to utilize the islets of the coral reef which lies parallel to the shore of the main land at the distance of 4 or 5 miles. I accordingly threw out a quadrilateral to the southward based on the last, (south-easternmost) side of the triangulation which lay convenient for the purpose, and found no great difficulty in extending the series by a succession of quadrilaterals as far as the lands-end.

The islets of the coral reef.

(14.) The islands are scarcely above the sea at high water of spring tides, and are composed of coral and sand and devoid of fresh water or anything to live upon, although they are covered with a coarse grass, weeds and some bushes and trees, the last planted by the fishermen who resort there from the main land: several of them were densely covered with high tangled bushes that caused much trouble to clear a ray through. Labor, material, food and water have to be transported thither by boat, and as constant communication by open boats or canoes must be maintained, there are only about three months, February, March and April, between the monsoons, during which this work can be carried on. The last four stations built and observed at, are of good permanent masonry, as also are two of those in advance, on the island of Rámesweram, observed to but not yet observed at. High scaffolds were required at all of the island stations, and in building these only one accident occurred throughout, which I think very fortunate, considering that we were all of us inexperienced in this kind of work, and that our materials and implements were of the most unwieldy and roughest description. An ordinary palmyra freshly cut down weighs about 1¼ tons, and each half tree over forty (40) feet in length, probably ¼ a ton, to raise which we had a working party of from 12 to 20 common coolies and 3 or 4 klassies. A few stout bamboos for sheers, props, &c., a pair of metal blocks with a stout cotton rope and plenty of "Coir" (cocoanut fibre) rope were all our implements, but they proved sufficient for the purpose.

Accident.

(15.) The one accident alluded to, occurred by a faulty beam, injured in the felling of the tree, having been inadvertently used on the top of the scaffolding to support the signal platform. On noticing this I ordered its removal, but it gave way in the process, and two klassies were precipitated to the ground from a height of about thirty (30) feet; one of them was hurt a good deal, and is scarcely well yet.

Conclusion of the island Approximate Series.

(16.) I completed these stations and cleared all the rays by the middle of April, when I found it necessary to desist, as it was useless to prepare the remaining stations in advance, some of which must be temporary stations, (being unavoidably on hillocks of drift-sand), unless the final observations could be carried beyond them to two or more permanent stations still farther in advance, and this was quite out of the question. I therefore contented myself with visiting the Islands of Kachi, and Neduvan (or "Delft") and ascertaining that there was no great difficulty in any of the rays in advance, as far as the completion of our share of the series.

Progress of the final observations.

(17.) Mr. Belcham meanwhile pushed on the final observations with vigour and success without interruption, except for one or two days when he overtook the building parties. On reaching Rámnád S. on the 18th March I joined him for the Azimuth observations, and after two days and nights instructions and assistance, found him quite able to complete the work alone, which he did after I left him without any mishap. I am glad to say he continued to work steadily, and made good and uninterrupted progress, until he brought the work to a close by the 1st May, when I ordered him to desist, and to return to quarters, as the entire party was much exhausted, and a large portion of it sick or ailing, officers included.

Mr. G. Belcham.

(20.) Mr. Belcham has done a good season's work having conducted the final observations with the 24-inch theodolite very creditably to himself, this being his first season, and quite to my satisfaction. The conduct of the observing and signal parties for the island series required much forethought and good arrangement; but he was equal to the occa-

sion, and no mishap or failure occurred to hinder the work throughout.

Mr. C. D. Potter.

(21.) Mr. Potter has worked willingly and well as usual, taking an interest in his work. He has built 7 masonry pillar stations, and traced and cleared 19 miles of rays. He suffered severely in health towards the end of the season.

Mr. E. W. Laseron.

(22.) Mr. Laseron commenced the season's work under the disadvantage of not having had any previous practical experience of ray tracing and clearing in a flat and wooded country, and he found much difficulty in making the "trial lines," laid off from his ray trace observations, come out right, even after repeated trials, and in this way he lost considerable time. He appears however to have worked hard and willingly, and will I do not doubt master the difficulty with a little more practice. He has built 3 high signal scaffolds, traced and cleared 64 miles of rays, and built, partially or entirely, 6 masonry stations. He also built closing pillars at, and delivered over charge of, 12 principal stations.

General features of the country, soil, &c.

(24.) The country is as flat as possible, although there is a slight slope down towards the sea of a few feet per mile. Inland the country is generally deep black (cotton) soil, which is immediately succeeded near the coast by deep sand. The black soil is extremely rotten, becoming impassable in wet weather and nothing but yawning cracks when dry. The former inland, is much wooded and intersected by tanks, and a net work of bunds, dykes, and supply channels for collecting water, and it is every where cultivated with high growing corn crops, so that the view in all directions is obstructed or confined to a limit of a mile or so even when the observer's eye is raised above the corn which grows up to ten feet in height. Moreover every tank bed (and tanks abound, witness Indian Atlas Sheet No. 80), is overgrown with a dense thicket of thorns of a kind of hard and matted "Bábul" (mimosa Arabica) that is exceedingly tedious to clear a ray through.

Except for the occasional sand hillocks, the vicinity of the coast offers no advantage over the inland tract, in as much as it is overgrown with palm forest, thorn jungle and cocoanut groves.

Bad signals and grazing rays.

(25.) Compared with previous seasons' triangulation, with hill stations, the signals and observations were very wild, as was to have been expected. Excepting the first few, nearly all the rays were unavoidably very low, grazing within 10 or 15 feet of the ground, and a few much closer still.

Factor of Refraction, inland largely negative: over sea positive, but small.

(26.) We have eleven rays more or less clear over the land giving a mean factor of positive refraction = + 0·023 of the contained arc. Thirty-six rays graze more or less badly over the land, giving a mean factor of negative refraction = − 0·111: the largest of these is − 0·289, and there are several others about one fourth of the contained arc.

Of sixteen rays over the sea, some clear and some grazing, only one gives negative refraction, (−0·037,) the rest are all positive, and generally between + 0·020 and +0·040, the mean being + 0·032 of the contained arc, or about half that of an ordinary series of hill stations.

Extension of the Madras Coast Series.

(28.) Besides the plan of the Island Series for the Ceylon connection, one hexagon of the Madras Coast Series to the north of Rámnád was laid out, and three of the stations built by Messrs. Potter and Laseron, and the former has also reconnoitred the country with a view to another hexagon in advance, but nearly all the rays require regular tracing and clearing.

Plan of work for the ensuing season.

(29.) It is much to be regretted that the remaining portion of the Island Series for the Ceylon connection cannot be begun before the end of January when the violent wind of the North-East monsoon moderates, and permits open boats, the only craft our funds admit of, to ply between the islands of Palks Straits to the east of the Pámban channel and Adam's bridge, and keep the signal and observing parties furnished with water and supplies.

I therefore propose employing the strength of the party on the approximate series (Madras Coast) to the north of Rámnád under my own immediate supervision, selecting and building the stations, tracing and clearing the rays between them until enough of the series has been laid out to occupy the observing party until it is time to take up the Island Series, so that as little time as possible may be lost in traversing the interval between the advanced part of the Madras Coast Series, and the uncompleted part of the Ceylon connection.

(30.) I am happy to state that I believe a considerable reduction may be effected by the adoption of only low masonry pillars and platforms, no larger than absolutely necessary for the sake of permanence, in place of the usual high towers. I commenced the Rámnád Longitudinal Series by building high masonry pillars with timber scaffoldings. Ten of these pillars, with a mean height of 21 feet have cost at the rate of Rs. 175 each and the cost of the observatory platform was Rs. 40 making a total of Rs. 215 per station, exclusive of supervision.

Reduction of cost.

Comparative cost of masonry pillars and timber scaffold stations.

(32.) Latterly I have constructed log or pile stations for the sand hills, and low masonry piers for the ordinary soil, with lofty scaffolds for the signals. I find the average cost of eleven observatory signal scaffolds with a mean height of 27 ft. to be only Rs. 30 per station, and I estimate the cost of low masonry platform stations to be about Rs. 20 each, making a total of Rs. 50 per station, showing a saving of Rs. 165 per station. I enclose a plan and elevation of such a station as I have found best adapted for this series and most economical, shewing the portable braced stand with observatory and signal platforms.

(33.) I may notice moreover that the 17 ft. stand has proved more steady in a wind than the 20 ft. pierced masonry pillars previously used.

Stability of 17 ft. braced stand.

(34.) One disadvantage of the lofty signal scaffolds is the difficulty of plumbing the signal apparatus in a wind, particularly in a high wind. This may be obviated by using heavier plummets supported by fine brass wire, and by protecting the plumb line by a long strip of cloth or matting spread on the windward side.

Disadvantage of lofty signal scaffolds.

(38.) Mr. Bond, Assistant Surveyor of No. 2 Extra Party, was placed under my orders for temporary employment in the vicinity of "Bangalore," so as to be ready to join Captain Campbell, R.E., at any time during the season on short notice, in case that officer (who was employed at Roorkee in the observations of the Transit of Venus,) should become available for Latitude observations on the Madras Meridional Series, or other work. I accordingly directed him to execute some minor triangulation in Mysore which was much needed by the fiscal and other surveys, to make a more extended connection of the G. T. Survey principal triangulation with that of Colonel Lambton, and to fill up a gap left in the net work of triangulation of the latter, on the north flank of the Bangalore Longitudinal and between the Great Arc and Mangalore Meridional Series, lying to the south of the "Chitaldroog" district of Mysore.

Mr. J. Bond, No. 2 Extra Party, temporarily attached for special employment near Bangalore.

Ordered to execute some minor triangulation in Mysore.

(39.) He left Bangalore on the 24th November with a party of 12 Klassies most of whom were quite new to the work, and starting from the side Rámadevara-betta —Dodnir-manga H.S. of the Great Arc (in Lat: 13° 30') he proceeded westwards, and in about seven weeks laid out a series of thirteen triangles reaching as far as Shimoga S., about 108 miles in length, and covering an area of 1,096 square miles. Two of these stations are previous G.T.S. points, besides the three initial and terminal stations above named, and four of them are identical with old stations of Colonel Lambton's Survey at which the ⊙ mark was found.

Takes the field and lays out the Series.

(40.) He then commenced to retrace his steps observing the angles, but was very shortly prostrated by sickness and obliged to return to Bangalore for medical treatment. The season was a very unhealthy one generally throughout that part of Mysore and the men of the party suffered considerably from fever, &c., as well as Mr. Bond.

The observations stopped by sickness for seven weeks.

The delay from this cause was more than a month. As soon as permitted by the doctor, Mr. Bond again took the field and the observing was resumed on the 28th of March after an interval of seven weeks during the best season for the observations, and continued till the end of May when he had completed 10 triangles in all.

(41.) But he now discovered that one of the rays of his approximate series which he had accepted without due examination, on the credit of Colonel Lambton's Chart of the triangulation in which this ray is shown (and therefore might well have been supposed practicable) was obstructed, and the observing was therefore brought to an end.

Approximate Series impracticable.

An alternative station was selected but the cloudy weather of the S.W. monsoon had set in, and no farther observations could be obtained. After waiting for three weeks more in the hope of completing the series, I ordered Mr. Bond to return to Bangalore where he arrived on the 24th June, leaving the three triangles connecting his work with its proper base, incomplete. I trust however that he may be able to complete this work shortly before the ensuing field season.

Revised.

Bad weather prevents completion of the Series.

(42.) Mr. Bond appears to have worked energetically and to have done his best. His men were many of them new to the work and insufficiently trained, and he was much delayed for want of good and timely signals, as well as by sickness.

(43.) I beg to append to this Report an alphabetical list of the proper names of the stations and land marks fixed during the season, together with those of the surrounding villages and some of the neighbouring towns, that will appear on the records of this party. The vernacular (Tamil) form of each place-name was obtained on the spot, as well as its etymology or root-meaning.

List of the proper names of the stations and points fixed, &c., given.

I do not suppose that all I have given in the list is correct, but it may be accepted as the current local tradition and usage, and as a near approximation to the approved method of transliteration.

(44.) I apprehend that such information, if faithfully and carefully collected, may prove of much general interest, and of special use towards removing from the face of the English maps and charts of India, the great diversity of rendering and erroneous spelling that have hitherto disfigured them, and I propose to give annually such a list as I have now drawn up of the common and particular place-names met with during the field season.

Root-meanings of the place-names presumed to be of use and interest.

Proper Names of Places and Common Village Names met with on the S. E. Coast of India, chiefly in the Madura District of Madras (Tamil Country).

Agraháram	From S., a village, street, or quarter of a town, set apart for brahmans.
Alankulam	Vil. pr. n. (?)="*Banyan tank*" fr. álei, the banyan, and kulam, a pond or tank.
Alattúr	Alei, the banyan (tree), and úru, a village or town.
Ammá	Mother, "*mamma*", Lady. Amman-Kovil="*Lady chapel*", a temple or place of worship devoted to one of the female deities or demons.
Anakattu	Eng. "*anicut*"; fr. Tel. addamu, between, across, and kattu (to bind) a bund, dam, embankment; also T. anei, a dam, dyke, &c.
Anappan	Pr. n. A Canarese caste or tribe found in Madura.
Aneipár Tívu	Anei=elephant, párei=rock; and tivu=island (Madura coast)="*Elephant-rock Island*".
Annapúnniken-patti	Contr. for annapúva-náyakkan, a man's pr. n., and patti, a fold, or small village.
Appanúr	Vil. pr. n. (?) fr. appu, a stake or large peg, a wedge; or fr. appan=father, and úru=town, or large village.
Appá Tívu	"*Abbot's Island*". Appa="papa", a term of respect. This island is also called "Shéra mudili" (loc. corr. for *Maulavi*) the name of a Muhammadan saint, whose tomb or shrine is much venerated.
Aramanei	"*King's house*", a palace; fr. arasan, a king, and manei, a house, dwelling.
Areikulam	Written *árei*, an edible water-plant, (marsilea quadrifolia), but stated to mean "*six tanks*", as if fr. T. áru, six, and kulam, a tank, reservoir.
Armugam Kottoi	"*Six faced (one's) fort*"; áru=six, and mukham; fr. S., the face; a name of Kartikeiya, the War-god, Subramanya.
Aru	A river. Com. use same as for six; in comp. árr, pronounced. átt: see below.
Asuran	Fr. S., a demon,

Athodei	"*River course*"; fr. áru q. v., and odei, a course (fr. otu=run, drive).
Attánkarei	"*River bank*" or "*River side*"; fr. áru q. v., and karei, a bank, shore.
Atúr	A common village name in S. I., possibly for 'álattúr', q. v.
Aykkudi	"*Shepherd's abode*"; fr. áyan, a shepherd, pastor; and kudi, a habitation, dwelling.

B is not a letter of the Tamil Alphabet, but p is sounded like it sometimes, as after m and n, and, with v, is used instead of it in foreign words, and also for p'h, and b'h.

Chadayan	(?) Pr. n. of a caste or tribe in S. I., erroneous for kadeiyan.
Chakkili Medu	"*Currier's mound*"; fr. chakkiliyan, a currier; and medu, a hillock.
Chakrákottei	From chakrá, S., the discus, Vishnu's weapon (a quoit) and kottei, a fort.
Chattram	Vulg. use for chattiram, a native rest-house. Hind.=chhattar.
Chávadi	The Anglo-Indian "*choultry*" of old writers, a native rest-house for travellers.
Cheri	An assemblage, a hamlet, a small village; allied to C. keri, a street, row, cf. H. kherá, Ar. and H. karya, a hamlet or small village.
Chinni appa Dargah	(?) "*Papa Chini's Dargah*" (Muhammadan shrine), a pr. n.
Chippi-kulam	"*Shell tank.*"; fr. T. chippi, a little shell.
*Daghopa and Dahgop	S., fr. deh, the body, and gup, to hide; a Buddhist altar, vimána or shrine (see foot note).
Dalaváy-puram	Dalaváy, the minister, or commander-in-chief, in S. I., and puram, a town.
Devipattanam	"*Devi's town*" S., Devi=goddess, a name of Párvati, Shivá's consort, and pattanam, a town, a seaport (?).
Dhanu-kodi	"*Bows point*"; fr. S. dhanas, a bow, and kodi, a point. The extreme S.E. point of Rámesweram Island, a sacred bathing place.

In vulgar colloquial use y is commonly prefixed to e initial.

Endal or Yenthal	A small tank; a com. affix to names of small villages in Madura.
Eri	A large street of water, lake, a big tank.
Etteyápuram	Pr. n., a town and zemindári (estate) of the Ettappan (a Náyakkan) family of Tinnevelly.

G only represented in Tamil by k which is pronounced as k when initial, or double, but like g when medial.

Gandha máda-parvatam	Pr. n. of the highest point of Rámesweram Island. S., parvata=a hill.
Giri	S. A mountain in S. I.; com. applied to a hill named in Hindu mythology or history.
Gopala pattanam	"*Cowherd's town* (or port)"; fr. S. gopál, a cowherd, and pattanam or pattinam, q. v.
Idam-bádal	Perhaps fr. idam, left, as there is a "Valam (=right)-bádal" across the fen close by. Idam also means a place. If for Itham-bádal="*Sweet songs*".
Ideiyan	A man of the herdsman caste, or tribe; (?) fr. idei=middle=middle-born, i. e., from Iswara's breast.
Ilampunam	Corrupt. for llama-nattam. Nattam is the village-site, or building ground.
Iswara	S. The deity, Supreme God, Lord. In S. I. used for Shivá. "Issuran-koil"="*Shivá's Temple*".
Kachi Tívu	"*Shingle Island*"; fr. Kachchi, a broken shell or sherd; this island is formed of broken coral.

* NOTE.—Pagoda (formerly pronounced pá-god) may be derived from this by metathesis pa-go-da=(da-go-pa, Dr. Sargent). It may be from Pey-gude Tel. (=Tam, Pey-kovil)="Demon's, or devil's temple," or house,

Kadaládi	"*Sea bather*"; fr. kadal, the sea, and adi, a player, bather; (fr. a local tradition).
Kadaleiyúr	Corrupt, fr. kadasi=last, final; ellei, a boundary, limit; and úru.
Kádamangalam	Perhaps fr. kadu, a jungle, and mangalam=prosperity, fortune. A flourishing village.
Kadavu-Santei, or Kathavu-Chanthei	"*door, or gateway fair*"; fr. kathavu, a door.
Kadeiyákkulam	"*End tank*"; fr. kadei=end, (market). The root-meaning is last (born)=low caste. The Kadayar are below the Kallar.
Kadeiyár (kulam)	"*Kadeiyan's (tank)*"; a caste or tribe of fishermen (mostly Christians now) about Rámesweram.
Kádu	A barren place, jungle; an untilled or un-irrigated field.
Kal, Kallu	A stone, rock.
Kál	The leg; a quarter, (cf. H. páon, and páo) a stake, stem, prop, pole, shaft, &c.
Kalak kudi	Fr. kalam, a threshing floor, barn. Open field (see Kalari).
Kalari	Barren or brackish ground, a threshing floor="*arena*".
Kaliman gundu	"*Clay-mound*", kaliman, clay, and kundu, a lump, boulder, heap.
Kallan	One of an indigenous tribe, addicted to thieving. Plur. kallar, the "colleries" of Orme's history and others.
Kammai, for Kanmáy	Com. use in Madura for an irrigation tank or reservoir, a common village name.
Kamma-patti	"*Tank fold*"; fr. kanmáy, a tank for irrigation, and patti, q. v.
Kammaya-naiken-patti	Pr. n.="*Kammaya Naik's fold*". Patti, a cattle fold, hence, a small village.
Kánjarangudi	Pr. n. (?) fr. kanjiram="Strychnos nux vomica", and kudi, a habitation, dwelling.
Kappal-madei	An anchorage; fr. kappal a vessel, a ship, and madei (?) allied to madu, a pool, a place in the sea deep enough to anchor in.
Káppiliyan	One of a Canarese agricultural caste or tribe in Madura, with com. agnomen "Gaundan" (T. *kavandan*).
Karei	A border, shore, bank. Common affix to village names.
Karisal-puli	Karisal=black soil, blackness, or any thing black, and puli=tiger.
Karshá-Kulam	Vulg. (?) for Karisara, for karisal, q. v., and kulam, a tank.
Kasavangundu	(?) for kusavan, or vulg. koshavan, a potter, and gundu, a boulder, rock:="*Potter's mount*".
Katari (or kithari)-Amman Tívu	Kithari, corrupt. for Catharine="*Lady Catharine's Isle*", so called from an old R. C. Shrine there.
Kidáthirukei	Kidá (?) short for Tadáthagei, n. of Minákshi; tiru, holy, and kei, the hand.
Kílakarei	"*East-shore*", v. sup.; about the largest seaport town between Tuticorin and Púmban.
Kíla-kidáram	"*East Kidáram*" (?) kidáram=a bowl, copper boiler, &c.
Kíle	In comp.=eastern; fr. kíle, below, because the country falls to the eastward.
Kodi-kánal	"*Creeper wood*"="*Rattan (cane) forest.*" The first English settlement on the Palney hills.
Kodi-medu	"*Flag-mount*"; fr. kodi, a flag, streamer, a creeper, &c., and medu, a mound.
Kodumudi	"*Flag (staff) point*"; fr. kodi, a flag, v. sup., and mudi, a crown, crest, topknot.
Kokkádi	(?) "*Cranes play*"; fr. kokku, a crane, and ádi=player.
Komba-úthi	"*Horn blast*" or "*Horn blower*"; fr. kombu, a horn, and úthu, blowing.
Koneri	"*King's lake*"; fr. kon=king, and eri, a lake, a large sheet of water.
Kottan Kulam	The old name of this place is Kunthi-nagaram, once a place of pilgrimage.
Kottei	A fort. Com. affix to pr. names of fortified villages.
Kovil or Koil	A (Hindu) temple or place of worship (?) fr. ko=king, pastor, and il, a house.

Kovil Kulam	"*Temple-pond*"="*Church-lake.*"
Kovil-patti	"*Church-fold*"; fr. kóvil, a temple, and patti, a cattle fold, a small village.
Kúdal-i	A junction. Com. term for the confluence of rivers.
Kudi	A house, dwelling.
Kudisei	A small dwelling=huts, cottages.
Kudi-irupu or Kudiyiruppu	A dwelling, residence; com. n. for a small hamlet in S. I., especially near the coast.
Kudirei-katti-mundal	"*Horse-bound-point*", local name for the Periapattanam headland; fr. kuthirei, a horse, and kattu, to bind. It is said a horse sacrifice was made here.
Kulam	A pond, tank, reservoir of water; usually for irrigation.
Kulaya-nallúr	Pr. kula-Sekhara-n.="*Race head-ornament*"; fr. the n. of an early Pándyan king; and nallaúru="*good-town*"="*fair-ville*".
Kumára-kurichi	Fr. a pr. n. of Subramanya, Kumáran=son (of Shivá), and kurichi =a settlement, village.
Kundu-kál	(?) "*Squatting point*"; kunthu=setting (on), kál, the leg, (?) going on tiptoe. The W.S.W. point of Rámesweram Island, fr. a legend about Hanumán.
Kunru	Pronounced kundru (and in Mal. kunnu), a hill, a small hill, a round stone, a boulder rock.
Kurichi or Kurichchi	A settlement. Com. n. for a small village or hamlet in S. I. properly on a hill, for kundrachi (?).
Kurtálam	(Vulg. "*Courtallum*")=(?) "*Stunted Banyans*" (? fr. kuttru, ? dwarf) and álei, the banyan.
Kurusadi	"*Cross-foot*"; an island nr. Pámban; so called fr. a R. C. Shrine, (kurukke=a cross) and adi, the foot.
Kuruvi-nattam	Fr. kuruvi, a bird, a small bird, and nattam, a village site, a village.
Kuttam	A tank, a large pond.
Kúttam	A collection, assemblage, a crowded group, cluster, &c.; applied to a collection of huts, a hamlet.
Kuttei	A small tank.
Kúvar-kuttam or Kúvat-kuttam	(?) "*Noise-tank*"; fr. kúval=cooing, a crowing noise, and (?) kuttam, q. v., applied to a little village of a few inhabitants.
Latchmi	Fr. S. Lakshmi, pr. n. of Vishnu's consort, or Sakti, goddess of wealth, fortune.
Letchmi-puram	"*Lakshmi's town*".
Lingam	The sacred phallic emblem, symbol of Shivá under which he is worshipped by Saivas.
Madam	Fr. S. and H., math, a school or college for brahmans, a cloister, monastery.
Madura	Town and district or collectorate: derivn. doubtful; perhaps more prly. spelt Madhura (Nelson).
Malei	A hill, mountain, com. use; hence Malabar for Malei-war, and Maleiyálam, the Malabar language.
Malei	Rain. Hence Malenádu, the Maluád or rainy district of Mysore.
Maleipatti	"*Hill-fold*"; very com. n. for vil. at foot of, or near a hill.
Maleswerapuram	Pr. n. (?)="*Hill-gods-town*".
Man	Earth, soil.
Manal	Sand.
Manapád (?)	"*Sand-hill*"; pr. n. of a headland on the Tinnevelly coast between Trichendúr and Cape Comorin.
Manaar	Vulg. use for Mannár=a town, settlement, fixed abode, fr. mannu to be fixed, lasting, to remain; or (?) fr. manuár=enemies, foes.
Mandalam	Fr. S., a region, circle, district, (cf. L. mundus, the world) "Coromandel" (?) for cholamandal, cf. tondamandalam, also= a small temple or shrine.
Mandala-mánikam	Pr. n.="*Region of gems*", or rubies. Mánikkam (fr. S. mani, a gem), a precious stone, gem, a ruby.

Mandapam	A covered court or hall, built with pillars, a rectangular open-sided hall, before or near a temple.
Manditop	Pr. n.; fr. mandi=a monkey, and toppu, a grove, a "*tope*".
Mangalam	Matrimony, praise, delight; com. affix to pr. ns. of wealthy villages of brahmans, rich in rice fields=a flourishing village.
Mannáli	Pr. n. of an island, perhaps fr. its being composed of manal=sand.
Mantri	A chief counsellor, prime minister; a com. prefix.
Marakkayar-pattanam	"*Skippers' town (or port)*"; fr. marakkalam, a ship, (mara, wood, and kalam, a vessel), marakkaya=ship-owner.
Máriyúr	Once a large seaport town on the Gulf of Manár.
Maravan, pl. Maravar	Pr. n. of a tribe of the inhabitants of Madura, of lawless and predatory habits.
Máyákulam	"*Everlasting-pond*"; fr. máy-á, that vanishes not, and kulam, a pond, tank.
Medu (see Metu)	A height, &c., comly. pronounced more as if written modu, moedu, or möru; e. g., Nagari Mor, a hill near Madras.
Mela-kal-úruni	Pr. n.="*upper (i.e. western)—kal-úruni*", (perhaps stone tank); fr. úruni, a common village tank.
Mela-madei	"*Upper (i.e. west)—sluice*"; fr. madei, a small water-sluice for irrigation, &c. The land first watered being nearest to the sluice is called Mel-madei, and the lowest or last watered land is called Kíl-madei.
Mele	In comp. mel=up, upon, (upper), hence western, west; because the country rises to the west.
Melmánthei	"*West mánthei*" (?) for manthei, mandei or mantei=a herd, flock, (?) assembly.
Metu or Medu	A height, hillock, rising ground, com. use for a swell of high land.
Mínáchi, also in T. Mínátchi	For S. Mínákshi="*Fish-eyed*"; a name of Párvati, consort of Shivá=káli.
Mínaugudi	(?) "*Fish-village*".
Mottúruni	Pr. n.; fr. mottei, bald headed, bare, (?) from being on an open bare plain, devoid of trees, &c.
Mudaliyár or Mudali	A title of respect, in com. use in Madras, applied to a Tamil caste.
Mudukulattúr	"*Old-tank-town*"; fr. muthu, ancient, kulam, a tank, and úru, a town.
Múkkeiyúr	Pr. n.="*Cape-town*" or "*Bill town*"; fr. múkku, the nose, bill, beak; (?) so named fr. being near a headland.
Mulli Tívu	"*Conch (shell)—Island*"; fr. mulli, a shankh, or conch shell, once abundant here.
Mundel or Munthal	A headland, cape, point, loc. use for munei, a headland, promontory.
Murugei-talei	Fr. murugei, coarse coral rock, and (?) talei, the head: a common affix, cf. leather*head*, gates*head*, &c.
Musal Tívu	"*Hare-Island*"; fr. musal or muyal, a hare. Hares are still found on Hare-Island at Tuticorin.
Muttupettei	"*Pearl-town*"; fr. muttu, a pearl (cf. H. moti), and pettei, a (market) town, a village with shops, a bazaar.
Muttúruni	"*Muttu's úruni*" (i.e. tank). Muttu, perhaps the name of the man who had the tank made. A common proper name fr. muttu, a pearl.
Nádu	A district, country, as opposed to town. In Madura comly. applied to Kalla tracts, (see kallan). The opposite of Kádu jungle.
Naduvupatti	"*Middle-fold*"; fr. nadu, middle, and patti, a fold or small village.
Naiken	Short for Náyakkan, a title borne by men of Telugu (or Telinga) race, a chief, leader.
Nája-mundel	Pr. n. (?) and mundel (q. v.) a headland.
Nallatanni Tívu	"*Sweetwater island*"; fr. nalla, good, and tannír, water (properly tannírru=cool water).

Nallúr "*Good-ville*"; fr. nalla, good, fair, and úru, a town.

Naripeiyúr (?) "*Fox-bag-ville*"; fr. nari, a fox, pei (or pai), a bag, and úru, a town or village.

Nattam The village site, ground reserved for building on. Com. village name in S. I.

Náyakkan Fr. S. náya, a leader=náya, guiding. In S. I. a title of warlike Telingas, (the "Poligars")=chief, leader; allied to náyar, the honoured Sudras of Malabar.

Neduvan Tívu On old maps "*Nedöcn*", locly. pronounced Nedum="*Long island*".

Negapatam Vulg. for Nága-pattanam. Nága, snake, "*dragon*", and pattanam, a town, (?) a seaport town.

Nellúr "*Rice town*", fr. nel, raw rice, "paddy", and úru, a town.

Nerinji-nattam "*Thistleham*" or "*thornville*"; fr. nerunjil (vulg. "*nerinchi*"), a weed bearing a thorny seed: (tribulus terrestris).

Nerinji-patti "*Thistlefold.*" See above.

Nochchúruui Fr. nochchi, a medicinal tree (vitex negundo), and úruni = a tank or well.

In Tamil w is vulgarly prefixed in pronouncing words beginning with o.

Oppilán Pr. n.=(?) "*the incomparable*"; fr. oppu=likeness, comparison, and illádavan=one destitute of,="*he who is without*". (?)

Ottangudi (?) "*Builders' village*"; fr. ottan, a well digger, or builder (a caste), and kudi, a dwelling.

Ottapidáram or Otta-pandáram Fr. a man's name, and a corruption. of "(Alagiya)-pándiya-puram", the ancient name.

P. in Tamil is pronounced like b sometimes, as after m and n, and stands for the labials (Surd and Sonant alike) p, p'h, b, and b'h.

Pád Tel. a hill, (?) corruption of H. pahár, a hill.

Pádi A village or town, (in comp. bádi) a row; com. affix to vil. pr. n. (?) a bar (in the sea).

Pádu A place, situation, location, besides many other meanings.

Pákkam Com. affix to vil. names near Madras; (?) allied to pakkam T., a side, vicinity, or (?) to bágam, a division, share.

Palaya Old. Cf. Gr. palaios, old.

Páleiyam A place or district under feudal tenure (a fief), a cantonment, military suburb, a village.

Pálkulam "*Milk-tank*"; fr. pál, milk, (cf. C. nál, and Gr. gala, milk).

Pallam A ditch, hole, pit, ravine, water course, hollow, &c.

Pallan, pl. Pallar A very low caste of labourers in S.I.

Palli A hamlet, also a small town, a village: a fane, mosque, &c.

Palli-vásal Com. use on the S. coast for a mosque, place of worship; fr. palli, a place of assemblage, and vásal, a door or gateway.

Palliamunei Derivation. uncertain: n. of an island said to be named from the mainland of which it perhaps once formed a part.

Pámban Fr. S. pámbu, a snake. Pr. n. of the town on Rámesweram Island, at the channel, dividing it from the mainland.

Pámbár "*Snake-river*". A small river of the Madura country.

Paneiyúr "*Palmyra-ville*"; from panei, the Palmyra palm, and úru, a town.

Paneiyeri-Enthal "*Palmyra-climbers' tank*"; fr. panei, v. sup. eru, climb, and enthal, a tank.

Pápánkulam "*Brahmans' tank*". Brahmans are called pápa, and pápán, for párpan (? = "*Seer*") in S.I.

Pápanásham Fr. S. = "*Sin-extinction*", a sacred bathing place near the lowest cataracts of the Támraparnei river.

Pár (?) for párei, a rock, crag: a common affix to pr. n. of villages, &c.

Parambu High ground, a stony mound, gravelly waste, a ridge.

Parapana-valasei (?) "*Brahmans' retreat*"; see pápán, valasei, Tel. a retreat.

Párei A rock, com. use.

Pareicheri "(Vulg. Parcherry)"="*Pariah's hamlet*", or quarters; fr. pareiyan, an out-caste, drummer, and cheri, a hamlet, place.

Parutti	Cotton, the cotton shrub.
Párvati	Pr. n. daughter of Himálayah, and consort or Sakti of Shivá; also called Durgá, Devi, Bhaváni, Káli, &c., at Cape Comorin ("kanniyá-kumári=the virgin maid") where there is a famous old temple in her honour; she is also called Bhagavati.
Pattanam	Fr. S., a town, a city, a large town.
Patti	A cattle-fold, herdmen's village, a small village (=c. hatti).
Pattinam *	A town by the sea or on a river. A seaport town, (a port).
Peisás-mundel	Fr. S. pisácha="*Demon-cape*". The northernmost point of Rámesweram Island.
Peria Kulam	"*Great tank*"; fr. periya, great, and kulam a tank.
Periapattanam	"*Great town*". This is said to have been an exceedingly large city some centuries ago.
Periúr and Perúr	"*Grand-ville*".
Perumál	"*Great one*"; fr. periya, great, and ál, a person. A common name for Vishnu in S. I.
Pettei	A suburb, a town or village with shops, a market town, usually contiguous to a fort.
Pey-kovil	"*Devil's temple*". The Shánár (or Sánáns) and other low tribes worship a demon for god, i.e. a malignant deity.
Pillei	A child, son, a title assumed by some of the higher Tamil castes (cf. L. filius; fr. fil, &c.).
Ponthampuli	Pr. n. (?) fr. pontu, a hole, cave, and puli=tamarind (tree).
Pothikulam	"*Baggage-pond*"; fr. pothi="*full of sacks*", or packs. A tank where they unpack and rest, &c.
Poy-chal-lá-meyir-ayan-kovil	Pr. n. "*The lieless truthful* (i.e. *most true*) *lord's temple*".
Pú	A flower; also pushpam or pudpam from the S.
Pudu or puthiya	New, com. use. Pudúr="new town"; Pudu-kottei="*new fort*", (vulg. "*Poodoo-Cottah*").
Pudu-madam	"*New College*"; fr. the previous, and madam, a school or college for brahmans.
Pul	Grass.
Púlánkál	"*Púlám-branch*"; fr. púlám, a plant (the twigs of which are used for a toothbrush), and kál=a leg, properly limb-branch.
Puli	A tiger.
Puli	A tamarind (tree) sourness.
Pulieri	"*Tamarind-lake*"; fr. puliya (-maram) the tamarind (-tree), and eri, q. v.
Pulli	A spot, point.
Púmurichán	"*Flower-broken*"; from pú, a flower, (which the coral much resembles), and murichán=plucked or bruised. Name of a channel through the coral reef.
Puram	Fr. S. pur, purá and púr, a town, city, a considerable town with brahman inhabitants; waram, or veram is vulgarly used for this word, as in "Conjeveram", for Kánchipuram; "Mauliveram" for Mahá-bali-puram, near Madras.
Puram	T. a side, the outside: comly. applied to an outlying village, a suburb, com. T. affix to v. and pr. n. This word is said to have no connection with the previous "puram".
Putti Tívu	(?) "*Hummock Island*". Putti and pottel, are applied locally to shoals, reefs and sandbanks in the sea, cf. pottei, a mound or hillock, local usage.
Púvarasanshallitívu	"*Portia (-tree)-Shingle Island*", puvarasu-maram=the tulip tree.
Púvanáyakkanpatti	"*Púva Naik's fold*", (pronounced more like Boghanaiken-p.), a man's pr. n., and patti, a fold = a small village.
Raghunáthapuram	Pr. n. "*Raghunáth's town*".

NOTE.—In Northern India "Pattan" is frequent, on the rivers of the Panjáb, as Pák-pattan, Hari-ka-pattan, &c., and it is said to mean *a ferry* there (cf. H. patni, a ferry man); also on the "Jumna" and "Ganges"; e.g. Indrapat (?), Patna; also it is exceedingly common on both coasts of Southern India:—"*Seringapatam*" (Sri-ranga-pattanam) is on the river "*Cauvery*" (Káveri).

Rájákapáliam	Vulg. for Rájákal-páleiyam. Rájákal (plural of Rájá) = kings, and páleiyam, q. v., = "*Kings'ton*".
Rámaswámi-madam	"*Rámaswámi's College*", on the S. coast of Madura founded by a former zemindár.
Rámesweram	Fr. S., Rámá, iswara=God, and puram (=? "*The town of Ráma's lord*").
Rámnád	Pr. n. of the zemindári estate and the town com. called by the natives Rámá-nátha-puram (*Lord Ráma's Town*) for which it stands.
Reddi	One of a Telinga (or Telugu) agricultural tribe or caste, of which there are some colonies in Tinnevelly and Madura.

S. in Tamil stands also for ch, j, jh, and sh, and the Sanskrit ksh, and is pronounced and transliterated variously.

Sambutti-yendal	Pr. n. Endal or yenthal, a small tank, com. in Madura.
Santei	(Vulg. shandy) a fair. The com. weekly village market of S. I.
Sáyalakudi	(?) "*Belle-house*" com. pr. n. of vils; fr. cháyal, beauty, and kudi, a dwelling.
Se-sen-sev-, &c. or Che-chen-, &c.	A com. prefix meaning red. See following.
Senchadainátháputam	"*Red-shocked lord's-town*"; fr. sen, red, chadai, matted hair, nátha, lord and puram, town.
Sengalanerodei	"*Red-water-course*"; fr. chengal (sen-kal, red-stone) neru, water and odei, a course (fr. odu=run).
Serveikáran	The title of the Ahambádiyan, tribe of Madura Tamils., hereditary servants or clansmen of the Sethupatis (Zemindárs of Rámnád).
Sethupati	"*Lord-of-the-causeway*"; title of the Prince of the Maravars, Zemindár of Rámnád; fr. chedu, a causeway= Adam's bridge, and the ancient causeway of Rámesweram.
Sevalpatti	"*Red-fold*"; fr. sivappu, red, and patti, a fold, village.
Shalli-Tivu	"*Shingle-island*"; fr. challi, broken pieces of stone, brick, shell, &c.
Shemanúr	Pr. n. perh. derived fr. Shapana, or Sámana, a Jaina sect in S. I.
Shera-mudali or muthali	Pr. n. for maulavi, a Muhammadan worthy, saint, or sage named Shera.
Shevelmedu	"*Red-mound*"; fr. sivappu, red, and medu, a mound, high ground.
Shivá or Sivá	The 3rd deity of the Hindu triad; Saivas regard him as creator, destroyer and regenerator, and worship him in the form of the linga, his type or emblem.
Soneiperiyán-Kottei	"*Grandee's-spring-fort*"; fr. shonei, a (water) spring, periyán=great one and kottei, a fort.
Sri	A name of Lakshmi, the consort or Sakti of Vishnu, goddess of prosperity, fortune.
Sundaramudeiyán	"*Beautiful-Udeiyán*"; fr. sundaram = beautiful and udeiyán, a title of the kallan tribe.
Suplápuram	Corrupt for Subramanya-puram = "*Town of subra-manya*" the Hindu Mars, god of war, son of Shivá.
Súrangudi	Pr. n. of a chief (súran = a hero; fr. S. suria, the sun), and kudi, a dwelling.
Taleimanár	(?) "*Head of Manaar*"; fr. talei, the head. The Ceylon end of Adam's bridge.
Taleiyáli	N. of an island; fr. talei, the head.
Támraparni	"*Copper-coloured*"; fr. S. támra, copper and varna, colour.
Tangamma-puram	"*Golden-lady-town*" (?).
Tani-chanthei	(!) "*Only-fair*"; (!) santei = a fair, market, (vulg. shandy). Old name Tani-cheyum.
Tanni-turei (? toni-turei, q. v.)	"*Water-ford*"; fr. tannír, water (prop. cool water), and turei, a ghát, ford, shore, &c.
Taravei	(?-vu.) A salt-marsh-swamp. com. use near the Madura coast.
Tareigudi	(?) "*Landham*", or (?) "*flat-house*"; fr. tarei, the ground, earth, a place, and kudi, q. v. (? a level place, flat).
Tattanadi	"*Parrot-river*"; fr. tattei, the green parrot, and nadi, a river.

Tedal or Tidal — High ground, a dry place in a river or marsh, a heap, swell of rising ground; tidar, titei and tittu all mean very much the same.

Tekkei — Vulg. for terku (ten) south, southern, in oppn. to vada, north, northern.

Tenkadá — For ten-kadal="*south-sea*", a place on the south coast of Rámesweram.

Tenkási — "*South Kási*", or Benares.

Teppukulam — "*Raft-tank*"; fr. teppam, a raft on which the idol is floated about.

Teri or Theri — Local name for the drifting sand hillocks or red sand wastes of Tinnevelly and Madura.

Thalaváypuram — "*Field marshal's town*"; fr. Talaváy=Dalaváy, title of the commander-in-chief, or minister of a South Indian Native Government.

Tidar — (Tedal, q. v.) a mound, dry bank in a marsh or river, &c.

Tinnevelly — Vulg. Eng. for com. Nat. pron. Tirnaveli, wh. is for Tiru-nel-veli="*Sacred-rice-hedge*". The town stands in the midst of rice fields.

Tiru — Blessed, holy, sacred; a name of Lakshmi=good fortune.

Tiruchúr — (Vulg. "*Trichoor*") (?) corruption of "Tiru-Shivá-per-úrú" = "*Holy Shivá's great town*".

Tirumálugandán Kottei — (?) "*Shivá-server's fort*"; fr. Tirumál, Holy one, and ukandán, obeyed.

Tirupatúr — (Vulg. "*Tripatoor*") for Tiru-pati (vulg. "*Tripetty*")=sacred-lord, and úru.

Tiruppuláni — Pr. n.; fr. tiru, holy, pul, grass, and áni ((?)=wearing) fr. the legend of Rámá having once slept here on the sacred (sacrificial) grass.

Tivu — An island (on Coromandel Coast *dívi*, on Malabar Coast *tív.* and *div.*) fr. S. dwípa=two waters.

Tíyanúr — Fr. tíyan= low-born, base.

Toniturei — "*Boat-ferry*", "ship-ford"; fr. toni, a boat, and turei, landing-place, ford, road=ghát.

Tulkapatti — "*Turks-fold*". Tulukkan or Tulukkar, as Muhammadans are called in S. I.

Turei — A landing place, the ford of a river, the haven of a sea.

Tuticorin — Corrupt. for Túttukudi, q. v.

Tutti-nattam — Fr. tutti, a plant ("*Sida Mauritana*") and nattam a village.

Tutti — A trifle, insignificant.

Túttukudi — The native name of "*Tuticorin*", said to mean "*scattered-habitation*"="*winnow village*".

U final is so softly sounded in Tamil as to be nearly mute.

Umuriampádu — "*(Sea)-weed-shore*", (?) from the accumulations of sea-weed so common about here.

Uppár — "*salt river*"; fr. uppu, salt, and áru, a river.

Uppu-tanni-tivu — "*salt-water-island*", in oppn. to "Nalla-tanni-tívu" (q.v.) an adjacent island where good water (to drink) is found.

Uru or Ur — A village, town, country; com. appd. to large villages of Canarese or Telugu people in Madura.

Uruni — A tank or well. The common village tank, accessible to all in the place.

Uth — Com. affix. (for úrru, prond. úttru) a spring, fountain.

Uttan or Vuttan — V. pr. n. (?).

Uttarakoshamangei — Pr. n., more fully, "Tiru-uttara-shri-koshamangei", a famous but decaying Shivá temple near Rámnád, about which there is a long legend.

V is used sometimes for b and w in writing foreign words in Tamil.

Vada — In comp.=north. By the English called Wada and Bada, e.g. Vadakarei, Wada-k. and Bada-k. "*North-bank*", *North-shore.*

Valam-bádal	(?) Perh. "Right (hand)-bádal", in oppn. to Idam-bádal, a vil. to left of the marsh close by.
Valasei	Tel.="*Removal*"=flight from home for fear of an army in the field,= "*a retreat*", com. n. of a village so occupied, Vulg. "Walsa".
Valei Tívu	(?) "*Sword-fish-island*"; fr. vál-mín=the sword-fish.
Válinokkam	Pr. n. of a headland S. coast of Madura.
Varam or-Veram	Vulg. colloq. form of puram a town, also waram and weram.
Vásal	A doorway, entrance, gate; pallivásal, a mosque loc. use.
Vayal	An open plain, a field, C. bailu. The vulg. "bile," "byle", vail, and boyal, &c., of Eng. maps.
Veli	A hedge, ward, wall; com. affix to village names, as "Tirnaveli" see "*Tinnevelly*".
Medu Vellakára	"*White-man's-mound*"; fr. velli, whiteness.
Velleiyammanpuram	"*White-goddess-town*"; fr. vellei, white, ammál, goddess, and puram, a town.
Vembár	"*Margosa river*"; fr. vembu, the margosa or "*Nim*" tree, and áru=river.
Veppam-kulam	"*Margosa tank*"; fr. veppu, the margosa or "*Nim*" tree, and kulam, a pond or tank.
Vettilei-mandapam	"*Betel mandapam*", written Verrilei (rr prond. = tt) on the mainland opposite to Pámban.
Vijayápati	"*Vijayá's lord*", (i. e. Shivá) Vijayá="Victorious", a n. of Párvati: hence Eng. "*Beejapore*" (for Vijayápur) and "*Vizianagram*" (for Vijayámanagaram).
Vilátikulam	(?) Vilátti, occas. form of vilá=the wood-apple (Feronia Elephantum), and kulam, a tank.
Vilvamarattupatti	"*Bel tree village*"; fr. Vilva-maram (in comp. marattu)=the sacred Bel tree (cratava religiosa).

W is not a Tamil letter, but it is vulgarly pronounced before o initial and u sometimes.

In Tamil y is vulgarly inserted or pronounced before a and e initial.

Yánei or anei	An Elephant.
Yelavelankál	(?) "*tender thorn branch*"; fr. yel = tender, velam = thorn (tree) ("*Acacia arabica*") and kál, the leg, a prop, branch, &c.
Yenádi	Pr. n. = (?) "why-first"?
Yendal	A very small tank, or reservoir com. affix to pr. n. of villages in Madura.
Yervádi or Ervádi	Pr. n.; (?) fr. eru a buffalo, and vádi an enclosure, yard.
Yettiyal	Pr. n. (?) for yetti-vayal; fr. Etti = a bitter and poisonous tree ("*Strychnos nux vomica*") and vayal, a plain, field, &c.

ABBREVIATIONS.

C = "Canarese"; Gr. = Greek; H. = Hindustani; L.=Latin; M.= Malayálam; S. = Sanskrit; T. = Tamil; Tel. = Telugu; R.C. = Roman Catholic; S. I.=South India; N., E., S., W. = North, East, South, West; = means equivalent to; com. = commonly; fr. = from or derived from; n. = name; pr. = properly; t.= town; v. = village; besides others in more common use.

Extract from the Narrative Report—dated 23rd August 1875—of Lieut. H. J. HARMAN, R.E., Assistant Superintendent 2nd Grade, in charge Assam Valley Triangulation.

(1.) I arrived at Shillong from Bangalore on October 4th 1874 and took over charge of the Party from W. G. Beverley Esq., on October 6th 1874.

(2.) The Party left "Gauháti", by march to "Jorhát", on November 5th 1874, in charge of Messrs. W. J. O'Sullivan and J. O. Hughes. With a few men I took passage in a steamer to "Kamlábári" near "Jorhát" and made arrangements for fixing the Treasury building in "Jorhát" from the stations "Bor Bhiti" and "Phakwa Dol", by running ray traces from these points into "Jorhát".—The final rays were each 6 miles in length and were opened out by Messrs. O'Sullivan and Hughes.

(3.) Meanwhile I visited the stations of the side of continuation and the stations "Bor Ghop" and "Gohaingáon" which were selected last season: and on the sands of the river laid out a triangulation to give data for cutting the ray "Bor Ghop" to "Gohaingáon" and to the Revenue Survey Pillar on the banks of the "Dikhu". This done I selected the position for the station of "Melankur" and obtained the bearing that the right flank ray from "Gohaingaon" should have so as to skirt the forest which borders the old "Dhy Ali". I could not get to the position of the "Dimú" Station, but got near enough to warrant the ray being cut through at once as a final ray. This line was successfully carried by Mr. O'Sullivan, and he suitably placed the "Dimú" Station at nearly 6 miles from "Gohaingáon". I returned to "Sibságar" on December 2nd and as I was under orders to join the Military Expedition (which had already left "Narainpúr" for the "Daphla" Hills) I visited the parties at "Jorhát" and reported myself to Major Godwin Austen (in charge of the "Daphla Expedition" Survey Party) at "Borpathár" (campNo. 2) on the 12th December.

(4.) The force had but a short distance to march, and I did not anticipate being with it more than 6 weeks, but it so happened that I did not get back to my Party until March 3rd, on which day I reached "Disangmuk". Now I had directed that as soon as the rays to "Jorhát" were clear, the party should move on at once to "Sibságar" and work solely in advancing the approximate series, because I intended to return by "Jorhát", build the station there and take the observations for fixing it: this plan was frustrated, and the angles must be observed on the march up next season.

(5.) During my absence Mr. O'Sullivan was in command of the party, with instructions to observe to any new peaks not already fixed by Mr. Beverley, but an opportunity did not offer. The rays to the Revenue Survey Pillar on the "Dikhu" were cut. A length for the side "Bor Ali" to "Bor Ghop" obtained, but a mistake crept in, and the ray "Bor Ghop"—"Gauriságar" in consequence fell out a good deal; this ray was 5¼ miles in length and had very heavy forest on it. The ray "Bor Ghop"—"Gohaingáon", 7 miles in length, passed entirely over grass country, except in the middle of the ray where it traversed a belt of trees bordering the "Darika" river. The rays on to "Melankur" station from "Bor Ghop" and Gohaingáon were carried up to the left bank of the "Brahmaputra", and the right flank ray from "Gohaingáon" to "Dimú" carried as before stated in para. 2.

(6.) On March 4th I crossed the river and cut the two rays on to "Melankur" till they met; the ray from "Gohaingáon" fell on the spot indicated on the chart, but the line from "Bor Ghop" was considerably out; the final ray to "Bor Ghop" was cut and the station of "Melankur" built by Mr. O'Sullivan (a post station requires 3 days to erect if the materials are near at hand). I ran a ray trace between the "Melankur" and "Dimú" stations, the cutting of the narrow gap took 15 men four full working days, but the final ray took 20 men 20 days, Mr. Hughes cutting the heavy forest extending from the "Brahmaputra" to the "Bolemár" river, a distance of 1 mile, while my detachment cut from the "Dimú" side to the "Bolemár". On this ray fell 2 miles of jheel, a formidable obstacle, traversed by elephants with very great difficulty. On March 15th I visited Mr. Hughes, who was then carrying a right flank ray from "Dimú" to "Tengápánia"; this line was for the first 1¼ miles clear, being across a jheel, then came a huge cane forest for ¾ of a mile up to a jheel full of trees of extreme hardness, and the men were working up to their waists in water; I found Mr. Hughes far from well, he had written to say that he feared he would not be able to stay out the season, and some cases of sickness were showing in his detachment, so I removed this party to the banks of the river and Mr. Hughes cut the forest portion of the "Melankur"—"Dimú" ray as above mentioned.

(7.) I had not been able to visit "Tengápánia" before I left for the "Daphla" Hills, nor had Mr. O'Sullivan the opportunity subsequently, and from a misconception of my letter of instructions, in which I wished the rays to "Melankur" to be completed before advancing, this ray was undertaken without a reconnoissance having been made, and it landed us in trouble; finding so much labor had already been expended on the line I did not like to desert it as in 3 miles more it would cross the old Assamese raised road, the "Dhy Ali;" so on March 17th my party shifted to the head of the ray;

the two following days I was on the line and we worked very hard, but accomplished 220 yards only; the jheel cane was terribly armed with crooked thorns on every surface, I have seen no cane like it elsewhere: the natives with their wooden sandals and naked legs could barely creep through the fallen stuff, and they suffered severely. On March 20th I left my party on the ray, and with a few men went to reconnoitre "Tengápánia": the tract of country between the "Dimú" river and "Tengápánia" is interseoted by the "Bolemár" river, several streams, and the old "Dhy Ali"; and has not been surveyed by the Revenue Survey, so to find where the ray would emerge on the "Dhy Ali" I ran a traverse from "Lasua Mírígaon"; this done we dragged a boat through the forest and I went down the "Bolemár" and decided to carry the line on.

(8.) I then selected the stations of "Kherkutia" and "Sísa" and gave off the ray "Melankur"—"Kherkutia", which Mr. O'Sullivan carried, building the station close to the spot selected. I measured a base on the sands of the river and laid out a plan for triangulating this side, which work Mr. Hughes executed and I also measured another long base at "Lasua" to connect on with this work and to find the sides "Kherkutia" to "Sísa". Mr. Hughes now took up the ray "Kherkutia" to "Dimú", of which I had already cut a part from the "Dimú" side, leaving 2½ miles of forest and cane to be cut by Mr. Hughes from the river side.

(9.) On April 1st I returned to "Disangmuk" and reported to you my intention of at once taking up observations on the 4 triangles now ready; but reports came in, that the "Tengápánia" ray was still in cane, though better progress was being made. The spring rain set in violently, and I got news that an elephant had been lost in the jungles about "Dibrugarh" for five days; so taking some men I went up to "Dibrugarh"; the river rose rapidly and I was able to take my boat everywhere and so selected the 7 stations necessary to carry the series on to "Dibrugarh" Church tower, and see the country well.

(10.) On April 11th I returned to "Disangmuk", and found that my Jemadar, 2 elephants and men from the "Tengápánia" ray, had not returned as ordered; they had not been heard of for 7 days and as it had been raining heavily since April 1st, and all the rivers were up and the country flooded, I went the next day in search of them; we had rather a rough time of it, but on April 17th were all safely back at "Disangmuk". On my journey I visited Mr. Hughes' ray "Kherkutia"—"Dimú" and found it had gone a mile and was in heavy forest and cane. On April 22nd Mr. O'Sullivan crossed the river from "Sísa" to aid Mr. Hughes in pushing on this line. On April 25th the ray suddenly got flooded from the overflow of the "Bolemár", and a few days afterwards as the water was still up, I directed that the work should close there for the season.

(11.) The forenoon of April 21st I left "Disangmuk" to observe the 4 triangles ready, and so much water was then out that it took us till nightfall to get over 5 miles of the path to "Sibságar." As expected I could not encamp within a mile of any of the stations "Gohaingaon", "Bor Ali" or "Bor Ghop". I had put off taking observations till so late because from December to March they cannot be speedily done, and I thought it most important I should examine the country ahead, and get all the stations selected this season up to "Dibrugarh", if possible. I was delayed at "Gauriságar" on account of the branch of a tree on the ray to "Bor Ghop" cutting the heliotrope and giving a grazing ray; and also at "Bor Ghop" on account of the heliotrope at "Gohaingaon" not being visible at the time of minimum refraction; it was difficult to remedy these defects, as all the lines were under water, so after having visited 4 stations and obtained the elements of the side "Gauriságar" to "Gohaingaon", from which the Topographical Survey were taking their triangulation into the Nágá Hills, I closed work on May 10th and dropped down the river "Brahmaputra" in my boats to "Gauháti", reaching that place on May 16th, the same day that Messrs. O'Sullivan and Hughes arrived by steamer from "Disangmuk", the steamer having been greatly delayed.

(13.) Mr. O'Sullivan managed the party satisfactorily while I was in the "Daphla Hills". The amount of final ray opened was 49 miles of which 6 miles were in forest, 30 over Chapori jungle, and 3 of village cutting; he selected the "Dimú" station and built excellent post stations at 3 places.

(14.) Mr. Hughes opened out 20 miles of final ray of which 7 miles were in heavy forest, 7 miles of light work and 2 of village clearing: built good post stations at "Bor Ghop" and "Dimú": built the high platform for shewing a heliotrope above "Phakwa Dol", and observed the angles for measuring the side "Melankur"—"Kherkutia" and for correcting the trial ray "Jorhát" to "Phakwa Dol".

Mr. Hughes has not worked this season in the manner I wished and had shown him; on most of his rays the work expended has not been at all judiciously applied and the labor has been excessive.

(15.) A man mounted on an elephant can rarely see over the surrounding grass, or whatever it is; so I tried to introduce the plan of aligning the main flags by the parts of the flags which overtop the grass, and not by the lower half of the flags which is the usual custom.

A tiny gap is carried as straight as can be done with small hand flags placed at very short intervals, and at every half mile a man ascends a small portable bamboo frame so as to overlook the grass

and plant a tall flag in the alignment with the back tall flags: this method obviously requires the least grass cutting possible: I have tried the method and with success; but this season, owing to Messrs. O'Sullivan and Hughes being sick and unable personally to superintend the cutting it has not been employed: again, in carrying a trial ray through forest it is plain that large trees should be avoided by shifting the line a foot or two parallel to itself, but for the same reason this has not been done; so that with exception of the ray "Melankur"—"Dimú" all the rays have been cut through as final rays, which is in great measure the cause of the small progress made, especially as the stations and the heliotropes are placed above the line of grass and the only obstacles are the trees. Before leaving "Gauháti" the establishment were put through a course of trying frames of cut bamboos, and any 12 men could construct and erect a stiff frame 50 feet high in 40 minutes, of course 50 feet is never necessary, 20 to 25 feet suffices in almost every case.

(16.) The district worked in this season (excepting "Gobaingaon" near "Sibságar") has only a small "Míri" village here and there; no local labor worth mentioning was available or procured: next season the "Míri" villages will be fewer in number; when nearer "Dibrugarh" the Commissioner will make special arrangements for us. There are no roads, only one or two paths were found of use; the main communications are the river and the rays cut; for the former, boats larger than small dug-outs are very scarce and men not easily found to work them, and a ray cut through forest is almost impassable for elephants. Provisions have to be entirely supplied to the parties at work from depôts where they are collected, so that to maintain local labor and move it on the work is rather a task. The leeches in April and the swarms of mosquitos about the middle of April were great plagues.

(17.) Of the ray "Kherkutia"—"Dimú" 1 mile remains uncut and of the ray "Dimú"—"Tengápánia" 1½ miles: when this work is done, there will be little cutting on the left bank of the "Brahmaputra", the whole of the remaining lines into "Dibrugarh" are over Chapori jungle, chaurs, and the river.

(18.) We came across several old Assamese embankments and "Alis" (roads) on our lines this year, all covered with tree forest, they are not shown on the maps. While travelling in my boat up one of the jáns (small deep streams) north of the "Dihing" river in search of a suitable site for a station I came upon the trijunction of 3 old "Alis" in the thickest tree forest, but whither they led the "Míris" who accompanied me could not say. Near the "Tengápánia" station is the junction of the "Dhy Ali" and the "Motiárigarh" (old embankment), and the angle is curiously enclosed with a great circular road.

(19.) The out-turn of area this season is insignificant, but I hope, Sir, you will take into consideration the many retarding influences we had to contend with.

Extract from the Narrative Report—dated 22nd September 1875—of W. C. ROSSENRODE, ESQ., Deputy Superintendent 3rd Grade, in charge Eastern Frontier Series.

(3.) Owing to the difficulty of obtaining carriage and the country being still under water, I sent on the baggage and some provisions in charge of the tindel on the 7th November 1874, to Jungjungia, which was to be my first station of observation.

(4.) I left Moulmein on the 19th November, accompanied by Mr. Beverley, in boats, reached Sittang on the 30th November, hired boats at once, and joined my camp at Jungjungia H.S. on the 1st December.

(5.) On the afternoon of the 1st December the men who had gone to Suplitong H.S. with the signal party, returned with the intelligence that they could not find the path to ascend the hill, nor could they induce the villagers to accompany and guide them. The guide took them to the foot of the hill and would go no further, for fear of losing himself in the dense grass and tree jungle. I manned a fresh party with axes, billhooks and sickles and ordered them to cut their way and get up to the station as quickly as they possibly could, without waiting or trying to obtain aid from the inhabitants. To wait for assistance was hopeless. Suplitong H.S. is so situated that for 20 to 25 miles in every direction there are no villages.

The party I sent cut their way up and reached the station on the 6th day after leaving camp, and directed their signals the day after clearing the jungle on the summit.

(7.) The observations at Jungjungia H.S. were concluded without further interruption on the 11th December, Kuladong, The-ye-khu, Myayabengkyo, Kaneindong, and Keokpondong Hill Stations were then visited in succession. From Keokpondong H. S. I had to march to Kambungun Tower Station. The route lay through the extensive Pegu plain covered with reed and grass jungle: this during the rains

is an immense swamp and it was still wet. Even in the middle of January some portions were impracticable for elephants. The march was circuitous and difficult and occupied 7 days, the direct distance from station to station being only 26 miles.

(8.) On completing the observations at Kambungun Tower Station on the 25th January 1875, I marched the next day and arrived at Chaiteo H.S. on the 1st February. A description of it is necessary, this hill being held in great sanctity by the Burmans and all the other tribes in the Province.

(9.) Chaiteo H.S. is 3600 feet above sea level. Stupendous projecting rocks, surmounted with masses of rock, rivet the attention of the traveller on his attaining the summit of this mountain, and he is lost in thought and speculation at the wonderful phenomenon which presents itself. The priests assert that superhuman agency alone has accomplished the miraculous lifting of these huge masses of rock in successive tiers, and that the gods who executed the work, reside beneath them. Each of the above rocks is crowned with a pagoda dedicated to Gaudama the Budhist Deity, and the Burmans, Shans, Karens, and other tribes, make pilgrimages from all parts of the Province to the shrines (pagodas) constructed on this sacred mountain.

(10.) The Principal pagoda, named Chaiteo, is constructed on a rock overhanging the south-western face of the hill; directly below it is a yawning precipice several hundred feet in depth. The pagoda as it stands on the rock overhanging the precipice gives one the impression on seeing it from a distance that it is poised in mid air. On approaching it however the rock, an immense one, it is seen, has firm hold of the hill side and projects like a rhinoceros horn over the precipice. On this projecting portion the pagoda has been constructed. This is the principal and most sacred pagoda in which are deposited the bones and a tooth of Gaudama. There is nothing artistic in the edifice itself, the nerve and courage of the artificers commend themselves to the admiration of all visitors who are able to appreciate these qualities. The pagoda is roughly constructed, its defects however are hidden by the covering of gold leaf over a thick coating of some black looking adhesive substance which is prepared by the Burmans and used for this purpose to obtain a smooth surface. This substance consolidates and adheres most tenaciously to the structure and the gold leaf put over it is so tenaciously grasped by it that when dry it becomes a solid mass difficult to remove.

There are several other pagodas which have their history, and the pilgrims visit each in succession daily during the dry months from December to May. A grand festival is held annually, during March and April. The day of the full moon in March was this year the grandest day of the festival. Prior to the commencement of this carnival, sheds and booths spring up in all directions all over the hill, constructed by one or more members of each community, for the accommodation of themselves and their families. Traders have their stalls well stocked with every requisite and fabulous prices are realized by them, the demand increasing as the days run on towards the termination of this festive season. To obtain a blessing, it is necessary to worship at each pagoda and each pilgrim must at all times use a lighted candle during worship, the consumption of candles is therefore enormous. They sell at 4, 6, 8, 10 and 12 annas each, the former prices are obtainable during the first month, and the latter during the succeeding month. After the expiry of the two months, the festival concludes and the pilgrims retire to their respective homes. Near the principal pagoda is a fissure in the rock, about 4 inches in width, 7 feet long, and 15 feet deep, into this offerings are cast, consisting of silver and copper coins, gold leaf, (beaten gold) rubies and other stones of lesser value. This fissure is the treasury box of the Budhist Deity Gaudama. On the pilgrims retiring, after making their offerings, men with long thin rods with bird lime attached to the ends, endeavour to secure for themselves the coins and other valuables cast into it, whatever adheres to the rod is brought up and appropriated. Cloths of cotton and silk are also offered, should the cloth be of great length it is wrapped round the pagoda, the smaller pieces do duty as flags, streamers and banners. Cocoanuts and plantains and food are the usual offerings to the priests and monks.

(11.) A well 20 cubits deep has been sunk near one of the pagodas, this feat was accomplished by a single man working daily for 6 years through the rocky strata; he was rewarded for his patience and perseverance by hitting upon a spring which provides a plentiful supply of water, and the well has never been known to be dry.

(13.) After completing the observations at Chaiteo H.S. I had to visit Toungoundong H.S. The routes to it were very circuitous and would have occupied me 9 and 10 days to reach the station. I ascertained that an old road through the hills was still partially in use which would save me 5 stages. I had this path, for it was nothing more, cleared, widened, and the overhanging branches removed, and although the marching was difficult and tedious and occupied 8, 10 and 12 hours daily, I saved 5 days by adopting it.

(17.) Suplitong H.S. was dreaded by every man in the native establishment. They had heard how Mr. Beverley had fared there the previous season; how the men with the signal lamps and heliotropes had been detained in a howling wilderness, in the early part of the season, until re-inforced by me;

how the men I had sent cut their way up to the station; how members of this party had returned sick and disabled, and suffered from fever for 2 months, one having died a raving maniac from fever contracted there; how Mr. Clancey who had cut the road, nearly succumbed from fever and how all his men, public and private had been prostrated and sent to Hospital, one having died there. His servants and Interpreter had deserted, and another Interpreter I had sent him had taken his discharge. The exaggerated accounts given by the men who had been there, of the dangers and difficulties to be encountered on the journey to Suplitong made such an impression on the minds of the men of my camp, that they dreaded the idea of going there. Disheartened and desponding they commenced the march. They were well fed and cared for. The preparatory arrangements had been well made for going and returning, the healthiest time was chosen after the jungle had been fired, and the difficulties and dangers, which were so appalling became less and less as the camp proceeded onwards. The summit was attained, the theodolite put up and the observations were completed the third day and we descended the hill returning by the same road and encamping at the same spots.

(19.) From Suplitong I proceeded to Thulu H.S. which I reached on the 10th of March making 12 consecutive stages. Owing to smoke and haze, the observations were not completed until the 21st I then visited Chaideo H.S. where I was detained 7 days from bad weather.

(20.) From Chaideo I visited Kyunkaban Station situated near the mouth of the Bheling river, here I was detained 8 days. The ray from this to Kalamatong H.S. was 32 miles in length and passed over a large expanse of water, the signals were at first unfit for observing; when the weather cleared up I succeeded in getting good signals and completed the observations. This was a most uncomfortable station to encamp at. Standing as it did close on the bank of the Bheling river, near its mouth, in dense tangled jungle difficult to cut and difficult to penetrate. The spot selected for the station was the highest available. A circular clearance of a hundred yards was made for the encampment. The elephants horses and the sick under the Native Doctor were located in a village 4 miles away.

(21.) I arrived at Kyunkabun Station on the 4th April during the spring equinox. Two days after the sun was partially eclipsed. The spring tides on this occasion were unusually high. The first washed over the encampment and submerged it, the platform was the only dry spot, upon which all the baggage, provisions, and other valuables were placed. As soon as the tide receded, a strong scaffold 15 feet high was erected for the baggage, and the tents were pitched upon raised scaffoldings 4 feet in height. It was most fortunate that no storms occurred during my stay at this station, for had one broken upon us and raised the water, as storms generally do, to a great height, we should one and all have perished, for there was not the remotest chance of escape encompassed as we were by tangled and impenetrable jungle, by the river and by two creeks, which would have proved formidable barriers.

(24.) There is a bar at the mouth of the river and the bore here is more formidable than any I have witnessed in other tidal rivers.

(25.) From Kyunkabun I proceeded to Kathbatong H.S. the centre of the next hexagon; owing to the smoke and haze with which the atmosphere was impregnated, observations proceeded rather slowly. The monsoon set in on the 21st April, with storms and rain, its usual accompaniments. The heavy down pour ushered in fine observing weather and I completed my observations and pushed on to Kalamatong which I reached in four days. Notwithstanding daily showers of rain, I hurried on not to lose the fine weather following rain, but on arriving at Kalamatong I found myself enveloped in cloud and mist. The rains had set in from the first shower which fell on the 21st April, every day was wet and the clouds and mist delayed me greatly. I took advantage of every break in the weather and completed my observations on the 13th day after my arrival.

(26.) There had been no rain from November to the 20th April, and I naturally expected a long break of a fortnight or three weeks duration between the first showers, and the regular setting in of the monsoon, which bout of good observing weather, would, I had hoped, enable me to complete the Kathbatong hexagon. In this however I was disappointed I could not visit the two remaining stations of this hexagon owing to the daily rain and the country becoming gradually submerged and Kalamatong which was the highest mountain for miles around, being generally capped with clouds; no signals from it to Mizantong with which it is connected, could be obtained. I had no other alternative but to close work and return to recess quarters.

(27.) In a densely wooded country, sparsely inhabited, without roads, the time occupied in marching alone is considerable, 85 days were this field season spent in travelling. The routes from station to station are circuitous, the tortuous course of the hill streams being generally adopted to save time and expense in cutting new and direct roads. Labor is the great drawback in Burma. It cannot be obtained, the inhabitants, as a rule, are unwilling and disinclined to work. The laboring classes all over India readily present themselves, when work offers, to add to their comforts, by earning as much as

they are able. The Burmans are too lazy to do so, and throughout the Province, they themselves engage the Madras and Chittagong coolies to plough their lands and reap their fields.

(31.) During this season the positions of the following towns have been determined, Shoay-gheen, Sittang, Chaito, Bhiling, Thatone, Moulmein, Amherst and the Great Pagoda in Pegu. I find that the observations taken at Thelakitong in season 1869-70 to Pegu Pagoda were incorrect, some other Pagoda was taken and an erroneous position was therefore assigned to it. The observations taken at Sanwinguntong during season 1869-70 were correct. This season the Pegu Pagoda was observed from five Principal and one Secondary station. Many Pagodas have been fixed and the positions of a great many more will be determined during the ensuing season when the two remaining stations of the Kathbatong figure and some of the stations of the Makbo Pentagon are visited. To secure as much secondary work as I possibly could, I engaged a Native Recorder, and was thus able to detach Mr. Clancey.

(32.) There was less sickness this season than the previous one, the average number of sick was 8 in my camp and 4 in Mr. Beverley's. There were 6 casualties. Three men were sent home, their recovery in this climate being hopeless, owing to continued debility and emaciation from fever.

(33.) Mr. Henry Beverley, Surveyor 1st Grade, has been engaged the whole season on approximate work. He commenced work by selecting the stations of Toungoundong and Thulu. He then proceeded to Sittang and constructed the pillar at Kámbúngún in the plains, surrounding it with a wooden platform 16 feet square and 18 feet high. He then constructed the wooden scaffolding over Chaideo rock, 26 feet high. Every description of work takes time to accomplish in this Province, and the construction of the above pillar and two wooden scaffoldings, detained Mr. Beverley from 13th December to 20th January. Had Colonel Brown, the Commissioner of Tenasserim, not interested himself, by personally addressing the Extra Assistant Commissioner (a Burman), Mr. Beverley would have been delayed much longer than he was.

(35.) On completing the above, he resumed approximate operations, and selected two simple figures, a Hexagon and a Pentagon, and closed work at Sendong H.S., after having fixed most of the stations of a compound figure in advance. Owing to the setting in of the rains this latter figure could not be completed. Some of the sides of the compound figure are long owing to Mr. Beverley's having no choice of ground, the isolated, inaccessible lime-stone hills rugged, jagged and fantastically shaped, in the valleys of the Atteran and Wiang rivers, being hopelessly unsuitable.

(36.) I had directed Mr. Beverley to observe all Pagodas, which were visible at each station that he visited, and to use his best endeavours to determine the position of the Pegu Pagoda. He was successful in seeing it from Thulu and Shoay-yongbia Hill Stations. He selected and constructed a station at Amherst which was finally fixed by his observations there and at Toungzun, and my angles at Kalamatong H.S. Mr. Beverley also contributed some secondaries, while carrying on approximate operations, and many other Pagodas, which he has observed in advance of the final work, will be fixed during the ensuing season when I visit the Principal Stations.

(37.) The lime-stone ranges of hills on the eastern flank of the Series are mostly precipitous and inaccessible and Mr. Beverley had great difficulty in fixing suitable stations. He had to abandon Zway-ga-beng and other hills more favorably situated, because the 24-inch Theodolite could not be carried up. With all his picking and choosing, he was compelled to adopt two of these difficult hills of lime-stone formation Mizantong H.S. and Makbo H.S., which with the aid of ladders and ramps, he managed to ascend. As this Party has, during its progress, encountered difficulties of every description, and every variety of ground, these two hills need not cause anxiety.

(38.) Mr. Beverley has accomplished a very satisfactory season's work. He lost the most favorable time of the year from the 13th December to 20th January in preparing the pillar and scaffolding at Kámbúngún and Chaideo stations; notwithstanding this loss, he with his usual zeal and energy advanced the approximate triangulation 100 miles of direct distance in a trying and difficult country with commendable cheerfulness and alacrity.

(41.) Mr. Clancey has worked well and satisfactorily. He takes much interest in his duties, and is assiduous to please. He has learned the Burmese language which will be very useful to him.

Extract from the Narrative Report—dated 13th September 1875—of W. G. BEVERLEY, ESQ., Officiating Assistant Superintendent 2nd Grade, in charge of the Burmah Party.

(2.) The Party was constituted under Departmental Order No. 44 of 6th August 1874, the establishment being transferred from the late Brahmaputra Series. Its object is to carry chains of secondary triangles from principal sides of the Eastern Frontier Series, in order to fix all the large towns, prominent and permanent objects, peaks, &c., in the province of British Burmah, for detail and Geological Surveys, and the light-houses &c. along the coast, for the Marine Survey.

(3.) A part of the establishment and heavy baggage left Calcutta for Rangoon with Mr. Collins on the 1st November; and the remainder with me on the 7th. Mr. Mitchell was transferred from the Eastern Frontier Series, and joined the Party at Rangoon. Work was commenced before the end of the month.

(4.) During the preceding season, Mr. Mitchell had in connection with the Eastern Frontier Series reconnoitred the country, and laid out an approximate triangulation from the principal side Keokpongdong H.S. to Kaneindong H.S. down to Rangoon, so as to fix that town, as well as Pegu. I considered it advisable, on commencing work, to examine Mr. Mitchell's selections and found it necessary to modify his plan to some extent, to save time in clearing rays and hill tops.

(5.) On my return from examining the country to the north, I took up the triangulation southwards to the coast, selecting stations after a careful reconnoissance of the ground. Most of these stations are fixed on old Pagodas, by which there was a great saving of time as regards ray cutting, and of expense in building stations. The approximate work of selecting stations, and the final work of observation, were carried on together as far as practicable. The triangulation was carried down to the mouth of the Rangoon river.

(6.) Mr. Collins had been left to clear the rays at the hill station of Ayodong; and as he had now nearly completed his work, I returned to take up the final observations from the stations north of Rangoon, as the atmosphere which hitherto had been pretty clear was gradually getting hazier, I went up as far as Taongnio H.S., but as Yomá H.S. in advance had not been cleared nor occupied by the signalmen, I was unable to complete my observations there. The angle at Cháglibá H.S., between Ayodong and Taongnio stations, could not be observed, as the signalmen had been compelled to abandon the latter station on 4th March, from the only spring there having ceased to run, and there being no water known to exist within 10 or 12 miles.

(7.) The triangulation from Taongnio and Cháglibá to the coast is incomplete; as the very dense haze, which prevailed from the beginning of March, prevented the requisite observations being taken at Ayodong, Cháglibá, and Shántejí, as shown by dotted lines in the chart accompanying. Two attempts were made after the rains set in to obtain observations, but without success.

(8.) The triangulation along the coast towards China Bakir light-house, was resumed in the middle of March; but from the nature of the ground the progress made was slow. Work was closed on the 24th of April, when the southwest monsoon set in with severe storms, and very heavy and continuous rain. In fact, the country had been gradually getting under water along the large streams, from the rising of the Irrawaddy river since the middle of March, when the snow at the sources begins melting. The cutters were frequently up to their waists in water, and suffered great inconveniences from the absence of drinkable water under a burning sun.

(9.) Mr. Mitchell at the commencement of the field season, opened the ray Chanakpho H.S. to Insingpaiá Station, and partially cleared the hills of Ayodong and Taongnio, taking some observations at the latter station. He took up the clearing of the ray Chanakpho to Ayodong, which was ultimately abandoned: he also took some final observations at Insingpaiá.

(10.) As there were no means of reaching Yomá Station directly from Taongnio, but by a circuitous route which would occupy nearly a fortnight, Mr. Mitchell was deputed to clear the summits of Kamlútong and Yomá, selected by him the previous year, to build the stations there, and commence final observations from the side Káneindong H. S. to Keokpongdong H. S., closing on the stations of Taongnio and Cháglibá to be visited by me. This was partly in conformity with the plan laid down by himself, and which, from my examination of the country, appeared to be feasible. Mr. Mitchell, however, after a second examination of the country, and after visiting 3 or 4 points where he took rough observations, found numerous difficulties in so carrying the triangulation, and was obliged to resort to the side Kámbúngún T.S. to Júngjúngiá H.S. from which he thought he could get over the country more rapidly.

(11.) Mr. Mitchell took observations from seven stations; but owing to very bad weather and frequent attacks of illness, he was unable to carry his final observations up to the point where they

would have been connected with the work executed by myself. He endeavoured, at risk of health and much inconvenience, to complete his work by remaining out until the middle of June, when field work was impossible from the incessant rain.

(13.) Mr. Collins was employed in clearing the stations of Chághlibá, Engtago and Ayodong, and building masonry pillars on them. The forest at the latter station was extremely dense, and the rays from it to Insingpaiá and Shántejí were cleared over three broad wooded ranges. Upwards of a month was occupied at Ayodong alone. The delay was chiefly due to the difficulty of procuring labor. Burmese coolies could not be obtained after the middle of December, and the immigrants entertained were almost useless. Several of these latter deserted shortly after obtaining an advance of pay; while those from the immigration office contained a large percentage of Brahmins, who systematically abstained from any and every kind of work on the pretence of illness.

(14.) When the rays at Ayodong were all cleared, Mr. Collins took some final observations there, and also at Kaiúngále Station with the 8-inch theodolite, and then proceeded and built a masonry pillar at Shántejí, but could not get observations, on account of the haze which had now become unusually thick. He joined me on the coast at the end of March, and was employed in carrying rays, &c.

(15.) Mr. Collins has throughout the season shown a great deal of zeal and energy, is a good and careful observer, and is rapidly becoming an efficient surveyor.

(16.) Two Burman interpreters and writers were entertained for this Party. One of these with Mr. Mitchell, died from fever in the field. The other was of very great service to me.

(17.) The men of the Native Establishment have worked well and cheerfully although in a new country and ignorant of the language and customs, and have given satisfaction. They are trained men selected from the Establishment of the late Brahmaputra Party, and sent to Burmah on higher rates of pay, but still much less than the pay given in this Province, and in some instances less than that given to the same class of men in the Eastern Frontier Party. In spite of the inducements of less work and very high wages offered in the Public Works Department, they have remained faithful to their agreements. The elephant keepers alone have been as usual with that class of men a cause of trouble and annoyance, and anxiety for the health and safety of the animals in their charge.

(18.) The triangulation has been carried over a variety of ground. The hilly portion is low and densely wooded, and the difficulties peculiar to this tract have been fully pointed out by Mr. Rossenrode, and noticed by yourself in your last year's Report to Government. These difficulties were to a certain extent greater to our Establishment which was quite new to the Province. The country along the coast is an equally difficult one for triangulation. It is low, and cut up with numerous tidal creeks and rivers. There are few or no paths through the low thick tamarisk and thorn jungle; and no drinkable water except at the villages which are small and far apart. The work on the coast can only be done by boats and coolies, both to be entertained at Rangoon, as they can rarely be got in the villages, and then only at exorbitant rates. Elephants cannot be used on account of the scarcity of fodder, and small supply of water procurable. The ground too, after inundation at every high tide, is extremely dangerous for laden animals.

(19.) The out-turn of work for the past year, would have been more satisfactory if there had been no break in the triangulation; and as the members of the Party are now better acquainted with the peculiarities of the country and people, a greater out-turn may be confidently expected in the ensuing field season, under favorable circumstances. The chief causes of delay in Burmah are the difficulty of procuring labor, and in moving with rapidity from one place to another; but the greatest is the haze arising from the burning of jungle and rice straw. On the coast, there is less haze to contend with, as there is very little jungle that can be burnt for clearings. Very little rain falls during the dry season: between the 7th of November and 23rd of April, there were only two slight showers.

(20.) There was much sickness in the camps at the commencement of the season; and both Messrs. Mitchell and Collins, and nearly every man of the Establishment, have suffered from malarious fever. In fact, there was always a large percentage of sick throughout. Three deaths occurred.

Extract from the Narrative Report—dated 16th August 1875—of Captain M. W. ROGERS, R.E., Officiating Deputy Superintendent 3rd Grade, in charge Jodhpur Series.

(2.) I returned from furlough on the 28th October, and on the 20th November relieved Lieutenant Hill, R.E., of the charge of the Party which he had held during my absence.

(3.) All arrangements for the field season had been made by Lieutenant Hill and he had sent off the assistants before my arrival. I had engaged the carriers for the Great Theodolite whilst at Ahmedabad and there was therefore no delay in taking the field which was done on the 23rd November.

(4.) I marched *viâ* Jodhpur to Nok H.S. in Jaisalmir, where observations were commenced on the 17th December; from thence the observations were carried on continuously through the heart of the great Jaisalmir and Bikanir desert as far as Marot in Bahâwalpur and were closed at Bhulan H.S. on the 21st of March.

(5.) The following is a general statement of the season's work. Observations were taken at 25 principal stations forming a pentagon, two hexagons, and one double polygon, fixing 23 new principal stations, embracing an area of 2472 square miles, and extending the series 104 miles along the meridian. An azimuth was observed at Mugrálá H.S. to two circumpolar stars. The Approximate Series was extended 64 miles to its junction with the Sutlej Series. The positions and heights of Bikanir and Pugal were fixed by minor triangulation, the area of which, exterior to the series, was 681 square miles.

(6.) Some explanation is needed as to the dearth of secondary and intersected points; this is due to the nature of the country, in which there are neither natural nor artificial objects of interest.

The total intersected points on the principal series were 8, of these 7 were intersected from the four last stations of the series, leaving a tract of about 90 miles by 30, in which there was only one point which could be intersected.

(7.) Mr. Price was in charge of the Approximate Series and extended it through the desert to the Sutlej Series. Bearing in mind the great difficulties of the country, I consider the amount of work he has done and the well proportioned good figures which he has been able to obtain, reflect great credit on his zeal, intelligence and hard work.

Mr. Price.

(8.) Mr. Torrens laid out and observed a minor series to Bikanir by which that city was fixed in height; he closed on to a side of the series emanating from the Gurhágarh, with very satisfactory agreement in results. He also fixed the position of Pugal by a short series and the Revenue Survey trijunction at the junction of the Bikanir, Jaisalmir and Bahâwalpur boundaries. He also closed 17 stations in Bikanir and Jaisalmir.

Mr. Torrens.

He observed with a 10-inch theodolite and his average triangular error was 1″·7. He has worked well and cheerfully and I am much pleased with the quality and quantity of his work.

(9.) Mr. Prunty joined the party from Head Quarters during last recess, and accompanied me during this season as observatory recorder. He is painstaking, willing and neat, and has now acquired the accuracy which was all he needed to make him a very good recorder. He has learnt the use of the theodolite and perfected himself in departmental routine and I am very well satisfied with him.

Mr. Prunty.

(12.) The country through which the series passed this season, is a sandy desert; the sand hills in Jaisalmir are from 50 to 150 feet in height and are distributed in such a confused manner over the country as to make it a work of great difficulty to select stations or to obtain any but very short sides. Towards the north, in Bahâwalpur, they diminish in height and become merely mounds of drifting sand, interspersed with open spaces of hard clay which are perfectly level like the beds of immense dry tanks.

(13.) The sand hills of Jaisalmir and Bikanir are covered with high coarse grass, which grows in large tufts, and with shrubs, of which the most common and largest is the Phog, a leafless shrub, from 5 to 8 feet in height with green twigs and pleasant smelling flower.

(14.) In the Jaisalmir desert there is a good deal of cultivation mostly "bájri". Most of the numerous small valleys formed by the sand hills are ploughed and sown, although miles from any village, and I believe that the grain produced is very good.

(15.) The villages are few and far apart; attached to each are numerous "dhánis", that is two or three huts erected in the desert, wherever there is either a well of brackish water or a small excavation

in the hard soil (which crops out at intervals) in which water collects during the rains. These 'dhánis' are inhabited during the rains and cold weather, when the desert is comparatively populous, but are deserted in the hot weather, when the inhabitants return to their villages.

(16.) In the portion of Bikanir, through which the series passed, there is hardly any cultivation. The occupation of the inhabitants is almost entirely pastoral, and they have large herds of cattle, sheep, goats and camels. From Pugal in Lat. 28½° to the valley of the Sutlej, with the exception of the villages lying on what was the bed of the old Hurkara river—about 40 miles south of the Sutlej—there are no villages and only a few wells of brackish water; this tract is the most desolate I have yet met with, and the inhabitants desert it in the hot weather, taking their camels into Sindh; this custom deprived me of my supply of water camels and obliged me to return earlier than I otherwise should have done.

(17.) In the cold weather, up to the end of December, this portion of the country is alive with flocks and herds which get water from innumerable "tobas" or small tanks excavated in the hard clay, which are as I have already mentioned abundant in Bahâwalpur and N.W. Bikanir, and I apprehend no difficulty whatever in taking the series in November through the portion remaining from which I had to retreat this season.

(18.) All the villages have large numbers of camels which roam in the desert and return every few days to the wells to drink, when such as are wanted are caught.

(19.) Nearly all the country I worked through belonged to three influential Thákurs, Bikampur and Birsilpur in Jaisalmir and the Rao of Pugal in Bikanir, which last belongs to one of the oldest Bhatti Rájput families and is reported to have held Pugal for more than 1,000 years.

The villages in which they live are larger, but quite as wretched in appearance as any I met with, the only distinction being that the Thákurs live in a sort of a half house, half fort built of mud and stones.

(20.) The cold was very great at times, the minimum thermometer twice registered 16°; this was very trying to the men who however enjoyed good health as a rule. My experience of the desert is that it is very healthy for people who are well fed and have good water to drink.

Bikanir.

(21.) The city of Bikanir to which a minor series was taken this season to fix its height, is a fine city built on a slightly elevated spot in the desert where the ground is hard and stony and intersected by ravines. It has a wall 3¼ miles in circuit, wholly built of stone and in good repair, it has 8 gates and three sally-ports; the wall is from 15 to 30 feet high and it has a ditch on three sides about 15 feet deep. There are many highly carved houses in the city and two imposing looking Jain temples. Water is plentiful from many very fine wells. The chief productions are sugar-candy and blankets, both of which are of a very superior kind. The population is about 35,000.

(22.) The fort of Bikanir which contains the Maharajah's palace is about 300 yards N.E. of the city. The palace rises above the battlements and gives it an imposing appearance: it is 1,100 yards in circumference and has two gates, numerous bastions and a ditch all round.

(23.) The Governments of Marwar, Jaisalmir, Bikanir and Bahâwalpur sent officials and men to accompany the camps, in their respective States, and rendered every assistance in their power, and very greatly was their assistance needed, for without it the work could not have been carried on for a day as the water for the camps, had to be brought on an average, 10 to 20 miles on camels.

My best thanks are due to the Political Agents Colonel Minchin, Major Walter and Captain Burton.

Extract from the Narrative Report—dated 8th September 1875—of Captain A. PULLAN, S.C., Officiating Deputy Superintendent 3rd Grade, in charge Kattywar Survey Party.

PERSONNEL.

Captain A. Pullan, S. C.,
John McGill, Esq., Asst. Supdt.

Surveyors and Asst. Surveyors.

Mr. J. Peyton.
" F. Bell.
" N. C. Gwynne.
" E. Wyatt.
" W. A. Fielding.
" W. Oldham.
" G. T. Hall.
" H. Corkery.

Head Sub-Surveyor.

Mr. Vissji Ragunath.

Sub-Surveyors.

Govindji Mahalay.
Narsu Dinkar.
Krishna Govind.
Shridhar Succaram.
Vishnu Moreshwar.
Bholaji Bhosekar.
Nilkant Vital.
Keshu Vital.
Tukaram Chowdry.
Ganesh Ránchandra.
Vishnu Bulwant.

Out-turn of Field work.

The out-turn of field work for the season 1874-75 was not so large as in the two preceding seasons. A considerable portion of the country under review, lying as it does along the borders of the Gulf of Cutch, was very difficult and tedious to survey, not only on account of the treacherous mud banks and almost impassable mangrove swamps, but also from the variable winds and sudden changes of tide among the creeks which threw constant hindrance in the way of the surveyors.

An area of 1877 square miles inclusive of overlaps, or 1749 square miles within graticule, was topographically surveyed, consisting of parts of Pránts Hállár and Machhu Kánthá in Kattywar and a portion of the southern seaboard of Cutch, which was surveyed in order to render the Sheets of Kattywar more complete and to delineate more clearly the head of the Gulf of Cutch. 2200 square miles were trigonometrically surveyed, 200 for the survey of the Cutch coast during the same season, and 2000 in advance preparatory to ensuing topographical operations, and 1117 linear miles of traverse were carried over the area of country topographically surveyed, demarcating the boundaries of States and checking the details of the Plane Table Survey.

It must be borne in mind that the out-turn of work for the two preceding seasons was exceptionally large owing to the wide area of flat 'Rann' it included, and such an out-turn can hardly be expected in future. I may here state that the agreement between our survey of the head of the Gulf and the coast line given by the Marine Survey of Lieutenant Taylor, I. N., is decidedly satisfactory, taking into consideration the difference of scale and mode of delineating ground.

At Rájkot, hearing from Mr. Bell, who was triangulating the seaboard of Cutch, that the nature of the ground on Sathsaida Bet rendered a stone or masonry pillar unadvisable, I devised a pillar composed of piles of hard teak seven feet long, four feet below the surface and three above, arranged in a circular form, the mark-stone being imbedded in the mud beaten hard all round with small pebbles and straw to bind it, and the cylinder being then filled up with shingle from the beach mixed with mud. This pillar is calculated to stand the wash of the monsoon waters better than a masonry pillar, which would offer unyielding resistance and tilt over from its own weight, whereas in the case of the pillars now erected the force of the water is dissipated, and I think they will all be found next season, *in statu quo*.

On arrival at Jámnagar or Nawánagar, the capital of the territories of H. H. the Jám, I found that the border of the Gulf, studded as it is with numerous small islands, intersected by tidal creeks, offered a very difficult piece of work for the Plane Tabler, not only on account of the heavy mud and quicksand, but also from the fact that the work had to be done by boat principally, and the surveyor would have to study carefully the state of the tide and the direction of the wind. This work I took up myself and completed all the northern and difficult portion of the board by the time that it became necessary to cross over to Cutch and examine the Plane Table work on that coast and also about Hanstal Creek. I therefore started on the 26th February for Hanstal *vid* Juria.

On arriving at Hanstal, I found Mr. Hall getting on very well and surveying the swamps with correctness and facility. I passed on, after examining Mr. Hall's Plane Table, to the opposite coast of Cutch and spent four days in a careful examination of Govindji Mahalay's Plane Table which I found correct and neatly executed. I then returned to Juria and marched along the coast to Balacheri in order to judge for myself of the general character of the coast line and swamps; the journey was a fatiguing and dangerous one and I was very nearly swamped in a quicksand from which I was with difficulty extricated by my khlassies.

I marched from Molila on the 6th April *en route* for Gogo. The heat was at this time intense, far

greater than I had hitherto experienced in Kattywar, and the hot season threatened to be exceptionally severe, I therefore reluctantly gave up the plan of completing Sheet 45 which would have kept the Plane Table parties out until near the end of May, and sent orders to the surveyors and sub-surveyors to the effect that when they had completed the boards they were working they were to march and join me at Gogo and from that port make arrangements for return to recess quarters.

After receiving all the Plane Tables and comparing their borders before taking them to Poona, I started from Gogo on the 12th May and opened office at Poona on the 17th May 1875.

J. McGill, Esq. Asst. Supdt.

Mr. McGill left Wadhwán on the 21st November 1874 to take up and complete the triangulation of Sheet 10a of Kattywar which had been left unfinished by Mr. Wyatt. After completing this work Mr. McGill marched *vid* Malia and the borders of the Rann and examined the southern Plane Tables of Sheet 31. Mr. McGill proceeded thence *vid* Rájkot to Gondal where he commenced the triangulation of Sheets 36 and 37—these Sheets were completed on the 6th April and Mr. McGill marched to Gogo at my request and thence proceeded to Poona.

Mr. McGill worked with the same zeal and ability which has characterized him for many years. His interesting memorandum on Sheet 10a is appended to my report.

Mr. F. Bell, Surveyor 3rd Grade.

Mr. Bell left recess quarters in advance of the rest of the party as I required him to furnish some few extra points on the seaboard of Cutch. Proceeding by boat to the port of Maudir, Mr. Bell commenced work on the 15th November at Charakla H. S., and worked very hard and well; having completed his triangulation he joined my camp on the 21st December and we conjointly computed and projected the points on the Plane Tables and made them over to the Plane Table Surveyors. Mr. Bell then proceeded to take up the triangulation of Sheet 38 which he completed by the end of March. His out-turn of work was 800 square miles, and I have every reason to be satisfied with the number and position of the intersected points.

Mr. N. C. Gwynne, Surveyor 4th Grade.

Mr. Gwynne, after completing Fair Sheets 33—35 of Kattywar, took up his first Plane Table on the 15th January 1875. Mr. Gwynne worked throughout the season with the willingness and energy which distinguish him, turning out 125 square miles of very difficult and hilly country in admirable style besides instructing Mr. H. Corkery, Assistant Surveyor and Sub-Surveyor Vishnu Bulwant. Mr. Gwynne's steady application in the drawing office during recess is worthy of particular notice.

Mr. W. A. Fielding, Asst. Surveyor 2nd Grade.

Mr. Fielding started from Wadhwán on the 24th November for Sheet 31. He was accompanied by Messrs. W. Oldham and H. Corkery, Assistant Surveyors, Sub-Surveyors Nilkant Vital and Ganesh Rámchandra and Traverse Surveyor Tukaram Chowdry. The whole of the Plane Table parties and Traverse party I placed under the orders and general superintendence of Mr. Fielding of whose intelligence and carefulness I had formed a high opinion and I was well satisfied with the result. Mr. Fielding having completed Sheet 31 marched southwards and took up R. Plane Table, S.W. Section of sheet 43. Mr. Fielding's out-turn of work was 154 square miles, very creditable when it is taken into consideration that in Sheet 31 he had to superintend the work of 2 European and 3 Native Assistants besides doing some Plane Table surveying himself.

Mr. W. Oldham, Asst. Surveyor 3rd Grade.

Mr. Oldham worked well throughout the season, first under Mr. Fielding's superintendence in Sheet 31 and afterwards on Sheets 43 and 45 under my own eye. I found Mr. Oldham's work very carefully done on every occasion that I examined it. He requires further practice in neat drawing and printing, and when these are acquired satisfactorily, he will be a valuable Plane Table Surveyor. His out-turn of work 200 square miles for this, his first season, is most creditable to him.

Mr. G. Hall, Asst. Surveyor 3rd Grade.

Mr. Hall worked very well throughout the season both on the borders of the Gulf of Cutch and also in hilly ground in Sheet 44. His out-turn of work was 180 square miles, and I have every reason to be satisfied with its quality.

Mr. H. Corkery, Asst. Surveyor 4th Grade.

Mr. Corkery was employed throughout the season in topographical work; his out-turn was 144 square miles, and both Plane Tables in execution and delineation of hilly country are very creditable to a young hand and show a marked improvement.

Mr. Visaji Ragunath, Head Sub-Surveyor.

Mr. Visaji Ragunath was employed during the major part of the season in projecting Plane Tables, computing Lats., Longs. of intersected points, and in general miscellaneous work; at the beginning of April, I sent him to run a Check Traverse across the Cutch portion of Sheet 31. This work he satisfactorily completed.

Govindji Mahalay executed the Plane Table survey of 171 square miles of country in his usual careful and artistic style. He has also been very useful as a draughtsman during the recess season. Narsu Dinkar was employed in running boundary traverses and check lines during the whole season. He executed in a satisfactory manner 323 linear miles of traverse, and is a useful and hardworking assistant. Krishna Govind was employed during the season as recorder to Mr. Bell. Shridhar Succaram executed 167 square miles of Plane Table survey slowly but accurately.

Vishnu Moreshwar worked very steadily throughout the field season. His out-turn was 196 square miles, and there was some improvement this season in his delineation of hilly ground. Bholaji Bhosekar was employed throughout the season in boundary traversing and running check lines; he completed 273 linear miles of traverse. In consequence of information received from you respecting the amount to be expended on the Native Establishment of this party, I was obliged to reduce two parties, one Plane Table and one Traverse party; Bholaji Bhosekar being the least useful of the Traverse Surveyors was therefore discharged. Nilkant Vital executed 164 square miles of topography with accuracy and some improvement in his style of drawing. Keshu Vital executed 146 square miles of topography; there is much room for improvement in his style of sketching ground. He is a good computer. Ganesh Rámchandra executed 170 square miles of topography in a very creditable way for so young a hand. Vishnu Bulwant is very useful in the drawing office and promises in time to be a really good draughtsman.

Principal Towns, &c.

The principal towns contained in the country now under consideration are; 1st, Jámnagar or Nawánagar, the capital of the territories of the Jám of Nawánagar which district comprises, roughly speaking, with the exception of a few small detached holdings, Sheets 42, 43, 44, 45 and the eastern halves of 52 and 53. The town which is on the banks of the little river Nágmati is clean and well built with good streets. The population according to the last census amounts to 34,744 souls. The Jám, a Jhareja Rájput, is gentlemanly and pleasant and from either liking or policy affects the society of Europeans, treating all who visit his territories with much courtesy and hospitality.

The other towns of note in the Jám's territories are Hariana, Dhunwao and Balamba. The last named town is supplied with good water by means of a canal four miles long which carries the sweet waters of the Aji up to the town; tradition has it that a rich Brahmin of Balamba was enamoured of the daughter of a Brahmin of Latipur; but as Balamba was notorious for its bad brackish water, the girl's father refused his consent until his daughter was sure of good water to drink in her new home. The suitor thereupon set to work and had the canal cut which now exists thereby winning his bride. A dam is now in course of construction near the village of Madhapur on the Aji which will, when completed, render the canal always full of sweet fresh water.

The town of Malia, on the banks of the Machhu was 50 years ago a very strong place; it is the only place of importance in Sheet 31: the inhabitants are principally "Miani" Mahomedans, but the Rája is a Jhareja Rájput of the Cutch family.

Near Jámnagar is a little pleasure house and temple called Rozi Mata, a favorite summer resort of the Jám's, situated on a small island or rather isthmus which juts out into the lagoons and swamps of the Gulf; the fresh breezes from the sea render Rozi a pleasant place of sojourn during the hot months; the island is covered with long grass and tangled thicket giving cover to herds of "Nylghai" or "Roz" which roam at will unmolested, the island as its name implies being their favorite haunt. Near the small village of Balacheri there is a bungalow on the shore of the Gulf built by the Jám and occupied during the hot months by the political officers; at a short distance from the bungalow is the village of Sachana, the inhabitants of which drive a thriving trade in fish of various kinds, and send a regular supply to the British Station of Rájkot.

Rivers.

The Machhu river flowing into the Rann of Cutch at Malia and losing itself in the salt sand and mud of the Gulf, is the principal drainage line in the country surveyed this season. The others are the Nágmati which rises in the hilly country 30 miles south of Jámnagar, the Aji the head of which only enters these sheets where it debouches 3 miles north of Hanstal tidal station into the Hanstal Creek, the Nani and Moti Phuljar, the Und and the Manwar.

General appearance of the country.

Sheet 31 calls for no further particular description as what I said in my Narrative Report for season 1873-74 of Sheet 32 will apply equally to the country in Sheet 31. Sheets 42 and 43 are flat and well cultivated up to the very edge of the mangrove swamps which are a leading feature of the country and which spread along the Gulf in a broad belt from Hanstal and even higher than that, southward over all the coast surveyed last season, near the town of Jámnagar all the islands and spits of thick rich mud are covered with tangled mangrove jungle in some places rising to an altitude of 40 feet but generally averaging from 8 to 10 feet in height. At high tide a little fleet of boats puts out from Beri Bunder carrying the wood cutters to their work in the lagoons, the white sails gleam on all sides among the masses of rich green foliage and the labourers cut and stack mangrove till a returning tide bears them homeward; the stock of firewood thus obtained is a godsend to Jámnagar as the supply of wood round the city is scanty, a large quantity is also laid in by the Bombay bound craft that put in at the little port of Beri.

The country in Sheet 44 is undulating, crossed here and there by low ridges—a stony and sterile land poorly cultivated; there are few villages of any size in Sheet 44 except on its eastern border where the country is somewhat less stony and the soil richer and better cultivated.

Quarries.

Throughout the low ranges which cross Sheets 43 and 44 are numerous stone quarries, where a coarse white sandstone is excavated; this stone though porous and friable when first brought to the surface, hardens greatly by exposure to rain and sun and becomes a useful building stone.

To meet the wishes of the Political Agent, I propose next season to triangulate Sheets 46, 47 and 48 in advance, and to survey topographically Sheets 36, 37 and 38 and the portion of Sheet 45 which still remains unfinished—the small portion of coast near Diu of which Sheet 41 consists, I shall also, I think, be able to complete as the triangulation has been done and nothing remains but the boundary traverses and topographical detail Survey.

TABULAR STATEMENT OF OUT-TURN OF WORK IN KATTYWAR DURING THE FIELD SEASON 1874-75.

Triangulation.

No.	Observers' Names.	Instruments used.	Area triangulated in square miles.	No. of Points Heights fixed.	No. of Points Position fixed.	No. of stations visited.	Triangles, 3 Angles observed.			Triangles, 2 Angles observed.	
							No. of triangles.	Mean triangular Error.	Discrepancy per mile.	No. of triangles.	Average discrepancy per mile.
								"	Feet		Feet
1	John McGill, Esq.,...	Cooke and Son's 7-Inch	1400	253	595	80	135	10·2	0·8	950	1·3
2	Mr. F. Bell, ...	Troughton and Simms' 6-Inch	800	69	206	55	76	9·3	0·5	428	0·8
		Totals, ...	2200	322	801	135	211	Mean 9·6	Mean 0·7	1378	Mean 1·1

Topography.

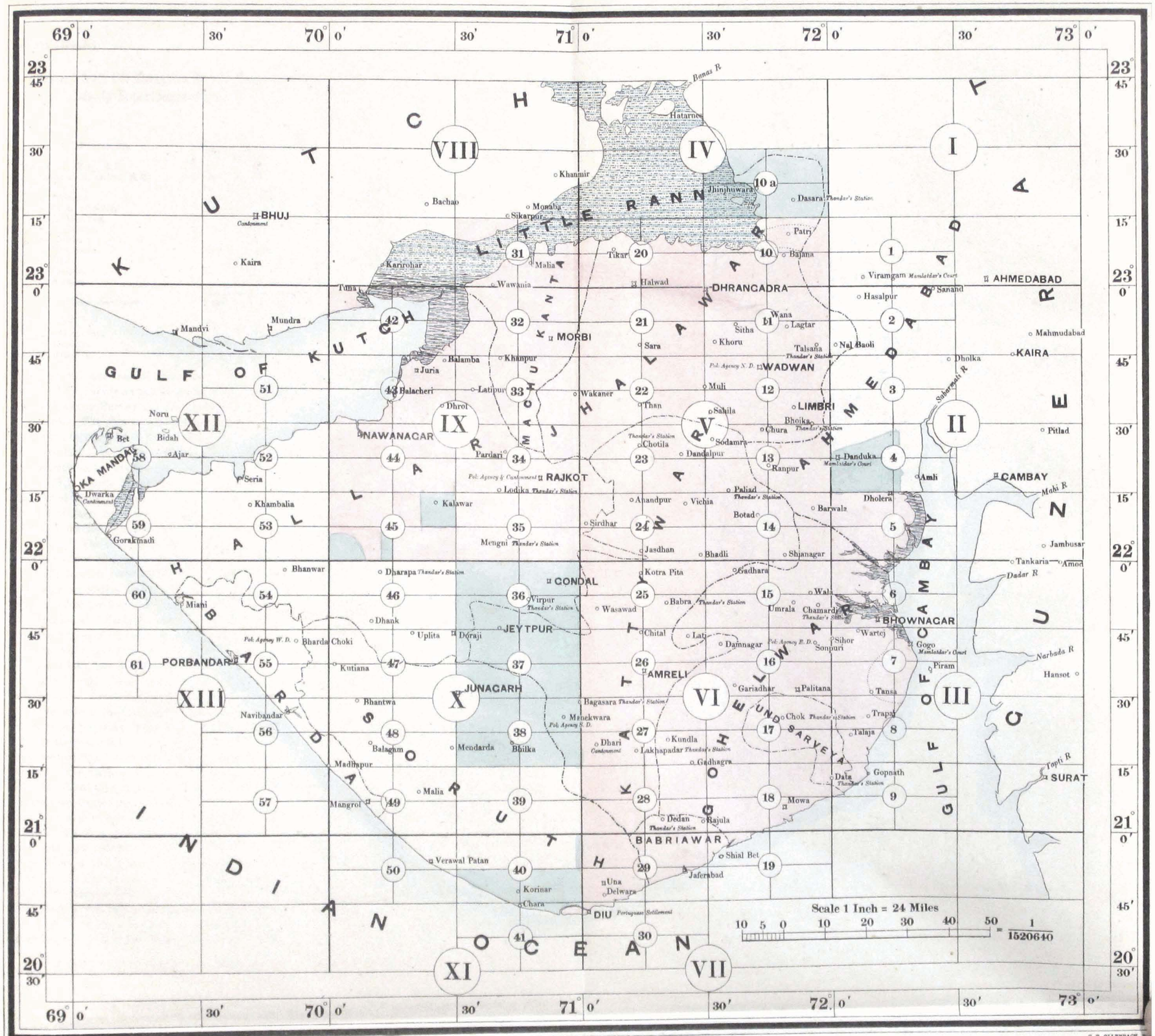
No.	Plane-tabling.	Area surveyed Scale 2 inches = 1 mile.	Average No. of plane table stations per square mile.	Remarks.
1	Captain A. Pullan, s.c. ...	30	5·8	
2	Mr. N. C. Gwynne, ...	125	7·3	
3	„ W. A. Fielding, ...	154	8·9	
4	„ W. Oldham, ...	200	12·8	
5	„ G. T. Hull, ...	180	5·5	
6	„ H. Corkery, ...	144	12·5	
	Native Surveyors.			
7	Govindji Mahalay, ...	171	6·0	
8	Shridhar Succaram, ...	167	9·0	
9	Vishnu Moreshwar, ...	196	12·7	
10	Keshu Vital, ...	146	10·0	
11	Nilkant Vital, ...	164	12·6	
12	Ganesh Rámchandra,... ...	170	12·4	
13	Vishnu Bulwant, ...	30	7·5	
	Total number of square miles surveyed inclusive of overlap ...	1877	...	

Traverses.

Names.	No. of linear miles traversed.		Average error per 1000 links.	Remarks.
	Taluka Boundary.	Check Line.		
Mr. Visaji Ragunath, ...	...	21·33		
Narsu Dinkar, ...	160·30	162·56	0·69	
Bholaji Bhosekar, ...	179·94	93·33	0·54	
Tukaram Chowdry, ...	143·78	355·26	0·79	
Totals, ...	484·02	632·48	Mean 0·67	

GREAT TRIGONOMETRICAL SURVEY OF INDIA.

INDEX CHART OF THE **KATTYWAR TOPOGRAPHICAL SURVEY.**



C. DYSON, Photo.

C. G. OLLENBACH, Engr.

The numerals **1, 2, 3** &c., indicate the sheets on the scale of one inch to the mile. The numerals **I, II, III &c.**, indicate the degree sheets, on the Scale of ½ inch to the mile.

The one inch sheets are divided into 4 sections known as the **N. E., N. W., S. E., & S. W.**, sections of the sheet; of these a few copies will be published on the Scale of the original Survey. *viz.*, 2 inches to the mile for the use of local officials.

Denotes country Topographically Surveyed up to 1874-75.

Ditto Triangulated in advance up to 1874-75.

Photozincographed at the Office of the Superintendent, Great Trigonometrical Survey, Dehra Dún, November 1875.

Extract from the Narrative Report—dated 15th October 1875—of Major C. T. HAIG, R.E., Deputy Superintendent 2nd Grade, in charge of the Guzerat Survey Party.

PERSONNEL.

Major C. T. Haig, R.E.
Lieutenant J. E. Gibbs, R.E.
Mr. J. Peyton.
" A. D'Souza.
" A. D. L. Christie.
" C. H. McAFee.
" E. J. Connor.
" J. Hickie.
" G. D. Cusson.
" G. Hall.
" S. Norman.
" C. Norman.

Native Surveyors.

Gopal Vishnu.
Luximon Gorpuray.
Ganesh Narayen.
Ganesh Bapuji 1st.
Raoji Narayen.
Mukand Dinkar.
Ganesh Bapuji 2nd.
Bhow Govind.
Govind Gopal.
Bulwant Rajaram.
Monaji Aboo.

Revenue Survey.

Mr. T. A. LeMesurier.

Native Surveyors.

Keshowram Ravishanker.
Jugal Mansukram.
Dowlat Lalbhai.
Gopal Ganesh.
Kuber Purbhudass.
Parbhu Kisor.
Trimbaklal Govardhan.

(3.) During the season an area of 1375 square miles was topographed: of this 983 square miles was on the scale of 4 inches to a mile and 392 square miles on the 2-inch scale. In the Dang Forests an area of about 550 square miles was triangulated, but this will have to be supplemented with further triangulation and traversing to furnish a sufficiency of data points for the final Survey. A small area in sheet 79, which remained incomplete at the close of the previous season, was completed with data points, by traversing; and an area of about 300 square miles of British territory previously triangulated was prepared for Survey on the 4-inch scale, by effecting the necessary connections between the fiscal details of the Revenue Survey and our triangulation stations by means of traversing.

(4.) The area topographically surveyed comprises the whole of sheets 81 and 82 (which completes the topography of Degree Sheet III), and the completion of sheet 14 of which one quarter was surveyed in the previous season; it thus fills up two gaps which last year presented on unsightly appearance on the Index map.

(5.) Sheets 81 and 82 include portion of the Dholka, Viramgám, and Dhandhuka talukas of the Ahmedabad Collectorate and portions of the Limri, Lakhtar, Wadhwán and Cambay states which have now been completely surveyed and sheet 14 includes portion of the Ankleswar taluka of the Broach Collectorate and of the Olpád* taluka of the Surat Collectorate.

(6.) The country in sheets 81 and 82 is very flat and the north-east portion of 81 and south-west portion of 82 are very woody. These sheets include the mouth and about 33 miles of the course of the Sábarmati river and about the same length of the Bhádhar, Bhogáwo and Rodh rivers, and also the water connection during the monsoon between the Nal and the Gulf of Cambay which I mentioned in para. 16 of my last year's report as probably existing. It is now established that during the monsoon the Peninsula of Kattywar becomes an island. Sheet 81 also includes a portion of the Nal lake, the greater portion of which is included in sheet 80, and was mentioned in my last year's report. When I wrote that report I thought the portion left in sheet 81 was so small that I spoke of sheet 80 containing the whole lake, but it appears that the extents of the lake in November varies very considerably from its extent in March. Many square miles which are dry in March and become the haunts of wild boar and wolves, are in November several feet under water. I would remark generally that the drainage of Guzerat is, from the flatness of the country, very capricious; some of the rivers lose themselves in marsh or in sand, resolving themselves into streams again further on, in their passage to the sea; others change their course in a perplexing way, and none of them have a sufficiently rapid fall to carry off at once any extraordinary rain fall, and so every year the towns on their banks and the bridges are in danger. The Sábarmati, which has lately overflowed its banks and done such damage to the city of Ahmedabad and to many villages on its banks—for the second time within the last few years—is also remarkable for the capricious way in which it alters its course. I have the Revenue Survey map of a village (Rinjha) dated 1856 on which an alteration in the fiscal details was made in 1867 owing to a change in the course of the Sábarmati, the left bank shifting $\frac{3}{8}$ and the right $\frac{5}{8}$ of a mile, the new left bank being $\frac{3}{16}$ of a mile to the right of the old right bank, and our Survey this year shews a still further divergence from the old course. To give another instance, it will be found in the correspondence of the Bombay Party that in 1855 a stage erected at a place called Sikutar Mátha for taking tidal observations, was washed clean away by the force of the current, the site of that stage is now half a mile inland and is only flooded at spring tides.

(7.) Sheets 81 and 82 are crossed by the Ahmedabad and Gogo road, but it scarcely deserves mention as in nearly the whole of its extent across these sheets it is out of repair, and in some places

* In last year's report para. 22, I gave three different ways in which this town is spelt, Olpád is now a fourth, but is that recently adopted and established by the Government of Bombay in the official list of names.

totally obliterated. Dhandhuka the chief town of one of the talukas of the Ahmedabad Collectorate is on this road and is about halfway between Ahmedabad and Gogo. It is in sheet 82. Dholka another taluka town and next to Ahmedabad the most important in the Collectorate, is in sheet 81. On account of the importance of Dholka I had all the principal thoroughfares traversed with a prismatic compass and chain so that the town could if necessary be mapped on a larger scale than that of 4 inches to a mile; but on this scale it is a most imposing feature in the map, being nearly 6 inches from north to south and 3 inches from east to west. The Thákur's towns of Koth and Gángad are also in this sheet, and Dholera (well known in connection with cotton) is in sheet 82. Sheet 81 contains a large area of Talukdari land interspersed with the Khálsa (I explained the meaning of these terms in para. 20 of my last year's report) but in sheet 82 the two classes of tenure are more separate, and I was therefore enabled to survey an area of 392 square miles of Talukdari land in that sheet on the 2-inch scale.

(8.) The country in sheet 14 is flat, and fairly wooded with babool and palm trees, though along the coast there is a considerable expanse of sand and mud which, on account of the number of intersecting creeks and nalas, required as much labour in surveying as cultivated land and even more, because of the difficulty of moving over the ground. The Kim and Sena rivers cross Sheet 14 from east to west. They are neither of much importance, not being navigable for large craft, but the Kim is the larger of the two; both have considerable estuaries, increasing the expanse of mud. The villages in this sheet are much more closely packed than in sheets 81 and 82: in the portion surveyed this season these are none of any great importance though all are fairly populous. Perhaps Eláo in the Anklesar taluka and Bagwa and Kursad in the Olpád taluka are the most so.

(9.) Leaving Poona on the 11th November we commenced work in sheet 81 on the 21st. Having a sufficiency of ground triangulated in advance for two years, I gave Plane Tables to both Mr. Christie and Mr. Connor who had previously always worked with a theodolite. The two Messrs. Norman and three Native Surveyors having but recently joined the Department in September and October, had also to learn the use of the Plane Table. I could not commence the instruction of all these pupils at once, and therefore I employed those who had to wait, in my Office, where there was always plenty of miscellaneous work to be done in connection with the mapping.

(10.) One new feature in the administration of my Party was the formation of a permanent Drawing Office. I found this absolutely necessary, because my mapping power had been most severely overtaxed by the great amount of mapping thrown upon it by the adoption of the 4-inch scale and I therefore kept Mr. Peyton and six Native Surveyors at my Head Quarter Camp and I supplemented this force at the beginning of the season by those hands who were waiting to be taught Plane Tabling. The Revenue Survey Surveyors were employed solely in plotting the traverses on the Plane Table Sections, as they came in, as checks to test their accuracy, and in transferring on to them the fiscal details from Revenue Survey village maps.

(11.) On leaving Ahmedabad I apportioned off the work to the different Surveyors, and took my Head Quarter Camp to a central position in their midst from which I could run out and see them each at work: I was disappointed at the rate at which the Survey of sheet 81 progressed, some of the talukdari villages interlaced with the Khálsa gave a great deal of trouble from the fiscal demarcations being obliterated, and from the patches of cultivation along the margins of the marshy connection between the Nal and the Bhádhar river not conforming to the field partition shewn on the village maps. All these patches were surveyed, but at the cost of a great deal of time. On the completion of sheets 81 and 82 we moved into sheet 14, which was completed by 15th May, and I myself opened Office in Poona on 20th April.

Lieutenant Gibbs, R.E.

(12.) During the early portion of the season, that is till the end of January, Lieutenant Gibbs was engaged in Plane Tabling, and he completed two Plane Tables in sheet 81 on the 4-inch scale, comprising 36 square miles. After this I sent him to examine the Plane Table containing the town of Dholka and then to continue the triangulation of the Dangs, which he commenced in the previous season.

(16.) He succeeded in fixing a great number of points, but found it impossible to fix any down in the ravines, on account of their being so tortuous and precipitous; it will therefore be necessary to supplement his operations with traverses running along the ravines, in order to give data points to the Plane Tablers who will be obliged to work either on the tops of the hills, or the bottoms of the valleys, and sketch in the precipices, and when in a ravine they would never be able to see the stations on the heights.

(17.) Lieutenant Gibbs had a very difficult task, as may easily be imagined from the fact that the whole of the country in the Dangs is mountainous and wooded and intersected with precipitous, tortuous ravines, and that his stations vary in height capriciously between 1500 and 5000 feet.

(18.) I kept Mr. Peyton during the whole field season at my Head Quarter Camp as the head of the Drawing Office, the strength and duties of which I have mentioned in para. 10.

Mr. Peyton.

(19,) Mr. D'Souza supervised all the Native Surveyors' Plane Tabling on the 4-inch scale, and instructed as well as supervised Messrs. Christie, S. Norman and C. Norman (partly instructed also by Mr. McAFee) and Gopal Vishnu, Govind Gopal, and Bulwant Rajaram, so that he was actively employed the whole season, as he altogether examined 41 Plane Tables on the 4-inch scale, and 1 Plane Table on the 2-inch scale, comprising an area of 736 square miles.

Mr. D'Souza.

(20.) Mr. Christie was employed the whole season in Plane Tabling on the 4-inch scale, and considering that it was his first season at that work, his out-turn is very creditable, both as to quantity and quality. Mr. Christie is also very observant of the country he surveys, and has given me a report describing fully each Plane Table that he completed.

Mr. Christie.

(21.) Mr. McAFee joined me on the 31st December and I kept him at the Head Quarter Office till the 5th February, when I gave him a Plane Table in sheet 81 on the 4-inch scale, and sent Mr. C. Norman with him for instruction. After starting Mr. C. Norman he was employed for the remainder of the season on the topography on the 2-inch scale in sheet 82, and had working under him Ganesh Bapuji 1st and Raoji Narayen; he is a very careful and accurate worker.

Mr. McAFee.

(22.) Mr. Connor, though he had learnt how to use a Plane Table before in the Kattywar Party, had never learnt how to utilize the Revenue Survey materials, Mr. D'Souza therefore gave him a helping hand at first, and then he soon went on with his Plane Table independently, but owing to his eyes failing him, not being strong enough to stand the continual glare, I had to find other work for him at my Head Quarters, in projecting the Plane Tables and other miscellaneous duties.

Mr. Connor.

(23.) Mr. Hickie was employed the whole season through in Plane Tabling, first in sheet 81 where he completed 3 Plane Tables on the 4-inch scale, then a Plane Table in sheet 82 on the 2-inch scale, and then 2 Plane Tables in sheet 14 on the 4-inch scale. He is a careful and accurate worker.

Mr. Hickie.

(24.) Mr. Cusson was also employed the whole season in Plane Tabling, first in sheet 81 where he completed 3 Plane Tables, one of which included the large town of Dholka, which he surveyed very accurately and mapped very neatly. He then completed a Plane Table in sheet 82 on the 2-inch scale, and then 2 Plane Tables in sheet 14 on the 4-inch scale. He is a very neat draftsman.

Mr. Cusson.

(25.) Mr. Hall after completing one Plane Table in sheet 81 on the 4-inch scale was transferred to the Kattywar Party.

Mr. Hall.

(26.) Mr. S. Norman was only appointed to the Department on 1st September, so he had every thing to learn. He rapidly acquired a knowledge of Plane Tabling, and during the season completed an out-turn of 94 square miles on the 4-inch scale very accurately and neatly.

Mr. S. Norman.

(27.) Mr. C. Norman only joined the Department on the 12th October, so like his brother had every thing to learn. His out-turn was only 59 square miles on the 4-inch scale, but he was employed in my Office projecting Plane Tables and on other miscellaneous work until the 8th February. He too promises well for duties both in the field and in office.

Mr. C. Norman.

(28). Mr. D'Souza reports well of all the Native Surveyors working under him. Gopal Vishnu who had hitherto been employed as a Traverse Surveyor, has turned out a very fair Plane Tabler. The two new hands Govind Gopal and Bulwant Rajaram both promise well.

Native Surveyors.

(29.) The Native Surveyors of the Revenue Survey Party were divided between two duties. Mr. T. A. Le Mesurier, the Assistant Superintendent, in charge with 3 Native Surveyors were employed traversing in sheets 31, 32, connecting the village boundary trijunctions and village sites of the British territory with the triangulation, while 4 Native Surveyors were employed in my Office transferring the fiscal details from the Revenue Survey village maps to our Plane Tables as they came in.

Revenue Survey.

(30.) It will perhaps be noticed that in my last year's report I only mentioned the Revenue Survey Party as consisting of 5 Native Surveyors, whereas in this report there are 7. Each season I have to consider the proportion of Native Surveyors to underlings that I require, and the Superintendent of the Guzerat Revenue Survey supplies me either with more Native Surveyors and less funds to

pay for underlings, or *vice versâ;* the total salaries of both being limited to Rupees 500 a month. During the past season I only required very little more ground to be prepared in advance of the topography, but that the drawing power was insufficient to meet my requirements. I therefore drew on the Superintendent Revenue Survey for 2 more Native Surveyors for employment in my Office.

Mapping.

(34.) I beg to inform you that, when we take the field at the end of this month, I expect that with the exception of part of the inking in of the fields on 4 sections, the whole of the *drawing* of the sections on the 4-inch scale will be completed, but there will remain a quantity of printing work on several sections, which will be carried on by the permanent Drawing Office that I shall take into the field. The drawing of the sections on the 2-inch scale has also been commenced, but will have to be finished in the field. I expect to have all the sections now in hand completed before we return to recess quarters.

(35.) I am happy to inform you that there is a marked improvement in the mapping of this recess over that of last year. Last year we worked under great disadvantages, but we learnt several lessons, which have been turned to account this year, and now the hands are classified into (1) free hand draftsmen, (2) second class draftsmen and (3) mechanical draftsmen, and the printers are also divided into (1) hand printers, (2) and (3) 1st and 2nd class type printers. To each section, before it is begun, is stitched a printed form called "Section Register" in which all the different stages through which the map has to pass are tabulated, and against each there is a space for the signature of the draftsman or examiner, who passes it through the particular stage, so that each map progresses regularly, and passes from one class of draftsman to another, according as the stages are divided among the different classes. This method could not be arrived at at once, and the want of it last year was the cause of many errors, which have taken up a great deal of time in correcting.

Computations.

(36.) All computations have been completed.

Extracts from Notes on the portion of the Dangs visited by Lieutenant J. E. Gibbs, R.E., in February—May 1875.

(1.) The country in which I have been working this season comprises portions of the Dang Forest, together with some Gaekwar territory, part of the Pimpalner taluka of Khandesh and part of the Báglán taluka of Násik.

(2.) I must preface my remarks with a few words concerning the notes that were published in the General Report for 1873-74. They were in some cases merely records of the impressions with which I was struck at the time, and which I was content to leave as such till I should verify or correct them this year, having no idea that they would go farther than the office table. I shall now have occasion to correct some of my statements of last year.

Aspect of the country.

(3.) The whole of the hills forming the Dangs may be looked upon as the first step of the trap formation leading to the Deccan table land. The second step is at the Ghâts bordering the east of the Dangs. The lower step is deeply cut into, as with a graver, by the water courses of the torrents of the rainy season. At the foot of the upper step the valleys rise to nearly the original level of the ground; thus in a direct distance of about 40 miles the water courses have a fall of about 1500 feet. The 'tread' of the lower step, and its valleys are clothed with forest. The upper step is fringed along its western edge by high peaks. The strata are perfectly horizontal and the peaks consist of vertical columns of basalt. Where these are equal in height they give the appearance of a tower, but where of unequal height and arranged like the half of a set of organ pipes, they give at a distance the illusion of *tilting*, which I noted last year, and which I again noticed on leaving the Dangs this year. On the upper step the aspect is quite different. From one of my stations on the peaks of the fringe, which there ran roughly north and south, to the north-east lay a flat plain dotted with low conical hills, bare of trees, to the east and south-east were high hills with flat tops, or peaks, but only clothed below with forest. To the west lay the Dangs, a monotonous expanse of forest. Looking down there scarcely appeared to be any hills, the valleys being too steep-sided and winding to show. Generally speaking the aspect of the country is wild and inhospitable, but occasionally picturesque gorges, and dells may be met with, though always of a wild character.

Hill Forts.

(4.) In the course of my work I visited the hill forts of Rupgarh, Songarh, and Sáler belonging to H. H. the Gaekwar.

Rupgarh Fort was taken from the Bhils by one of the Gackwars, but has long since been abandoned, and is in ruins. It lies in a very silent position on the frontier, and at one time was useful for keeping the Bhíls in check. Last year I made a note of a perennial spring supplying a tank in the fort. Dissatisfied at the time with the information I received that the tank was supplied by a spring, I examined the place, and thought over the matter this year. The level this year in March was within an inch or two the same as in May last year. The tank is at the highest part of the fort, which stands on a mass of rock high above any thing else within miles, so that it could not be a spring of descent. The water is cold, and there is neither motion in it, nor overflow, as would be caused by a spring from a great depth. A syphon could not exist through rocks of so jointed a kind as trap. The only explanation therefore that I can give for the presence of this constant supply is that, as in the case at the ponds made on the South Downs of England, the daily sea breezes laden with vapour reach Rupgarh almost without obstruction, and there, being checked and meeting with the cold surface of the water already there, they are deprived of their vapour, which condenses to collect in the tank.

Songarh Fort is on the hill to the west of the once walled town of Songarh. It was originally seized from the Bhíls, some families of whom still hold Jaghirs in connection with it. It has a garrison of 25 men, and there are 35 guns in it, which are rusty and honey combed. The only portion of the defences at all kept in repair is the entrance at the northern end. From the top of the hill two high walls run down splaying out, and are connected at the bottom by a very high wall in which is a gateway. In the lower part of the enclosed space are the ruins of what must have been a fine palace with several stories. Songarh is the Head Quarters of the Pargana.

Sáler Fort stands on an immense mass of basaltic rock on the top of the upper step. This mass of rock is very steeply precipitous on the southern side, where it is slightly concave, the horns of the crescent flanking the ground between. The security of the fort lies in its natural inaccessibility. The ascent is by a zigzag rock-cut staircase up the southern cliff, completely in view from the ridge above, as far as the simple but ingenious system of gate-defences that bar access to a narrow ledge along and halfway up the western face. From the northern end of this ledge is another rock-cut staircase leading to the second set of defences that are just below the level of the spring of the 'roof'. The most active of goats could not ascend by any but the regular path. On the top are cattle and goats that have been carried up when young, a good supply of water in tanks at the foot of the roof-slope (which is about 200 feet high), and rock-cut casemates for the garrison.

Climate and Health.

(5.) I think that the evil reports about the Dangs are exaggerated. Whether this year and the last have been exceptionally healthy or not I do not know, but judging from them I think that with a little care there need be very little danger of sickness between the end of February and the middle or end of May. I believe that during that period there is little or nothing to fear in the air. Without doubt the water is unfit to drink, not only because in many places it is mixed with the rank products of rotting vegetation, but that it is still impregnated with the malaria of the cold season. The sovereign cure for this I believe lies in distilling all water for drinking or cooking purposes. Hindús, who drink water in large quantities, and who will not touch distilled water because stills were unknown to their forefathers, suffer considerably, and I had several very serious cases of remittent fever among the Hindús of my party. The rest all enjoyed very good health.

Inhabitants.

(6.) Last year the statistics I collected about 14 villages that I visited in forest tracts, showed that the percentage of children was 36·55 and this year the statistics of 26 villages gives as the percentage 37·96. On comparison with the Census Report of the Bombay Presidency, I find that the proportion is a little over that for the whole Presidency taken together, and therefore my conclusion last year that the population here was rapidly decreasing may be erroneous, still I believe I was not very wrong, and think that, considering the few old people one sees, the percentage of children is small.

The hillmen generally are very superstitious and their worship being dictated by fear, stones erected to Wághdeo (the tiger god) and Nágdeo (the snake god) are very common.

As I worked more in the heart of the Forest this year than last, I naturally saw more Bhils. They are however disappearing from the country. The Bhíl chiefs are 14 in number, 5 being styled Rájá, and the rest Naik.

I visited a manufactory of Káth, the Parsee Overseer showing me every thing. The process was just the same as I described last year. I was amused, if not shocked, by the nonchalance of primitive innocence with which several young women, *habillées peutêtre, mais non vêtues*, stood around. Some were absolutely less clad than the men. The dirtiness of the people is rivalled by the dirtiness of the process.

At one village *vidi mirabile monstrum* in the form of a young woman built by nature to be a left-handed amazon. Her right breast was supplying the wants of her baby, but it is fortunate she had not twins.

The Forest.

(7.) While working in and along the boundary of Gaekwar territory, I was surprised to see the wretched state of the trees, especially teak. One might reckon on the core of any teak tree over a foot in diameter being rotten, and the trees were all misshapen. I was agreeably struck by the contrast on working into the Dang States. The superiority in size, symmetry and healthy growth of the trees under the Forest Department over those in the uncared for Gaekwar districts, catches even the untrained eye at once, and speaks volumes in praise of the care and efforts of the Department. The trees are tall, thick and straight, and solid throughout, and the old trees that are felled are replaced by healthy saplings. In some dells the trees were particularly fine with tall straight trunks, not branching till they had attained a great height.

Botany.

(9.) Last year in my notes the trees &c., mentioned were put down irrespective of order, I have therefore repeated their names in the following list of species I have identified. The native names are those given me by the hillmen, who seem to have names for all trees and plants. Besides the following I noticed several that I hope next year to be able to identify.

Capparideæ—Capparis pedunculosa, a small shrub with recurved thorns and umbels of small white flowers having long gynophors.—2500 feet.

Malvaceæ—Hibiscus Rosa Sinensis (Jasodi), the shoe flower in Sáler gardens.

Bombax—Malabaricum (Sáonwar), red silk cotton tree, described last year.—Dang Valleys.

Sterculiaceæ—Sterculia urens (Khandol) described last year.—Dang Valleys.

Tiliaceæ—Grewia abutilifolia (Dhamon), a small tree with 3-nerved leaves and cymes of small yellow flowers, having petals much smaller than sepals; drupes small yellow said to be edible; wood hard and strong.—2000 feet.

Rutaceæ.—Ægle Marmelos (Bil) with 3-foliolate leaves (emblematic of the Hindú Trinity), and large globose fruit having a woody rind and many seeds in a sweet aromatic orange pulp, valuable in dysentery.—1500 feet.

Anacardiaceæ.—Mangifera Indica (Am), the common mango, near village sites.

Celastrineæ.—Celastrus paniculata (Kárkángun), a scandent shrub with pendulous panicles of tiny greenish flowers; the seeds yield lamp-oil.—Dang Valleys.

Rhamneæ.—Zizyphus rugosa (Turan), a small tree with recurved prickles; fleshy white fruit with crustaceous stone, having a mawkish taste, and being much eaten by the inhabitants.—Common even over 3000 feet (See Hooker's Flora of India).

Rhamnus Wightii (Ragatrura), a small shrub with shortly accuminate fascicled leaves; panicles starting opposite to one of the lowest leaves of a tuft; berries, ⅛ size of a pea, superior, 4-seeded, red-orange; calyx persistent—evidently rare as I only saw one specimen, and few of the villagers knew its name.

Leguminosæ—Erythrina Indica (Pangara), a tree armed with black prickles; leaves 3-foliolate; racemes of bright scarlet flowers in March. Wood used for sword sheaths (Bird-wood).—Dang Valleys.

Erythrina suberosa (also called Pangara), very similar to the above but with cork like bark.—Dang Valleys.

Butea frondosa (Palas Kankara), known to Europeans as the Dák, a shrub with 3-foliolate, leaves leaflets large, used as plates or drinking cups; tomentose racemes of large silky orange-red flowers in February and March; legumes downy, one seeded.—Everywhere.

Pongamia glabra (Kurunj), a tree with 5—7-foliolate leaves with large glabrous leaflets; axillary racemes of shortly pedicelled pink and white papilionaceous flowers.—Dang Valleys.

Dalbergia latifolia (the Sisu of the Bombay Presidency), the black-wood tree.—1500 feet.

Dalbergia ougeinensis (Tanaj), a large tree with 3-foliolate leaves, leaflets large, reddish when young; racemes of small pink flowers; wood tough, strong, and heavy.—Up to 1500 feet.

Cassia fistula (Báwa), a small tree with pinnate leaves having 5 pairs of leaflets; pendulous racemes of bright yellow flowers; pods long, cylindrical, divided by spurious traverse plates into one-seeded cells; seeds hard, shiny, collected by red beetles.—Everywhere.

Tamarindus Indica (Amli or Chinch), near village sites.

Bauhinia Racemosa (Aapta), a small tree or shrub; leaves used when dry for making 'biris' or native cigarettes; terminal racemes of small white flowers.—Common everywhere.

Acacia Catechu (Khair) mentioned last year.—Common everywhere.

Albizzia Lebbek (Siris), a large tree with black bark, and dark heart-wood somewhat like black-wood; leaves abruptly bipinnate; pinnæ 2—6 pairs; leaflets 10—15 pairs, very oblique; raceme axillary, long peduncled with many close 10—15 flowered heads.—Up to 1500 feet.

Cicer Arietinum (Chana), gram cultivated about Songarh.

Phaseolus Mungo (Urid) cultivated in small patches in the Dangs.

Combretaceæ.—Anogeissus Latifolius (Dáora), a tree with white bark and wood, and light green elliptical leaves; it yields a very fine strong white gum.—In valleys and up to 1500 feet.

Terminalia Chebula (Herdi), leaves large, oblong and downy when young; petioles short with pair of glands at apex; panicles of purple oval drupes having a bloom; drupes (myrobolans) valuable for their tannin.—2500 feet.

Terminalia Arjuna (Mota Sádra), a large tree with smooth bark and dark heart-wood.—Up to 1500 feet.

Myrtaceæ.—Sizygium Jambolanum (Jámbul), a tree with light colored bark and opposite, entire shining leaves; 3-forked panicles of small white flowers with calyptrate corolla; good timber and edible fruit.—Near village sites.

Sizygium Salicifolium (Jámbul), a shrub with willow-shaped leaves; lax panicles of small white flowers.—In beds of rivers.

Careya arborea (Kumbi), a tree with large entire membraneous leaves, much eaten by a small white caterpillar; leaves after flowers; flowers with 2—3 hundred long white stamens; style long, honey at base; fruit the size of a small apple, edible.—2000 feet.

Cucurbitaceæ.—Cucumis trigonus with oval fruit, yellow striped with green, very bitter; climbing or creeping about shrubs.—2000 feet.

Loranthaceæ.—Loranthus bicolar (Bhendgol), a very common parasite especially on the Aapta; flowers long, slender, scarlet and green; leaves opposite, entire; disc accrescent round inferior ovary.—Everywhere.

Rubiaceæ.—Nauclea cordifolia (Hedu), a large tree with roundish downy stipulate leaves, and round heads of flowers.—Valleys.

Gardenia dumetorum (Gál), a small spinous tree with opposite, simple entire leaves having interpetiolar stipules; flowers sessile, axillary, solitary, white fading to yellow; fruit round.—Everywhere.

Gardenia lucida? (Tendrum), very similar to the above but with large flowers; flowers full of honey; stigma large, brown and sticky.—Everywhere.

Compositæ.—Blumea holoserica, a small downy herb with deeply serrate leaves, and yellow flower-heads in elongated panicles. So common all over disused clearings, that at first I thought it must be cultivated.

Oleaceæ.—Jasminum Sambac (Bhat Mogra), a shrub with fragrant, double white flowers.—In Sáler Gardens.

Sapotaceæ.—Bassia latifolia. (Mahwa), mentioned last year. There appear to be 2 varieties, the one with red and the other with green leaves.—Both in great numbers above the Ghâts near Pimpalner, and also common in the Dangs.

Ebenaceæ.—Diospyros exsculpta (Temburni), a small tree with large leaves downy beneath; fruit edible with rather pleasant flavour.—1500 feet.

Apocynaceæ.—Carissa Carandas, a spinous shrub with shining coriaceous leaves, and fragrant white flowers; purple berry with sweet acid pulp; flowers in March.—Common everywhere.

Wrightia tinctoria (Kála Kura), a small tree or shrub with white wood, and lax panicles of fragrant white flowers appearing in April; style very short and anthers low down the tube.—Common everywhere.

Holarrhena antidysenterica (Doli Kurli), a shrub very similar to the above, but with wider leaves, and puberulous flowers having partially coherent anthers which form a pyramid above the limb of the corolla.—Common everywhere.

Asclepiadaceæ.—Calotropis Gigantea (Madár), a shrub abounding in milky juice, opposite leaves and interpetiolar umbels of purple flowers.—Common on all clearings.

Bignoniaceæ.—Bignonia Quadrilocularis (Waras), a very handsome tree when in full bloom with its large bunches of crimped white flowers.—Valleys and up to 1500 feet.

Cordiaceæ.—Cordia Myxa (Bhokar), a small tree with simple alternate leaves, panicles of white flowers, and edible berries with glutinous pulp.—1500 feet.

Verbenaceæ.—Tectona Grandis (Sagwan), the teak tree.—Valleys and up to 1500 feet.

Gmelina arborea (Sheoni), with opposite entire leaves, velvetty beneath; inflorescence a raceme; drupes yellow, superior, calyx persistent; fruit much eaten by wild animals.—1500 feet.

Vitex Nirgundi or Bicolor (Nirgundi), a shrub with opposite 3 or 5-foliolate leave and panicles of small bluish purple flowers.—Common in valleys and above the Ghâts.

Euphorbiaceæ.—Phyllanthus Emblica (Aonla), a small tree with axillary clusters of flowers; drupe fleshy, edible.—Valleys.

Urticaceæ.—Ficus benghalensis (Waror Bar), the Banyan tree.—Common everywhere.

Ficus religiosa (Pipal), with cordate, narrowly accuminate leaves.—Everywhere.

Ficus pseudotjiela (Pipri), a tall handsome tree with long petioled, oblong-ovate, shining leaves.—Common.

Ficus cordifolia (Páer), a tree with leaves somewhat like those of the Pipal, and clusters of small sessile round fruit.—Common.

Ficus glomerata (Umbar), a crooked tree covered with figs, purple when ripe, and always full of worms or flies.—Common especially by streams.

Artocarpaceæ.—Artocarpus integrifolia (Panas), the Jack tree, with shining dark green coriaceous leaves and huge fruit with shagreen exterior.—Western borders of Dangs.

Orchidaceæ.—I saw several specimens on trees, but none in flowers.

Amaryllidaceæ.—Crinum parvum (Karwand), stem about 9 inches high, about 3 white flowers in umbel; the bulbs were generally so fixed in the crevices of rocks that they could not be taken out whole; flowers in May.—Common on tops of Dang hills and on the Ghâts.

Palmaceæ.—Borassus flabelliformis (Tári), tapped for its saccharine juice, drunk under the name of tári or toddy.—Common in the western Dangs and again at the foot of the upper Ghâts.

Phœnix Sylvestris (Kajur), the common wild date palm; fruit yellow when ripe.—Western Dangs.

Gramineæ.—Eleusine coracana (Nágli or Násni), cultivated for food and export, being given to Banjáras in exchange for salt.

Oryza sativa (Chokha), common rice, occasionally raised in small quantities for food.

Holcus spicatus (Bájri), cultivated for food.

Bambusa vulgaris (Welu), growing to 60 feet high in thick clumps.—Western Dangs.

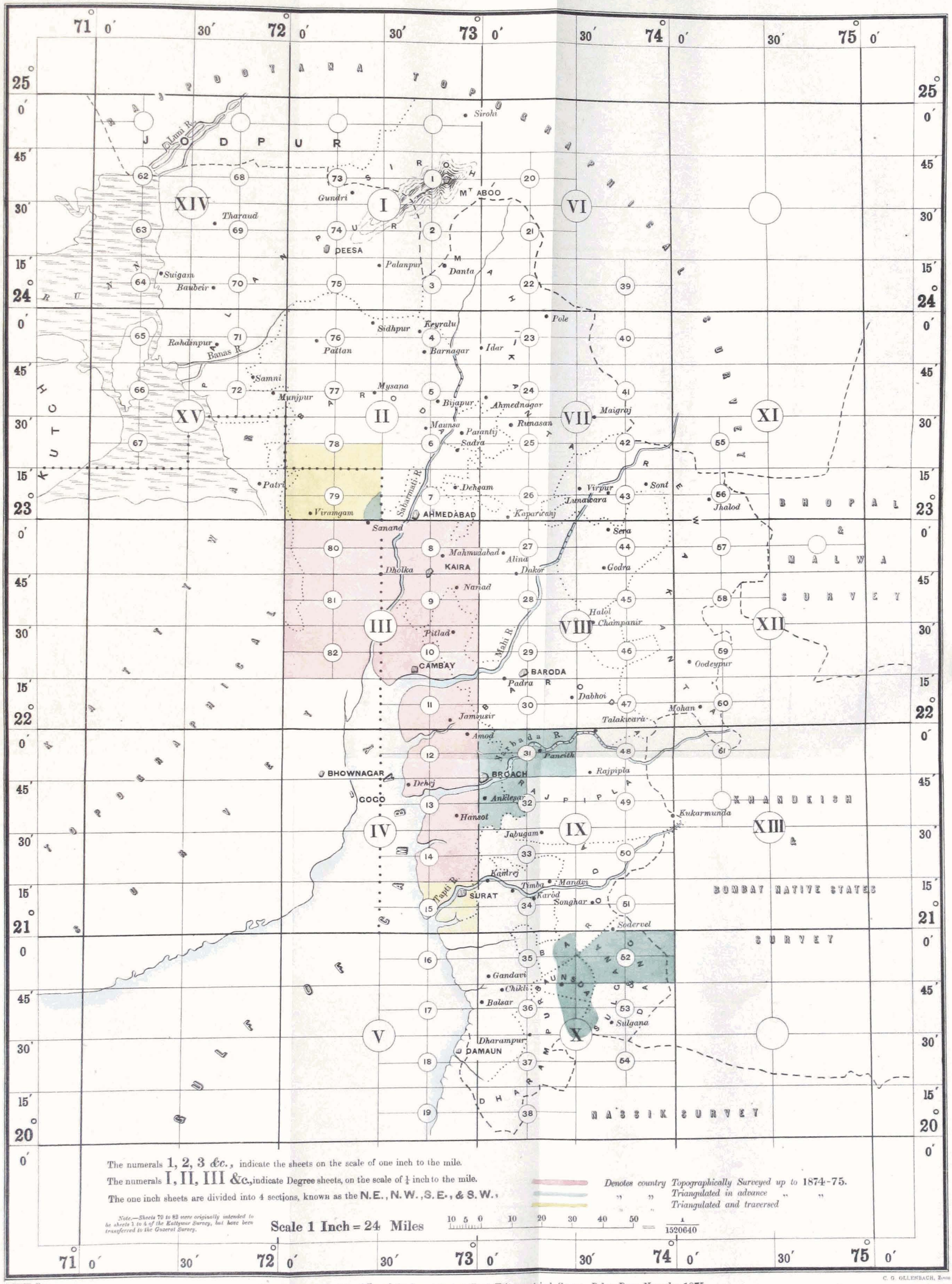
Bambusa stricta (Bás), a small straight species of Bamboo with long thin branches.—Western Dangs.

Geology.

There is of course a great sameness in the lithology of the district, the greater part of the rocks varying from black to grey crystalline basalts, diorites, and the like. On the tops of several of the hills of the 'lower step' I met with rocks full of acicular white crystals. I saw very few large crystal masses. There are no alluvial deposits, and the rocks of the river beds are polished and rounded by the attrition of the gritty particles carried down by the monsoon torrents.

GREAT TRIGONOMETRICAL SURVEY OF INDIA

INDEX CHART OF THE GUZERAT TOPOGRAPHICAL SURVEY



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

The numerals I, II, III &c., indicate Degree sheets, on the scale of ½ inch to the mile.

The one inch sheets are divided into 4 sections, known as the N.E., N.W., S.E., & S.W.

Note.—Sheets 79 to 82 were originally intended to be sheets 1 to 4 of the Kattywar Survey, but have been transferred to the Guzerat Survey.

Denotes country Topographically Surveyed up to 1874-75.
" " Triangulated in advance " "
" " Triangulated and traversed

Scale 1 Inch = 24 Miles 10 5 0 10 20 30 40 50 = 1/1520640

C. DYSON, Photo.

Photozincographed at the Office of the Superintendent Great Trigonometrical Survey, Dehra Dun, November 1875.

C. G. OLLENBACH, Zincog.

TABULAR STATEMENT OF WORK IN GUZERAT, DURING THE FIELD SEASON 1874-75.

Triangulation.

Observer's Names.	Instrument used.	Area triangulated sq. miles.	No. of Stations visited.	3 Angles observed.					2 Angles observed.				Remarks.
				Triangles.	Triangular error.	Error per mile.	No. of Heights.	Discrepancy in Height.	Triangles.	Error per mile.	No. of Points.	No. of Heights.	
Lieut. J. E. Gibbs, ... (Recorder Bulwant Atmaram.)	Troughton & Simms' 10-inch	147* / 412†	27	35	4·6	1·7‡ in.	24	0·9§ ft.	138	4·1‖ in.	92	61	*Primary Triangulation. †Secondary Triangulation. ‡Mean diff. of 15 common sides. ‖Mean diff. of 40 common sides. §Mean diff. of 21 common heights.

Plane Tabling.

No.	Names.	Plane Tabling in Square Miles. 4-inch scale.	2-inch scale.	Stations per sq. mile.	Remarks.
1	Lieut. J. E. Gibbs, ...	37·3	.....	6·6	*Employed the whole time in supervising natives and in teaching new hands. †Joined 31st December, was also employed in supervising natives and in teaching Mr. C. Norman. ‡Transferred to Kattywar Party 9th January.
2	Mr. D'Souza* ...	.....	.....	.....	
3	„ Christie, ...	124·4	.....	13·3	
4	„ McAFee† ...	12·5	140.0	5·4	
5	„ E. J. Connor, ...	18·3	.....	22·8	
6	„ J. Hickie, ...	94·6	70·1	10·7	
7	„ G. D. Cusson, ...	95·4	57·8	7·8	
8	„ G. Hall‡ ...	18·3	.....	15·7	
9	„ S. Norman, ...	93·7	.....	13·3	
10	„ C. Norman, ...	59·3	.....	11·5	
	Native Surveyors.				
1	Gopal Vishnu, ...	87·7	.....	12·5	
2	Raoji Narayen, ...	93·7	28·5	9·5	
3	Bhow Govind, ..	93·7	52·8	9·8	
4	Luximon Gorpuray, ...	39·0	.....	16·9	
5	Mukand Dinkar, ...	54·8	.....	11·0	
6	Ganesh Bapuji 1st, ...	58·1	51·2	11·1	
7	Govind Gopal, ...	37·8	.....	15·5	
8	Bulwant Rajaram, ...	39·0	.....	14·5	
				average	
		1057·6	400·4	10·7	Total No. of Plane Table Stations 15,636.
	Total, ...	or 1458 sq. miles			Including overlaps.

Traversing.

No.	Names.	Linear Distance in miles.	Remarks.
1	Mr. E. J. Connor, ...	3·649	A sufficiency of traverses has not been computed as yet for obtaining a fair average for the errors.
2	Ganesh Bapuji 2nd, ...	129·286	
	Revenue Survey.		
1	Jugal Mansukram, ...	169·555	
2	Gopal Ganesh, ...	117·110	
3	Trimbaklal Goverdhan, ...	27·984	
	Total, ...	447·584	
	Number of points fixed, ...	1133	

Permanent Drawing Office.

No.	Names.	Employment.
1	Mr. J. Peyton, ...	Head Draftsman.
2	Ganesh Narayen, ...	Draftsman left sick on 27th Decr.
3	Monaji Aboo, ...	Hand printing.
4	Luximon Gorpuray, ...	Printing from 29th January.
5	Mukand Dinkar, ...	„ „ 16th February.
	Revenue Survey.	
1	Keshowram Ravishankar,	Plotting Traverses and Revenue Survey fiscal details on Plane Tables.
2	Kuber Parbhudass, ...	
3	Dowlat Lalbhai, ...	
4	Parbhu Kisor, ...	

Extract from the Narrative Report—dated 15th November 1875—of Captain H. R. THUILLIER, R.E., Officiating Deputy Superintendent 1st Grade, in charge of the Kumaun and Garhwal and the Dehra Dun Survey Parties.

In the spring of 1874, the Establishment of the Kumaun and Garhwál Party was broken up into two detachments; one was sent under Mr. E. C. Ryall to resume the Survey of the higher ranges in Kumaun and Garhwál, the operations of which will be described hereafter, the other detachment, as per margin, under my own superintendence, was employed during the field season 1874-75 in carrying on the Survey of Dehra Dún which was commenced in the previous year.

PERSONNEL.

Captain H. R. Thuillier, R.E.
Lieutenant St. G. C. Gore, R.E., Asst. Supdt.

Surveyors and Asst. Surveyors.

Mr. C. J. Neuville.
" J. Low.
" L. J. Pocock.
" H. Todd.
" T. Kinney.
" E. P. Wrixon.

Native Surveyors.

11 Native Surveyors.

(2.) The field operations commenced early in October. Lieutenant Gore, was entrusted with the supervision of the village boundary traverses: Messrs. Low, Todd and Kinney, each with two Native Surveyors, were deputed to take up the topography of the Western Dún commencing at the Jumna. Mr. L. Pocock was directed to complete the triangulation of the Eastern Dún and subsequently to proceed to Jaunsár Báwar for the same purpose; and Mr. Wrixon to carry main traverses in the Eastern Dún for fixing trijunction pillars for checks on the boundary traverses.

Out-turn of work.

(3.) During the season, 225 square miles of country have been topographically surveyed on the scale of 4 inches to the mile; the triangulation of the Dún has been completed and the whole of Jaunsár Báwar covered with a net-work of triangles, comprising a total area of 470 square miles. 70 linear miles of main theodolite traverses, 328 miles of boundary traverses and 63 miles of check survey lines were run.

Topography.

(4.) The whole of the topography has been done most carefully and the measurements have been very searching. 63 linear miles of check survey were executed across the detail work of the Native Plane Tablers to test its correctness, and the hill sketching was examined *in situ* during the progress of the work. The results of these tests were very satisfactory and proved the work to be minutely accurate.

(5.) The area topographically surveyed is smaller than I had expected to have completed, but several causes tended to this result. The Native Surveyors with only two exceptions were raw hands and had to be taught Plane Tabling, for their work during the previous season (which was their first season of surveying) had been restricted to traversing. Their progress too when trained proved far slower than I had anticipated, so that the brunt of the work fell on the European Assistants. This in a great measure however was due to the intricacy of the ground, and the large amount of detail met with throughout the ground over which the topography was carried. The tabular statement will shew this by the amount of chaining and the large proportion of plane table stations which were found requisite for filling in the interior details. For the first 3 months of the field season also, the luxuriant vegetation for which the Dún is proverbial and the high *bhábur* grass which covers a large proportion of the low-lands, proved a great obstacle to the progress of the Plane Tablers. This grass is generally burnt in the month of February and until that time the surveyor is much delayed by having to cut lines for his chain measurements. The field season also was shorter than I might have made it, but this I was compelled to cut short owing to the large amount of mapping which had to be undertaken during the recess, this having been greatly augmented by the large area brought in by the Kumaun and Garhwál detachment during the same season. Under these circumstances and bearing in mind that it was our first season of working on the 4-inch scale, I trust this out-turn will be considered satisfactory.

Traverses.

(6.) The whole of the traversing required for the completion of the Survey of the Dún was finished. All precautions, as described in my last report, were taken to insure accuracy of results. The main theodolite traverses were in all cases run between trigonometrical stations, but in consequence of the ground being more rugged and broken than that met with in the previous season, the ratio of error is somewhat larger, though still satisfactory.

Boundary traverses and their errors.

(7.) The boundary traverses were all completed and comprise 121 villages and estates. These traverses are in all cases well tied in by check points furnished either trigonometrically or by the main theodolite traverses. They were executed by the Native Surveyors with the plane table and circular protractor, and were all reduced in the field and found to stand the usual tests in a satisfactory manner. The ground was more or less bad throughout for chaining, especially about the low-lands at the foot of the hills, a large portion of

the work having to be carried over broken ground and ravines with steep declivities, the measurements of which required very heavy corrections for reduction to the horizontal level. The boundaries also were very intricate, the average distance between each station in 5726 stations being only 4·58 chains. Notwithstanding these trials, the errors are very fairly small.

Remarks on the country.

(8.) The country surveyed during the season comprises ground of every variety, from the flat cultivated lands in the vicinity of the Asan, a tributary of the Jumna and the main drainage channel of the Western Dún, to the crest of the Mussooree range which rises to a height of over 7000 feet above sea level. The low spurs and broken ground about the foot of the hills gave an infinity of labour and trouble in surveying, being for the most part covered with thick Sál forest and cut up by deep precipitous ravines and 'raus' with beds of boulders lower down; these raus spread out leaving broad undulating plateaux between them which are for the most part well cultivated, except in places where shingle crops out.

Aneroid heights.

(10.) Numerous heights, in addition to those obtained trigonometrically, have been fixed by Aneroid barometers throughout the season's work.

Triangulation and Traversing in advance of the detail survey.

(11.) The amount of triangulation and traversing in advance of the portion topographically surveyed, covers in the Dún an area of 125 square miles, this being the extent of the Zamíndárí lands which remains to be surveyed by this party. In addition to this, the whole of Jaunsár Báwar, comprising an area of about 360 square miles, is ready for the topography to be commenced. The survey of this portion of the district which is composed entirely of hills and mountains, is to be done on the scale of 2 inches to the mile and will admit, I am afraid, of little are no traversing.

(12.) I now proceed to report separately on each officer's work, the details of which are tabulated on page 45—a.

Lieutenant Gore, R.E.

(13.) Lieutenant Gore took the field on the 7th October and was employed until 22nd November in superintending the village boundary traverses in the neighborhood of Rájpur and Dehra. On relieving him of this duty I entrusted him with the topography of sections 13, 14 and 24 bordering the Jumna. Having completed these sections, he took up sections 38, 39 and 49 in the beginning of February. About the middle of March, I sent Lieutenant Gore's party to complete all the low village lands lying among the forest of the Eastern Dún, in the vicinity of the Song and Suswa; this being the most favorable time of the year for surveying this ground, on account of the *bhábur* grass being all cleared and its freedom from the malaria of the neighbouring marshes. Much of this land is covered with rank vegetation nourished by the amount of water furnished by these streams and their numerous tributaries. The greatest obstacles to the survey being the cane brakes which were inaccessible to man or elephant. Lieutenant Gore with the help of the Native Surveyors completed the work allotted to him by the 20th April. Lieutenant Gore having been transferred to the topographical branch of the department, I have much pleasure in recording the valuable assistance I have invariably received from him since he has been under my orders, during which time he has conducted his duties with ability and energy to my entire satisfaction, and I consider him in every way qualified for independent charge of survey operations.

Mr. Neuville.

(14.) Mr. Neuville was employed the whole season in my office in the miscellaneous current work of which there was a large amount.

Mr. Low.

(15.) Mr. Low was employed all the season in Plane Tabling. He commenced on section 7 in the Khádir lands of the Jumna, where he experienced much delay from the high grass which covers all that portion. In January he took up the north and east portions of section 27 which was most intricate and difficult ground, cut up by deep ravines and low hills covered with forest. He then completed the hilly portion of section 37, and leaving his two Native Surveyors to fill in the low ground, he commenced section 46, which consists entirely of hills and runs up to the Mussooree and Landour settlement. By the end of the season he completed this section and section 57 which also consists entirely of hills. I was well satisfied with Mr. Low's diligence and the accuracy of his work.

Mr. L. Pocock.

(16.) Mr. Pocock was employed from the middle of October till the beginning of April on triangulation. He first completed the remaining portion of the Eastern Dún covering an area of 110 square miles, and on 22nd January started for Jaunsár Báwar, the triangulation of which he successfully completed by the end of March. This portion of his work embraces an area of 360 square miles, which is well covered with points. I have every reason to be well satisfied with Mr. Pocock's exertions and the results of his work.

(17.) Mr. Todd was employed on topography throughout the season. He commenced work on 19th October with two Native Surveyors and during the season completed sections 9, 15, 26 and half of 56. Of these sections the ground in 15 and 26 was most intricate and difficult. The delineations of the features have been very artistically and faithfully rendered and the varied character of the ground has been shewn with excellent effect, but the labour involved in surveying such a large amount of detail was great and very tedious. The work of the Native Surveyors was rigorously examined. Section 56 consists entirely of hills, the ground being very precipitous and difficult to move about in. This portion of the work was also done with Mr. Todd's usual care and accuracy and the quality of his work is highly creditable to him. Mr. Todd closed work on the 30th April.

Mr. H. Todd.

(18.) Mr. Kinney commenced field work on 17th October and was engaged in Plane Tabling during the entire season. He was first entrusted with sections 3 and 8 in the low ground of the valley of the Asan, and was provided with two Native Surveyors whom he had to train. He completed these sections by the 20th January, when I transferred his Native Surveyors and sent him to take up the topography of the hills in sections 25, 35 & 36. The ground in the two former of these sections is high with bold open features rising to a height of about 7000 feet and was easy to sketch, but in the central and lower portions of 36, the hills are much broken up into small confused masses, covered for the most part with forest and intersected by narrow and intricate ravines, resulting in an unusual amount of detail in the smaller natural features. A portion of this section which I had hoped to have had completed had to be left for the next field season. Mr. Kinney has worked hard and well, his sketching and delineation of ground is remarkably good and characteristic.

Mr. Kinney.

(19.) Mr. Wrixon was employed in minor triangulation in the rough ground between the Dehra and Rájpur road and the Song Nadi. He subsequently took up the traverse of the road from Dehra to Hardwár and then carried a line up the right bank of the Ganges from Hardwár to Tapoban. I regret I am unable to report favorably of Mr. Wrixon's work or conduct.

Mr. Wrixon.

(20.) The topography done by the Native Surveyors, considering that it was their first season in Plane Tabling, was very fair and found to be minutely accurate, but they are very indifferent draftsmen. In this however they are improving, and will I have no doubt next season turn out more artistic work. I have been well satisfied with the diligence of all the Native Surveyors with two exceptions, one of whom was discharged and the pay of the second reduced.

Native Surveyors.

(21.) The party was employed during the recess on computations and mapping. All the computations connected with the previous season's triangulation and traversing were completed. The mapping includes the preparation of 7 Sheets of the Dehra Dún Survey on the scale of 4 inches to the mile which have been completed and sent to the Head Quarter's Office for publication.

Recess of 1875.

(22.) The detail survey of the remaining portion of the Zamíndárí lands in the Dún will be resumed and completed. The topography of Jaunsár Báwar, on the scale of 2 inches to the mile, will also be taken up by a portion of the party at the commencement of the field season, and I trust to be able to complete the survey of this portion of the district also during the ensuing season.

Programme for field season 1875-76.

INDEX MAP

OF THE

DEHRA DUN AND SIWALIK SURVEY

Scale, 1 Inch = 4 miles

The Numerals I, II, III, &c., indicate the sheets on the scale of 4 inches to the mile.

The Numerals 1, 2, 3, &c., indicate the plane table sections.

Government Forest Boundaries

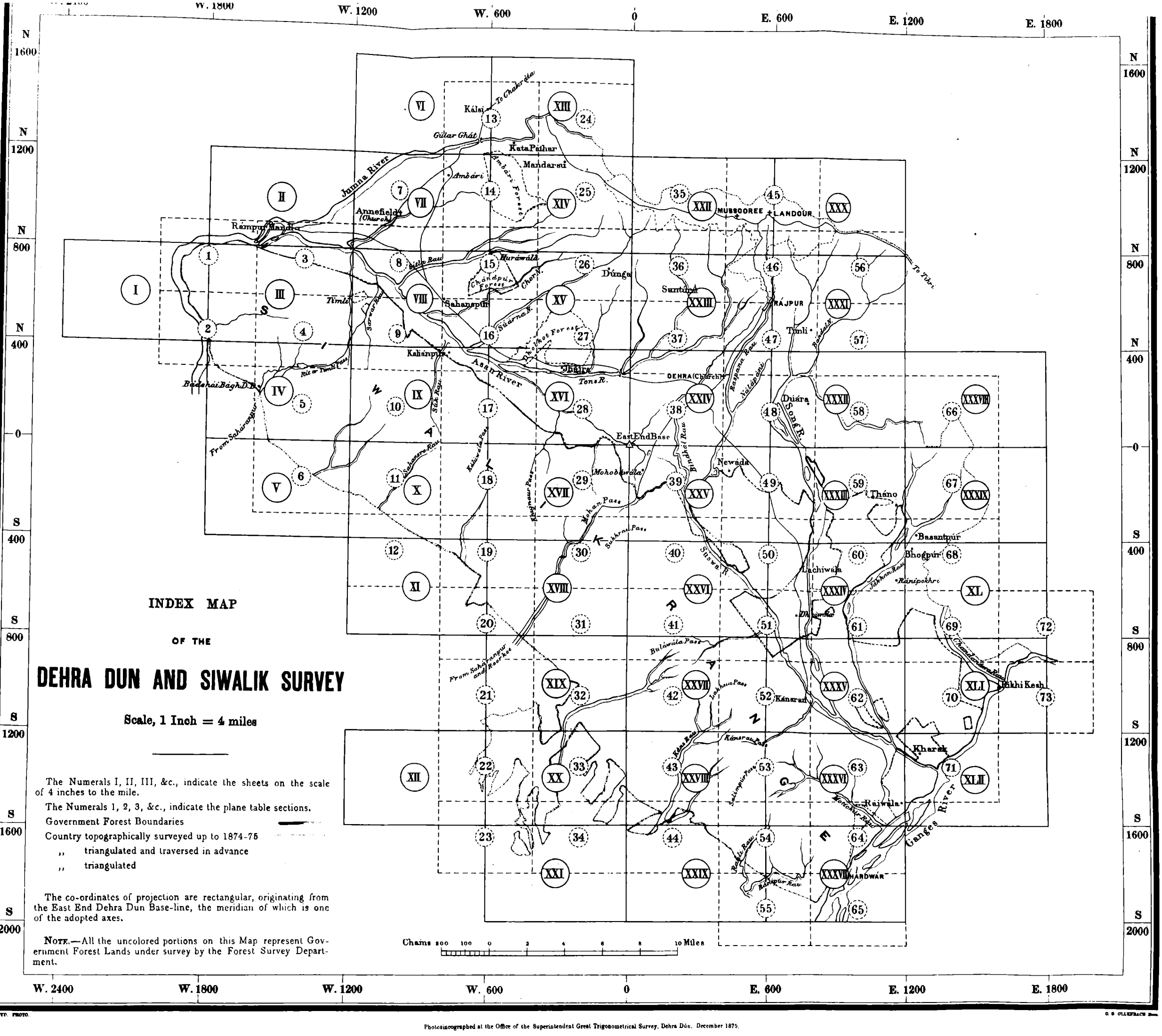
Country topographically surveyed up to 1874-75

,, triangulated and traversed in advance

,, triangulated

The co-ordinates of projection are rectangular, originating from the East End Dehra Dun Base-line, the meridian of which is one of the adopted axes.

NOTE.—All the uncolored portions on this Map represent Government Forest Lands under survey by the Forest Survey Department.



T. LLOYD. PHOTO.

O. & C. ULLERSACH Bonn.

Photozincographed at the Office of the Superintendent Great Trigonometrical Survey, Dehra Dún, December 1875.

DEHRA DUN SURVEY.

Tabular statement of out-turn of work. Season 1874-75.

Details of Triangulation.

OBSERVER'S NAME.	Instrument used.	Area triangulated in square miles.	No. of stations visited.	No. of points fixed by intersection but not visited.	No. of stations whose positions and heights have been fixed.	No. of stations whose positions only have been fixed.	No. of hill tops cleared of forest.	Average number of trigonometrical points per square mile.	Average area in square miles to each trigonometrical height.	No. of triangles of which all three angles have been observed.	Mean triangular error.	No. of triangles of which only two angles have been observed.	No. of boundary pillars fixed.
	Inch.										"		
Mr. L. Pocock, ...	12	470	75	557	191	441	5	1·4	2·4	112	11	1064	7
„ E. Wrixon, ...	7	*20	23	39	...	62	...	...	...	7	40	103	15
Totals, ...	...	490	98	596	191	503	5	...	...	119	...	1167	22

* Approximate.

Details of Topography. Scale 4 *inches* = 1 *mile.*

NAMES.	Area in acres.	No. of acres per Plane Table Station.	LINEAR MILES.		REMARKS.
			Chain measurements.	Check lines.	
Lieut. St. G. Gore, R.E., ...	36,825	3·8	627·3	17·7	Level and broken ground.
and 4 Native Surveyors, ...	5,992	10·5	...	...	Hills.
Mr. J. Low, ...	15,404	2·3	329·0	19·3	Comparatively level ground.
and 2 Native Surveyors, ...	6,630	3·3	115·8		Ravines and low hills covered with forest.
	8,178	25·7	8·2	...	Hills.
Mr. H. Todd, ...	24,379	1·9	578·1	9·9	Very intricate ground consisting of ravines and low hills mostly covered with forest.
and 2 Native Surveyors, ...	4,600	19·4	...	...	Hills.
Mr. T. Kinney, ...	22,620	7·0	233·6	15·7	Partly level and partly ravines and low hills.
and 2 Native Surveyors up to 20th January, ...	15,760	22·1	...	...	Hills.
Mr. E. Wrixon, ...	3,369	11·2	40·4	...	Flat and tolerably open ground.
Totals, ...	1,43,757 or 224·6 sq. miles.	...	1932·4	62·6	

Details of Traversing.

NAMES.	Linear miles of traverse.	Number of stations.	Average distance in chains between stations.	Average error per 1000 links.	Average angular error.	REMARKS.
Mr. E. Wrixon, ... (Theodolite traverses)	70	271	20·67	1·00	11"	
Native Surveyors, ... (Plane Table and protractor traverses)	328	5726	4·58	2·90	...	
Totals, ...	398	5997	...	...	...	

KUMAUN AND GARHWAL SURVEY.

(23.) My last report treated the operations of this party up to the beginning of July 1874, when it returned to recess quarters at Almora, which place was selected on account of its being close to the ground of field operations—a matter of much importance on account of the limited period in which survey operations could be carried on in the higher snowy ranges. Experience has proved that the best time for operations in these high altitudes is immediately after the rainy season, when the snow line is at its highest and the atmosphere bright and clear.

(24.) The party, which consisted of the members as per margin, had but a short rest at Almora and made an early start for the field while the rains were still in progress. This involved much discomfort on the march and some risk of malarious fever, but was necessary in order to secure every day of the short time available for surveying.

E. C. Ryall, Esq. Asst. Supdt.

Assistant Surveyors.

Mr. C. H. McAFee.
„ E. F. Litchfield.
„ I. S. Pocock.
„ J. F. McCarthy.

(25.) Mr. Ryall has submitted the following report of the operations under his charge.

"Active operations were commenced on all sides by the 13th September.

"It was my original intention to conduct a series of triangles along the Tibetan frontier with a view of laying down peaks, &c., in the Sutlej Valley. I abandoned this project when I learnt that the undertaking would press too heavily on your estimate of expenses. I proceeded instead therefore to inspect the topographical work finished during the previous summer and the ground where the Plane Tabling was about to be done. After completing my inspection tour, I proceeded to continue the Milam triangulation. The total length of the Milam triangulation is 48 miles, of which 32 was finished during previous and 16 during the season under review. The greater portion of this work was very trying; it required all the skill and nerve I possessed to pierce to stupendous gorge overhung by the lofty snowy mountains of Chirkhana and Hasaling with a series of triangles. The steepness of the gorge may be conceived when it is understood that the direct horizontal distance from Hasaling snowy peak to the Gori river is rather less than 1¾ miles and that it towers 14,000 feet above it. In this triangulation Mr. McAFee assisted me by observing at three of the base stations.

"The extent of triangulation finished by me covers an area of 200 square miles, comprising five stations visited of an average height of 13,300 feet above sea level.

"As far as regards altitude and physical formation, the two districts of Kumaun and Garhwál may be divided into five belts or zones. I shall describe these in succession beginning with No. 1 from the north.

Description of country.

No. 1 Zone. The average width of this belt is about 15 miles. In length it extends from the Mána Valley in the west to that of Byáns, bordering on the Nepal frontier, in the east. It comprises within it, besides the two above mentioned valleys, those of Niti, Milam, Rálam and Dharma. The average height of the basins of these valleys is about 14,000 feet above sea level, the highest basin (15,500) being that of Mána and the lowest (12,500) that of Byáns. The average altitude above sea level of the main and minor ranges within this belt is about 20,000 feet. The ground though lofty, is for the most part undulating. Access to the tops of most of the spurs or ranges is not difficult, though very trying in consequence of the great tenuity of the air. With the exception of the main ranges which divide the above mentioned six valleys, the whole formation of this zone is of slate of almost every conceivable color and in various stages of decay.

The ranges that are excepted, are entirely composed of granite, that is so far as I could judge, for I could not perceive any or the slightest order of stratification among them. Fuel can be seldom had over 12,500 feet; grass never over 13,500.

No. 2 Zone. This belt consists of ranges of extremely precipitous and rugged lofty mountain barriers running parallel to and south of Zone No. 1. Its average width may be put down at 10 miles, its maximum is about 17. The whole of these ranges are stupendously lofty, the mean height of the peaks on them being about 22,000 feet, and the formation throughout is of granite, except in some few places where it is of gneiss. The drainage from the comparatively undulating and open valleys of Mána, Niti, Milam, Rálam, Dharma and Byáns lying in Zone No. 1, breaks through these enormous barries, and the six gorges so formed average in mid height about 4 miles in breadth. The widest, the gorge of the Niti or Dhauli river, towards Joshimath, being about 6 miles. The narrowest is that of Milam being about 3 miles. The sides of these gorges are overhung, as a matter of course, by almost sheer precipices, capped by towering needle-like peaks. The easiest of them, where the triangulation has been carried through, were converted into stations, ascent to most of which was not accomplished without imminent risk of life. The widest portion *viz.*, 17 miles of this

belt consists entirely of a wild and uninhabited valley called the Rishiganga, at the head of which is the Nanda Doví mountain 25,669 feet high. This valley is extremely precipitous and broken; the ground beyond the first 7 or 8 miles consisting of bare rocks, snow-beds and glaciers, with no signs of vegetation. The hills fall abruptly down to the river which dashes like a torrent between perpendicular walls of rock, which form its banks.

"No. 3 Zone consists of from 6 to 7 miles of spurs emanating from the foot of the snowy ranges and running mostly in a southerly direction. The average height of these spurs is about 12,000 feet above sea level; they are composed partly of stratified gneiss and partly of crystallized lime-stone, the former occurring about 4 miles towards the north and the latter about 3 miles towards the south. In consequence of the stratified nature of their formation, the spurs are, as a rule, precipitous on one side and sloping on the other. The surveyors working among them had no difficulty therefore in getting about.

"The operations of the snow party under my direction were almost entirely confined to ground in the above three zones. It may be thought perhaps that to treat similarly the remaining portion of Kumaun and Garhwál previously surveyed, would be irrelevant to this report. In order however not to leave the subject in an incomplete form, I shall proceed in a cursory manner with the description of the remaining zones.

"No. 4 Zone is by far the broadest; it averages about 50 miles, and the average height of the ranges in it is about 7,000 feet above sea level. The differences however between the heights of contiguous spurs are so trifling, that to one looking at the whole of this belt of country from a commanding point, all the ranges would appear to be nearly of one uniform height, no great contrast is to be seen anywhere. The width of this zone is greatest in Kumaun and least in Garhwál. From any point in the middle of this zone and from its southern extremities, the snowy ranges appear to rise very abruptly and seem to gird its northern limits like an immense wall, towering about 12,000 feet above it. Unlike the mountains found in most parts of the Himalayas, as far as I have seen of them, the mountains in this 4th zone appear to be much waterworn and so present very minute and intricate features. They have given topographical surveyors much hard work, entailing upon them at the same time the exercise of much judgement as to what detail should be suppressed, in order to make room for expressing the more important features. With the exception of some portions lying towards the north which is of gneiss, the principal formations are of lime-stone, slate, mica-schist and quartzose rocks.

"No. 5 Zone. This might be called the Siwalik formation of Kumaun and Garhwál. Kumaun has very little of it, the widest part in it lies to the west of Káládhúngi where it is about 8 miles. To the east of Káládhúngi this formation loses much of its Siwalik like aspect, and might be termed simply a sand-stone range, of an average height of about 4,000 feet having an average width of about 5 miles. Garhwál however has the largest share of this sand-stone formation. The widest tract of the sand-stone country in this district, consists of the Patli and Kotli Dúns, which average in breadth about 12 miles, inclusive of the outer ranges girding them. The average height of the ranges in this last or sand-stone zone, with the exception of that noted as lying in Kumaun to the east of Káládhúngi, is about 2,000 feet above sea level.

Mr. McAFee. "Mr. McAFee was entrusted with the triangulation of the country about Choudans, which lies at the foot of the Dharma and Byáns Valleys. He succeeded with praiseworthy application in getting through about 600 square miles of triangulation by 24th November, when he closed work and retraced his steps to Naini Tal.

Mr. Litchfield. "Mr Litchfield was deputed to take up the Plane Tabling of the southern half of the Níti Valley and of the valley of the Rishiganga river, a description of which has been already given. On completing these sections he was directed to resume work in the higher valleys of the Pindar river. He accomplished the work allotted to him in a very creditable manner but not without undergoing great exposure and privations especially in the Rishiganga Valley, the survey of which is perhaps the most formidable undertaking in the whole range of the Himalayas yet accomplished. The amount of his field work consisted in sketching an area of 837 square miles. Considering the quantity and quality of his sketching, he deserves much credit for his successful labours.

Mr. I. Pocock. "Mr. I. Pocock was entrusted first with the sketching of the upper portion of the Mána Valley, in sections 21, 22 and 29, which he successfully completed by 5th October.

"Mr. Pocock's survey of this portion of the Mána Valley, was a most arduous and enterprising feat for which he deserves much commendation. On the completion of this piece of work Mr. Pocock was directed to resume the sketching of the Jowar Valley, which he had been obliged to relinquish

in the beginning of July owing to the inclemency of the weather. After doing this, he completed section 63 and a portion of 62 lying on the eastern frontier of Kumaun from which he made a reconnoissance of the Nepal border. He then retraced his steps towards Rudrprayág in Garhwál, to sketch a small portion belonging to section 8, which had been inadvertently omitted when the survey of that part of the country was done. Advantage was taken of this opportunity to provide Mr. Pocock with aneroid barometers, for the determination of heights of places along his route from Almora *viâ* Srinagar through Tihri-Garhwál to Landour.

"Mr. Pocock after an arduous field season closed work on 20th March and arrived at Dehra on 31st March.

Mr. McCarthy.

"From what I could learn of the ground in the Niti Valley, I formed an opinion that the upper portion was, though very lofty, yet comparatively easy to survey; I therefore made over this portion to Mr. McCarthy, as he was the least experienced hand in the party. He accomplished the undertaking with credit, for it was accurate. His rendering of the ground, as far as giving adequate expression to the features, was however very poor.

"I have good reason to anticipate that more than ordinary difficulties will be met with in the north-eastern frontier of Kumaun in the valleys of Dharma and Byáns, the survey of which remains to be done. Their inhabitants are notorious for rascality and drunkenness, in fact they are little better than mere savages, and their proximity to the Nepal and Tibetan frontiers, renders them a very difficult people to deal with."

Out-turn of work.

(27). The area topographically surveyed on the scale of 1-inch to the mile, comprises 2,176 square miles and the portion of country triangulated covers 800 square miles. I cannot abstain from drawing particular attention to the survey of the upper part of the Mána Valley, a most difficult undertaking successfully performed by Mr. I. Pocock. In an area of 108 square miles, the average height of the ground surveyed was over 21,000 feet, the average height of the Plane Table stations was 19,500 feet and the maximum height visited by Mr. Pocock was 22,040 feet above sea level. This value was obtained differentially by observations of the boiling point at the place itself and at a trigonometrical station of known height, and approximates to the greatest height reached on any mountain by man. The Messrs. Schlagentweit in 1855, *Vide* their Vol. II, India and High Asia, ascended the flanks of this same mountain, Kamet (their Ibi Gámin), to a height of 22,259 feet, on an undefined spot, the height of which they obtained from observations with a mountain barometer, and Mr. W. H. Johnson in the report of the survey operations in Kashmir for 1863-64, is said to have visited a point "upwards of 23,000 feet above the sea". The whole of the topographical work was in very elevated regions and the ground in which Messrs. Litchfield and McCarthy were employed, was not very far below that of Mr. Pocock's in point of height. In these barren and inhospitable regions, besides the natural physical difficulties which were in themselves very trying, the commissariat arrangements were a source of much anxiety. On considering the trials of such an enterprise, the risks that must have been incurred in ascending mountains of such stupendous height and in traversing glaciers, the physical exertions in such rarefied air and the exposure to extreme cold, I think it will be admitted that these operations were of a most arduous nature and that Mr. Ryall and the Assistants employed under him are deserving of great praise for their energy and determination in overcoming such difficulties.

Recess of 1875.

(28.) During the recess this portion of the party was engaged in the computations of the snow triangulation and in the preparation of the fair maps of the Kumaun and Garhwál Survey. The following sheets have been completed and submitted to the Photozincographic Office for publication.

Skeleton sheets Nos. VI (2nd edition) XI, XII, XIX, XX, XXI, XXII, XXIII, XXXI, XXXVIII.

Shaded sheets Nos. XII, XXII, XXXVIII.

78° 0′ 78° 15′ 78° 30′ 78° 45′ 79° 0′ 79° 15′ 79° 30′ 79° 45′

31° 15′ 31° 0′ 30° 45′ 30° 30′ 30° 15′ 30° 0′ 29° 45′ 29° 30′ 29° 15′ 29° 0′

Part of NÁRI-KHORSUM or Chinese Tibet

Sutlej River

X 20 Mána Pass 18000

Gangotri

III 6 13 XI 21 29 XIX 37 Niti Pass 16570 45 XXVII

Vishnuganga River

Niti

TIHRI GARHWÁL

Kedarnath

Badrinath

IV 7 14 XII 22 30 XX 38 46 XXVIII 54

Madimaheswar

Unta dhura P. 17770

Bhagirathi R.

Uklimath

Joshimath

Dhauli River

Alaknanda R.

Lanpiya dhura 18000

Milam

V 8 15 XIII 23 31 XXI 39 Nanda Devi 25669 47 XXIX 55 61 XXXVI 64

Bhilangana R.

Philang R.

TIHRI

Mandakini R.

Rudrprayág

△Trisul 23406

Karnprayág

SRINAGAR

Deoprayág

Pauri

I 1 Tapoban 3 VI 9 Chaulghát D.B. 16 XIV 24 32 XXII 40 48 XXX 56 62 XXXVII 65

Lohba D.B.

Pindar River

Káimur

Ganges River

Nayár River

HARDWÁR

II 4 VII 10 17 XV 25 Ganai 33 XXIII 41 Baijnath 49 XXXI 57 63 XXXVIII

Bágesar

Ramganga River

Gori River

Kali River

Askot

Dwarahath D.B.

Kotdwara

Bmsar

Sarju River

RANIKHET

5 VIII 11 Rámganga R. 18 XVI 26 34 XXIV ALMORA 42 50 XXXII 58

Kosi or Kosila River

Pithorágarh

NAJIBABAD

Rámeswar

Kálágarh

Bajan

Pacheswar

Loha ghát

IX 12 Lohdhung R. 19 RÁMNAGAR XVII Kotah 27 Naini Tal 35 XXV 43 51 XXXIII 59

BIJNOR

Champáwat

Kali R.

Káladhúngi

Gola River

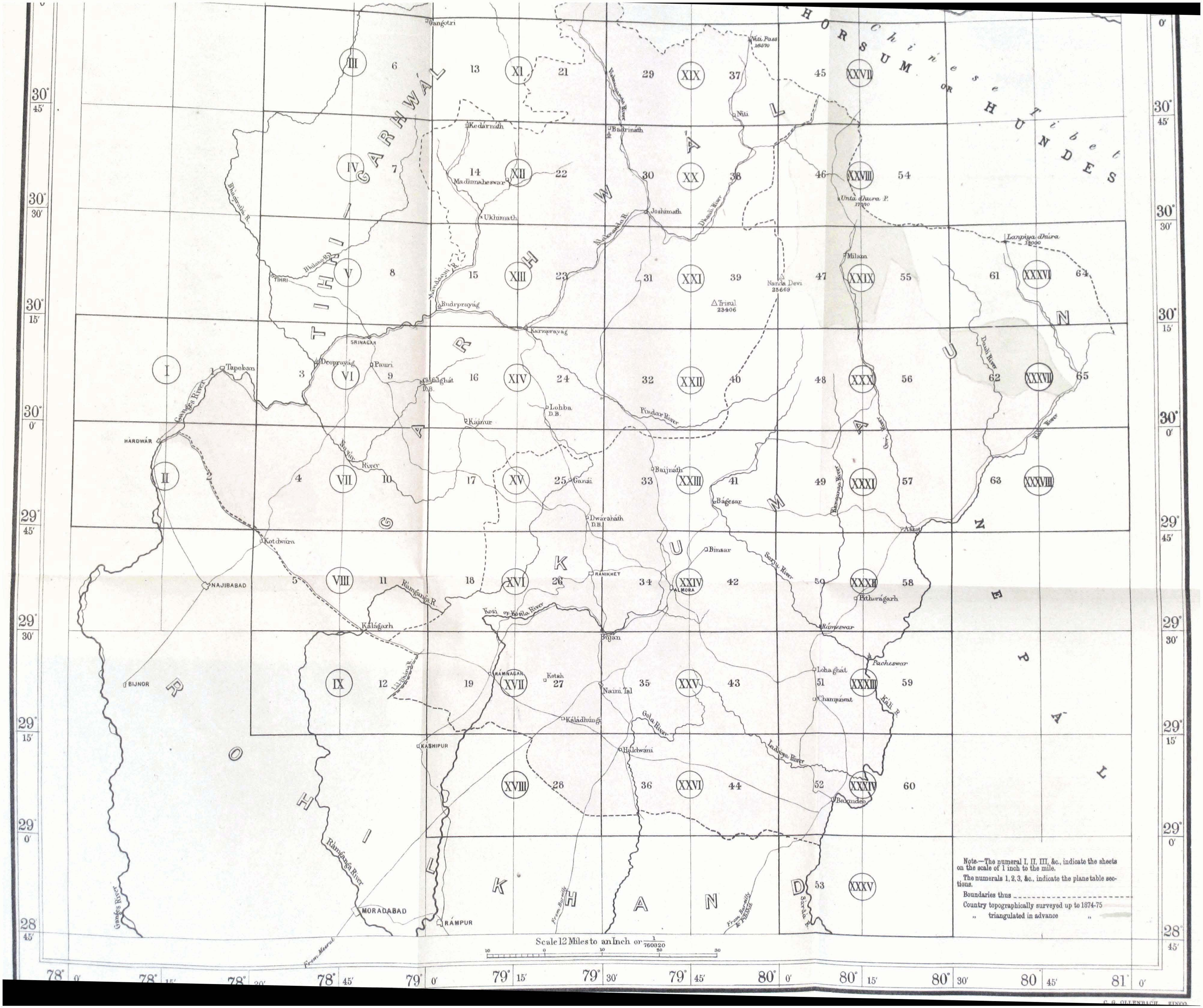
KASHIPUR

Haldwani

Ladhiya River

XVIII 28 36 XXVI 44 52 XXXIV Baramdeo 60

Note.—The numeral I, II, III, &c., indicate the sheets on the scale of 1 inch to the mile.



GARHWÁL
TIHRI
KUMAON
HORSUM or HUNDES
Chinese Tibet
NEPAL
ROHILKHAND
Gangotri
Kedárnáth
Badrinath
Madimaheswar
Ukhimath
Joshimath
Niti Pass 16570
Niti
Unta dhura P. 17350
Lanpiya dhura 18000
Milam
Nanda Devi 25669
Trisul 23406
Tihri
Rudrprayág
Karnprayág
Srinagar
Deoprayág
Pauri
Chipalghát D.B.
Lohba D.B.
Kainur
Tapoban
Hardwár
Ganges River
Bhagirathi R.
Bhilangna R.
Mandágini R.
Alaknanda R.
Vishnuganga River
Dhauli River
Pindar River
Nayár River
Baijnáth
Gansái
Bágesar
Dwárahath D.B.
Binsar
Ranikhet
Almora
Sarju River
Ramganga River
Askot
Pithorágarh
Rámeswar
Pacheswar
Kotdwára
Najibabad
Kálágarh
Rámganga R.
Kosi or Kosila River
Sujan
Ramnagar
Kotah
Naini Tal
Kaladhungi
Gola River
Haldwáni
Lohaghát
Champávat
Káli R.
Ladhiya River
Barmdeo
Bijnor
Kashipur
Moradabad
Rámpur
Rámganga River
Sarda R.
From Meerut
From Bareilly
From Bareilly & Pilibhit
Note.—The numeral I, II, III, &c., indicate the sheets on the scale of 1 inch to the mile.
The numerals 1, 2, 3, &c., indicate the plane table sections.
Boundaries thus
Country topographically surveyed up to 1874-75
„ triangulated in advance „
Scale 12 Miles to an Inch or 1/760320
10 0 10 20 30
78° 0′ 78° 15′ 78° 30′ 78° 45′ 79° 0′ 79° 15′ 79° 30′ 79° 45′ 80° 0′ 80° 15′ 80° 30′ 80° 45′ 81° 0′
30° 45′ 30° 30′ 30° 15′ 30° 0′ 29° 45′ 29° 30′ 29° 15′ 29° 0′ 28° 45′
C. G. OLLENBACH ZINCO.

KUMAUN AND GARHWAL SURVEY.

Tabular statement of out-turn of work. Season 1874-75.

Details of Triangulation.

Observer's Names.	Area of triangulation in square miles.	Number of stations visited.	Number of triangles completed.	Number of intersected points fixed.	Number of points whose heights have been determined.	Average altitude in feet above sea level of stations visited.	Remarks.
Mr. E. C. Ryall, ...	200	*5	†5	0	5	13,300	* Mr. McAFee assisted Mr. Ryall by taking observations at 3 of the base stations. The area about 50 square miles embraced by these stations has been included in the out-turn shewn against Mr. McAFee.
Mr. C. H. McA'Fee, ...	600	21	18	56	40	11,500	† Angles observed at 2 of the forward stations during previous field season contribute towards making up this number.
Totals, ...	800	26	23	56	45	...	

Details of Topography. Scale 1 *inch*=1 *mile.*

Names.	Area surveyed in square miles.	Average number of Plane Table stations per square mile.	In feet above sea level.			Area of glaciers in square miles.	Remarks.
			Average height of ground surveyed.	Average height of Plane-Table stations.	Maximum height of points visited.		
Mr. E. F. Litchfield,	309	0·30	20,000	17,500	19,200	55	Very rugged and precipitous ground, principally in the Rishiganga Valley. Includes 50 square miles of reconnoissance of the eastern portion of that valley.
	348	0·40	17,000	15,000	17,000	12	About the upper sources of the Pindar river. Ground partly very rugged.
	180	0·60	12,500	11,000	15,000	...	About the lower parts of the Pindar and Rámganga Valleys; ground easy.
„ I. S. Pocock,	108	0·50	21,200	19,500	22,040	49	Bold high ground in the upper part of the Mána Valley, culminating in some of the loftiest Himalayan peaks.
	614	0·90	12,500	11,500	14,500	11	About Jowar and Choudans; ground easy. Includes 187 square miles of reconnoissance of the Nepal border.
	2	†4·00	†2,800	†2,100	3,500	...	About Rudrprayág on the Alaknanda river; ground easy, details very intricate.
„ J. F. McCarthy,	330	0·94	20,500	18,000	20,500	41	Bold and commanding ground about the upper parts of the Niti Valley, partly precipitous and partly undulating.
	305	1·10	18,000	12,500	15,000	...	Chiefly to the east and west of Joshimath; ground partly rugged and generally otherwise.
	2178	*0·68	*17,400	*15,000	...	168	* These averages do not include the quantities marked thus †.

Extract from the Narrative Report—dated 15th July 1875—of Captain J. R. McCULLAGH, R.E., Officiating Assistant Superintendent 1st Grade, in charge Leveling Party.

Movements of the party.

(2.) On the 30th November 1874 operations were commenced at the S. W. end of the Bangalore Base, and the point of origin to which the heights of all the Bench-marks are referred, is the metal plate in the floor of the observatory at or about ground level. The trigonometrical value of this has been taken at 3117·775 feet.

(3.) From this the line of levels was carried *viâ* Túmkúr, Sira, Hiriyur Tallak and Rámpur to Honúr H. S. and into Bellary, continued *viâ* Alúr, Adoni, Mádawáram; and the season's work was closed at Raichore Railway Station on the 3rd April 1875.

(4.) On the 5th the return march, about 257 miles in length, was commenced and the party reached Bangalore on the 30th April.

Conduct of the operations.

(5.) Before commencing operations the collimation of the levels was adjusted; it was again examined on the 1st February and finally tested on completion of the work, when one level was found to be almost in perfect adjustment and the other only very slightly thrown out.

(6.) The staves were compared with the portable standard bar on the 9th December, on the 1st February and finally on the 3rd April, the day on which work was closed.

(7.) Throughout the season the rules and instructions laid down for the conduct of leveling operations, were strictly adhered to.

Nature of the country.

(8.) From a short distance out of Bangalore, the general appearance of the country passed through is bare, uninteresting and far from picturesque; although it is decidedly undulating, and might in some places be called hilly, until the neighbourhood of Bellary is approached, but from that on to Raichore there is not much to complain of in the way of impediment to leveling.

(9.) For the first 18 sections the sum of the rises and falls, passed over by the staves, gives an average of 65·7 feet per mile; up to section 42 this was slightly reduced being 60·3 feet. As far as section 59 it becomes 55·1 feet; and over the whole line the average rise and fall stands at 47·9 feet per mile.

(10.) During the operations the roads were kept to as far as possible, but the line was carried across country for a distance of about 33 miles.

(11.) The Haggri and Tungabhadra rivers were met with, and had to be crossed; the former three times, first by a bridge at Hiriyur, secondly about five miles from Honúr H. S. where there was not much water, but over a mile of deep sand, and thirdly at Moka village, where also there was little water but again about a mile and a half of very heavy sand in the river bed.

(12.) The Tungabhadra, at Mádawáram village, was a somewhat more formidable obstacle, being about half a mile across with high steep banks; the waterway was some 25 to 30 chains in width, but fortunately there were islands (of sand) which were capable of being made use of by taking a zigzag course.

Weather and its influence on the health of the party.

(13.) During the months of December and January, the nights and early mornings were very raw and cold, and heavy mists hung about until the sun was well up. From the middle of February it began to get warm, and before the close of the working season it was decidedly hot weather.

Out-turn of work.

(20.) The following is the out-turn of work for the season: 297 miles of double leveling embracing the determination of the heights of 210 Permanent Bench-marks, buildings, temples &c., &c; 2 Trigonometrical stations, Honúr H. S. and Bandúr Z. D. S. of the Great Arc Series; also the G. T. S. Bench-mark at the Mainwaring tank, Bellary, laid down by Lieutenant Harman, R.E., in the previous season; the "level of top of rails" at Bellary, Adoni and Raichore Railway Stations; 8 Bench-marks of the Public Works Department; and 16 Boundary pillars of the Revenue Survey.

At Raichore the usual G. T. S. Bench-mark has been engraved on the rock *in sitû*, the position being indicated by a paka pillar, in a situation, outside the Railway Station Compound, convenient for the resumption of the leveling operations at any future time.

(21.) The computations are now complete and the following table shows a comparison between the determinations of height of a few of the points connected as obtained by G. T. S. Triangulation, G. T. S. Spirit Leveling, and the Madras and G. I. P. Railway Departments.

Office duties.

SITES.	Heights.	REMARKS.
S. W. end of the Bangalore Base,	3117·775	Origin of the spirit leveling operations season 1874-75, to which the values of all the Bench-marks are referred.
Bandúr Z. D. S., ...	1452 1452·075	By triangulation. „ spirit leveling.
Honúr H. S., ...	1583 1583·460	„ triangulation. „ spirit leveling.
Bellary, (Level of top of rails), ...	1484·16 1486·879	„ Madras Railway. From sea level at Madras. „ spirit leveling.
Adoni, (Level of top of rails), ...	1364·35 1368·193	„ Madras Railway. „ spirit leveling.
Raichore, (Level of top of rails),	1311·21 1314·83 1315·517	„ Madras Railway. „ G. I. P. Railway. From sea level at Bombay. „ spirit leveling.

Extract from the Narrative Report—dated 4th August 1875—of Captain A. W. BAIRD, R.E., Officiating Assistant Superintendent 1st Grade, in charge Tidal and Leveling Party.

(2.) When I visited Hanstal Tidal Station in August 1874, I found that there was a considerable deposit of fine mud in the small pipe in connection with the cylinder: this caused a slight retardation in the flow of the water from the sea to the cylinder and *vice versâ*. This of course had to be rectified as soon as possible; the cleaning out of the pipe was a difficult job, and Mr. Rendell completed it in a satisfactory manner, without losing more than a day or two of the work of the Self Registering Tide Gauge. When every thing was again in thorough working order, Mr. Rendell left with his detachment for Nawanár Tidal Station to await my arrival.

The inspecting party at Hanstal Tidal Station.

(3.) Having made all preparations for commencing leveling operations, I took the field with the greater part of the Native Establishment on the 16th October and marched direct for Jorya. On my arrival there I at once engaged native boats to convey us across the Gulf to Mundra. We reached Mundra on the 21st October and camped there.

Remainder of party take the field and cross to Cutch.

(4.) I visited Nawanár Tidal Station as soon as possible after my arrival at Mundra, and found Mr. Rendell engaged in the repairs of the platform round the observatory, which had suffered considerably from the heavy seas during the monsoon, since I had inspected the station in July.

Visit Nawanár Tidal Station.

(5.) Having examined the foreshore at Nawanár, I saw that nothing could be done as yet towards getting up the small iron pipe and the flexible pipe, as the sand bank had rather increased than otherwise, since I had last seen it. I could also trace a very decided difference in the configuration of the spit at the point where the creek joins the sea; so that I had hopes in 2 or 3 weeks that the bank would be washed down sufficiently for the pipe to be taken up, and moreover the wind was blowing strongly from the north which would drive the sand back along the coast. I then gave Mr. Rendell instructions for his work during the field season—that he should wait at Nawanár for a week or two and try to put the station in order as soon as possible, then take up the inspection of the observatories in turn, and generally keep the stations in working order. The daily morning reports from the stations came to my office during the whole field season. In this way Mr. Rendell was enabled to work advantageously: and at the same time I was kept informed of what was going on at each station, while I conducted the leveling operations.

Programme of work for field season.

Leveling operations.

(8.) The country between Nawanár Tidal Station and the mainland proper, is more or less a mud swamp or *Small Runn*, and is covered at the high tides of the 2 or 3 days following every new and full moon. I had therefore to wait until the very *low high tides* which would occur about the 2 days following the "Moon's first quarter" in order to drive the levels across this treacherous bit of ground satisfactorily.

(10.) While waiting to begin work, I had several iron pegs with flat plates fixed on the top, constructed to place the legs of the Level Stand upon, when working over shaky ground. I was in hopes that I should then be able to isolate the instrument to a certain extent, and so lessen the tendency of the bubble to move when reading the scale after the staff had been observed. To a certain extent this answered, but I soon became aware how futile this plan was, for the ground was painfully difficult to level over. I saw that I must modify the routine of working in order to obtain thoroughly good results of the leveling and at the same time get over a respectable distance per diem.

(11.) I therefore arranged that the second leveler should read the bubble scale, after I had observed the staff, while I actually had my eye at the instrument (for the slightest movement would have caused the bubble to move 4 or 5 divisions and perhaps one end to disappear altogether). I read the levels in the same way for the second leveler, while he observed with his level. Even with all this care, on this ground, and when crossing the portions on the Runn proper, we had often to take several sets of observations before they were perfectly satisfactory.

Range of the leveling operations.

(13.) The leveling operations were to be carried out in two sections, the first from Nawanár Tidal Station along the Cutch coast, across the Runn between Shikarpúr and Málliá, then along the Kattywar coast to Balumba, thence over another portion of the Runn to Hanstal Tidal Station. The second series to commence at Hanstal Tidal Station across the Runn to Jorya and thence along the Kattywar coast of the Gulf and across the small Runn of Okhá Mandal to Okhá Tidal Station opposite the Island of Bet. Branch lines of course were to be taken to such Trigonometrical Stations as were conveniently near the main line of levels. The Bench-mark stones properly cut had been laid down the previous year (3 at each Tidal Station) and the others about 10 miles apart along the route, and these had also been laid down with reference to the Trigonometrical Stations to be connected.

Nature of country on the Cutch side up to the Runn.

(14.) From Mundra to Shikarpúr the line to be leveled over was distant from the Gulf from 5 miles at Mundra to 15 miles at Anjár; the country was tolerably flat till within a short distance of Anjár, where we met with some steep hills and then descended again to about the same relative level as near Mundra. From Anjár the ground continued flat for a few miles and then became undulating almost right away to Shikarpúr. From Anjár to Shikarpúr the coast line (if I may use that expression for the demarcation between the mainland and the Runn) was from 5 to 7 miles distant from the line of leveling. One peculiar feature in the roads in Cutch, along which we took our levels, is that they are as a rule 2 or 3 feet and in some cases 5 feet below the general surface of the country in the immediate vicinity. I was more particularly struck with this when I had to visit Nawanár in the monsoon last year, for the roads then appeared more like small canals than anything else.

Great Trigonometrical Stations in Cutch connected.

(15.) The Trigonometrical Stations in Cutch which I connected were found to be in first-rate repair, and as they had been constructed more than 20 years previous to the time we visited them, it shows that with ordinary precautions on the part of the Native Authorities, our Survey marks ought to remain in perfect preservation. The stations I visited were either on the tops of hills or of some very high towers in the principal towns. I may mention that it took me the whole of a day and working as rapidly as possible to connect Butchow H.S., a distance of about ¼ of a mile from our main line.

Country on either side of the Runn between Shikarpúr and Málliá.

(16.) Between Shikarpúr and the Runn the country is almost entirely uncultivated, and there is a series of hillocks composed of fine black sand which are covered with dense vegetation. These hillocks appear to be moveable; they are dotted here and there over the plain, but the hillocks in the immediate vicinity of the Runn here are tolerably high, and form an almost uninterrupted chain for a mile or two to the west and running nearly parallel to the general line of the Runn.

On the Kattywar side opposite there are no hillocks but a tract of waste land for one or two miles which is cut up by a great number of Nullahs, then we find a mile or two of cultivated fields occupied by the "Meanas" (who are considered a race of professional thieves).

The Meanas

The villages of these Meanas are scattered all over the country here, and there are some 200 of them near the town of Málliá. Each village consists of a few straw huts surrounded by a straw hedge, and

the flag of the headman of the village, is conspicuous in each case on a long bamboo stuck into the ground in front of his hut. These Meanas are considered most troublesome people by the Officers of the Political Agency.

The Runn between Málliá and Shikarpúr.

(17.) The Runn itself between Shikarpúr on the Cutch side and Málliá on the Kattywar side, is some 8 miles across; but of this only about 6 miles can be used for the determination of the general level of the Runn, as the ground close to the mainland on each side is from a foot to 18 inches higher.

There are two Bench-marks enclosed in large blocks of masonry in the Runn itself, and situated about one mile on either side of the centre line of the Runn. These Bench-marks were laid down about 10 months before the leveling operations were commenced, and had plenty of time to settle. This part of the Runn is perfectly dry from November till the end of March, but about the end of April or beginning of May, it is covered by the water from the extraordinary high tides, and the water is also forced up by very high south-westerly winds which always prevail at that time. The Hanstal creek, being almost like a funnel at the end of the Gulf, is acted on by the full force of this wind, and the water from the Gulf is thus conveyed far up the Runn.

The ground over which we leveled was almost quite dry and has the usual appearance, blackish grey colour with here and there patches of glistening white from the salt deposited after evaporation.

Arrangements for getting a true value of the level of the Runn at each point where staff was put up. Also for fixing the line of levels so that it could be re-leveled over the same points in future.

(18.) I deemed it a necessary precaution in leveling over the Runn both here and afterwards that the lines should be driven in a perfectly straight direction from point to point, and also that at each point where the staff was put up, I should get an exact value of the ground immediately round that point. Accordingly starting from the Bench-mark on the Runn nearer the Cutch coast, we leveled in a direct line to a point on the sand hill close to which there is a Bench-mark on the Cutch coast, *viz.*, Pathewalla Dhoi. Again the next line was taken directly between the two Bench-marks on the Runn, and a third section from the Bench-mark nearer the Kattywar coast direct to a point on the Kattywar mainland and closing on Bench-mark No. 2 Málliá.

At each point where a value of the level of the Runn was to be determined, the Muccadum was ordered to drive the pegs (very large ones) into the ground until the top was just flush with the surface; this he tested by a mason's level which he carried in his hand, the brad was then put in and he scraped away the earth all round to a depth of about ½ an inch from the surface to allow the staff to turn freely: thus the level of every point on the Runn where the staff was put up will be evaluated.

Málliá to Balumba.

(19.) The country from Málliá to Balumba is almost entirely black soil and tolerably flat, and one or two pretty large streams had to be crossed.

The Runn from Balumba to Hanstal Tidal Station.

(20.) There are no Bench-marks between Balumba B.M. and Hanstal Tidal Station. The first 4 miles is across cultivated fields intersected by Nullahs, in most cases filled with fresh water. Having carried the line into the Runn, I made similar arrangements for determining the value of the different points where the staves were erected as before.

The work on the Runn as affected by the atmosphere.

(21.) In the very early morning the observations on the Runn are very satisfactory, every thing is so very clear, but after 9 o'clock, even in the cold weather, it is almost impossible to work except at ridiculously short distances, unless perhaps on a very cloudy day; on a clear day about noon and up to 4 P.M., the atmosphere has the appearance of water boiling hard, and taking observations at that time is of course out of the question. A heliotrope seen at a short distance looks like an immense flame of fire. Even at a mile distant everything seems doubled above and reflected underneath as well. Small scrub not more than 6 inches or a foot high look immense bushes, and in one place between Hanstal and Jorya, there is a patch of this about a mile across, which may be considered as well defined a feature on the Runn as a forest on a plain.

The first section closing at Hanstal Tidal Station.

(22.) The first section of leveling operations closed on the 3rd Bench-mark at Hanstal Tidal Station and finally on the planed surface of the bed plate of the S. R. T. Gauge.

The second section, Hanstal Tidal Station to Okhá, commenced: and the Runn from Hanstal to Jorya leveled over.

(23.) Having inspected the work at Hanstal Tidal Station, which was found satisfactory, and having seen Mr. Rendell at Jorya and made arrangements for getting up some extra piping from Bombay for Nawanár Tidal Station according to your wishes in order that 2 months work might be carried out for that station, from 7th March to 7th May, I again returned to

Hanstal and commenced the second section, Hanstal to Okhá. The origin was again the planed surface of the bed plate of S. R. T. Gauge. Similar arrangements were made as formerly for the Runn and we had some 14 miles of it to determine between Hanstal Tidal Station and Somarthal B.M. There are also 2 Trigonometrical Stations of the net-work series of the Kattywar party on this line. These served as closing and re-starting points for each day's work, and their heights were of course determined. From Somarthal B.M., the ground is slightly undulating, and within 1 mile of Jorya, is cultivated. Jorya T.S. was connected and also a Branch line of (10 miles) was taken to Haditada H.S., a principal station.

Jorya to Gúrgut close to the Runn of Okhá Mandal.

(24.) The line from Jorya to Okhá Tidal Station was taken *viâ* Nawánagar and Khambhália to Gúrgut which is on the Kattywar side of the Runn of Okhá Mandal. The country as a rule was pretty flat with the usual cotton soil up to about 7 miles from Khambhália when it began to be hilly and the ground very hard and rocky. From Khambhália also to Gúrgut it was undulating and hilly the whole way. One or two rivers had to be crossed on this line; they were of course almost dried up at the time we were working.

The Runn of Okhá Mandal.

(26) The line of levels after passing Gúrgut had to be taken across the Runn of Okhá Mandal to Topni Ness B.M. in Okhá Mandal. This Runn which is about 2 miles broad, extends from the gulf of Cutch right away the whole length of Okhá Mandal, and is only separated from the open sea by a strip of sand hillocks about $\frac{3}{4}$ of a mile long and from 200 to 300 yards broad. The Runn therefore causes the Okhá Mandal to be a small peninsula joined to Kattywar by the strip of sand bank above mentioned, close to the village of Madi.

From Topni Ness to Okhá Tidal Station.

(27.) Close to the Runn the ground is very steep and rocky. About a mile further on, it becomes undulating and then tolerably flat right away to Okhá Tidal Station. A great number of coral beds are exposed on the surface between Armra and Okhá Tidal Station; this evidently shows that at a not very distant period it must have been covered by the sea. Okhá Tidal Station is situated at the end of the peninsula and at the point where the gulf joins the sea. I have described it in a former report.

Closed leveling operations at Okhá Tidal Station.

(28.) The leveling operations were completed and closed on the 3 Bench-marks at Okhá Tidal Station and the S. R. T. Gauge bed plate as at Hanstal.

March to Dwárka. Preparation for dismantling the Tidal Observatories.

(30.) Having closed leveling operations I marched to Dwárka and made arrangements with Mr. Rendell for dismantling the stations; and as you had ordered me to do all I could to get complete work from 7th March to 7th May out of Nawanár Tidal Station, and that the instruments at the other observatories should be kept working simultaneously, I arranged that Okhá Tidal Station should be the first dismantled and as soon after the 7th May as possible.

Okhá Tidal Station dismantled.

(33.) Previous to dismantling Okhá Tidal Station, I sent out the Kalassies who remained and some coolies to collect stones to build large mounds or platforms round the Bench-marks and the cylinder which you had ordered me to leave *in statu quo*. By the evening of the 15th of May the whole of the instruments and all the piping, except 50 feet in connection with the cylinder, were put on board the boat which was moved close by for the purpose. The cylinder had been emptied of water and dried out at the bottom (there was no sediment of any description here) and filled with clean dry sand. A thick wooden board closed the top (being secured by bolts and nuts) and an immense mound of stones was raised over it. On the 16th Mr. Rendell sailed for Nawanár to perform the dismantling of Nawanár Tidal Station which was done in exactly the same way as at Okhá.

Okhá Tidal Station as it was left.

(35.) On the day after Mr. Rendell sailed, I left Okhá Tidal Station for Dwárka. All that remained visible of the station being 4 immense mounds of stones. The station was handed over to the charge of the Assistant Resident at Dwárka.

Marched to Rájkot.

(36.) I now marched rapidly from Dwárka to Rájkot and started the office there, and a day or two afterwards went out to Hanstal Tidal Station where Mr. Rendell meanwhile had arrived to dismantle that station. I found he had completed every thing very satisfactorily.

Work during the recess up to date.

(37.) The duplicate sheets of the leveling operations have been completed and computed, but the abstracts cannot be made out until the level of origin at Nawanár Tidal Station above mean level of sea and also that of the closing points at Hanstal Tidal Station and Okhá Tidal Station have been determined. The Tidal diagrams

have all been carefully inked in; the time computations in duplicate have been brought up; and the correction of the diagrams for zero and for time is now in hand. Experiments for Index errors of thermometers and anemometers have also been completed.

Personnel of the Party.

(40.) Mr. Rendell has worked through the whole field season to my entire satisfaction. I have already reported that he is most useful to me in every way connected with the work at the tidal observatories. He has been most painstaking in carrying out everything I wished, and it is mainly owing to his care and vigilance that the work at Nawanár, for the 2 particular months you wished, has been successfully accomplished.

Nursing Dass has worked throughout the season the second level. He is a first rate leveler, a very quick and careful observer and does his work generally to my entire satisfaction and fully bears out the good name he has got from Officers under whom he has previously served.

Damoder Ramchundra, Dhondu Venayek and Shitaram Yeshwant have all worked well at the Tidal Observatories, and give promise of being very useful.

Out-turn of leveling operation.

(41.) The following statement shows the amount of leveling done by the party.

274½ miles on Main line by two independent levelers.
29¼ „ Branch „ „ „
38 Bench-marks, built in masonry platforms, connected.
17 Principal stations connected.
3 Minor stations „
45 Paka points duly inscribed and connected.

Assistance rendered by Political Officers.

(42.) I would again beg to report that I am much indebted to the Political Agents of Cutch and Kattywar and to the Assistant Resident at Dwárka for the assistance they have uniformly rendered me.

General success of the operations; completion of one part of the project.

(43.) In conclusion I think the Party may fairly be congratulated on the general success of the project in having secured both at Okhá and Hanstal Tidal Stations, complete sets of tidal combined with meteorological observations which will compare most favourably with what has been done both in England and America, and in having so far succeeded at Nawanár Tidal Station that the observations taken will be sufficient to evaluate (by differentiating with both Okhá and Hanstal which were working simultaneously) the principal data required.

The leveling operations combined with the tidal observations complete the work necessary for one part of the project and fix the level of about 30 miles of the Runn of Cutch for the season 1874-75, and a repetition of the work some 20 years hence will effectually settle the question of Secular Depression in this peculiar region.

Extract from the Narrative Report—dated 28th September 1875—of Captain W. M. CAMPBELL, R.E., Officiating Deputy Superintendent 2nd Grade, G. T. Survey, in charge Astronomical Party No. 2.

At the date of my last Annual Report, October 1873, I was employed in the reduction of the Electro-Longitude observations, made by Captain Herschel and myself during the preceding season 1872-73.

These reductions were so far complete that I was enabled to give the results of one measurement, that of the arc Bangalore-Mangalore, and subsequently, in time to be included in the General Report, an approximate value of Madras-Bangalore.

(2.) The prosecution of the field operations was suspended in consequence of Captain Herschel's taking furlough in August 1873, and the reductions were also stopped immediately after the submission of my report, because I was unexpectedly obliged to apply for six months furlough to Europe, which was granted.

(3.) I had some months previously been warned that my services would be placed at the disposal of Colonel Tennant for the observation of the Transit of Venus, from a date which was then uncertain.

While I was in England, I was put on duty to assist Colonel Strange in the preparation of the instruments intended for Colonel Tennant's use during the Transit. These formed a very full and handsome equipment, consisting of a 6-inch equatorial, a transit instrument, a photoheliograph, an astronomical clock and quadruple chronograph, all, with the exception of the photoheliograph, ordered from Messrs. Cooke & Sons at so late a date that there was great doubt as to their being got ready in time. I remained on this duty as long as I thought prudent, with a view to joining Colonel Tennant in time for all necessary preparations, and when I left England, the transit instrument and a small part of the equatorial were still in the makers' hands.

(4.) I joined Colonel Tennant at Roorkee on 29th September 1874, some of the instruments had then arrived and the rest came in gradually, all reaching us before the Transit took place. In addition to the special equipment above enumerated, Colonel Tennant had the loan of the new 36-inch theodolite, designed for the Great Trigonometrical Survey by Colonel Strange, which had just arrived from England, and he put it in my charge for the Transit. Our time was very fully occupied in preparations up to the day of the Transit.

(5.) My special duty during the event, was to note the times of all the contacts, and also, while the planet was within the sun's disc, to take chronographic transits of both limbs of the sun and planet over the wires of the theodolite, using the horizontal wires during the early part of the Transit, both sets alternately for a short time about the middle, and the vertical wires afterwards. I found the observation of contact with such an instrument very difficult, because the limbs approached, especially at egress, very slowly, and as practice with the model had shown the probability of the contact being suddenly completed by the formation of the "black drop", the momentary expectation of this lasted over minutes, during the whole of which the motion of the instrument both vertical and horizontal had to be maintained by the tangent screws.

During the Transit I never left the telescope, and secured a large number of the observations of sun and planet described above, which when reduced will afford so many determinations of the relative positions of the two.

(6.) With regard to the 36-inch theodolite, I may remark that it is a magnificent instrument, elaborated in its details to an unusual degree, and as far as I can judge, its performances are excellent. A theodolite, with its large horizontal circle and comparatively short telescope, cannot be a convenient instrument for astronomical work, but I envy the surveyor who may have to use this instrument for triangulation, if his work lies in a moderately level country, *compelling him to resort neither to the tops of high hills nor towers.*

(7.) I left Colonel Tennant in April, and proceeded for a short time to Head Quarters, for the purpose of discussing with the Superintendent the programme of operations during the ensuing field season, when it is intended that I should go on with the Electro-Longitude observations with Captain Heaviside, R.E. as my colleague. I then proceeded by Calcutta and Madras to resume my proper duty at Bangalore.

(8.) At Calcutta I had several consultations with Mr. Schwendler, Electrician of the Government Telegraph Department, on the subject of the electrical arrangements of our chronographs and the electrical portion of our work generally. I found him extremely obliging, and ready to assist me in undertaking experiments as to the chronographic arrangements under discussion, to which I shall refer again. I also obtained from him some useful general information, with reference to our operations.

(9.) I was engaged for nearly a fortnight at Madras in forwarding the determination of the difference of longitude between Roorkee and the Madras Observatory by the electric telegraph, which was required to enable Colonel Tennant to reduce his Transit of Venus observations.

(10.) After arrival at Bangalore it was a matter of some time to pick up the threads of the work, which had been in abeyance for more than a year and a half, and was of so novel a kind, that no cut and dried plan of procedure had been adopted. At first I had no assistance beyond that of my native writer and but little progress in the reduction was practicable. Since my reinforcement by Messrs. Keelan and Bond, the reductions have made rapid progress and are now nearly complete.

(11.) My own time has been very much occupied with the instrumental equipment. I would refer to my last report, and that of Captain Herschel, on this subject, which contain detailed descriptions of the equipment and the performances of its various parts. 1st, one of the transit telescopes was condemned, as being to a certain extent untrustworthy, owing to uncertainties in its line of collimation. 2nd, the electric arrangements of the chronograph were bitterly complained of by both of us, as giving endless trouble and anxiety to such a degree that up to the close of the season's work we could never safely reckon on getting through a night's observations without a hitch.

(12.) I first turned my attention to the faulty Transit, encouraged in the work by the fact that a similar failing in the Transit circle of the Cambridge Observatory, which was under investigation when I wrote my last report (*vide* para 20), had been since traced to bad soldering and corrected (*vide* Monthly Notices of Royal Astronomical Society for February 1875, page 186). The idea of such a cause, when suggested to my mind, commended itself as that which would best explain the effects we had observed, indeed it at once made clear what before was obscure. My first step was to carry out the process described as contemplated in my last report and by a little filing the reversal of the object half tube (*i.e.* revolution on its own axis through 180°) at its connection to the axis, was rendered possible.

Half an hour's observation of collimators then showed that the fault was in that part, because the errors previously observed remained identically the same, except that their signs were changed.

(13.) I then took the tube to Madras and showed it to Mr. Doderet, the Mathematical Instrument Maker to Government. When we examined it with a magnifying glass, signs of yielding round the base of the tube became apparent, and farther search showed that the tube had been spliced, in order probably to make it correspond to the focal length of the object glass after the latter had been ground. The existence of such patching must be considered sufficiently discreditable to makers of the rank of Messrs. Cooke & Son, and it was also imperfectly and clumsily executed. Very little doubt remained as to our having found the seat of the mischief, and Mr. Doderet, at my request, immediately took steps to strengthen the splicing and make it effectual.

(14.) When I received the tube from Madras and put the telescope through exactly the same course of observations as before, I found that the fault, if not absolutely, was practically eliminated, as I failed to discover any certain indication of what had previously been most gross quantities.

This result must be considered very satisfactory with regard to our future observations, and moreover, having now a clear knowledge of the nature of the old fault, it may be possible to amend the method by which the collimation and level corrections for the instrument were deduced during season 1872-73.

(15.) I next attacked the arrangements of the chronograph. As already remarked I had some consultation at Calcutta with Mr. Schwendler on this subject.

My object was, 1st, to get rid of the induction coils, involving the troublesome Bunsen Batteries, and frictional electricity, and 2nd, to throw aside also if possible all chemically prepared paper. I had several alternative schemes in view.

1st.—To record by lines traced on prepared paper by means of electric currents.

2nd.—To prick holes in the paper by mechanical means put in action by electric currents.

3rd.—To use pens drawing continuous lines, the signals being recorded by sudden jerks to one side caused by electric currents.

(16.) The arguments in favor of the first were theoretically greater instantaneity of signal record, and no change being required in the parts of the chronograph for its adoption. Against it, the necessity of prepared paper, very similar to what we had already found so objectionable, and the probable necessity for strong battery power. It was to perfect this method that Mr. Schwendler so kindly undertook to execute experiments.

The second method I was familiar with, being the same as that of Colonel Tennant's chronograph, and I knew it to be perfectly trustworthy and simple, but on the other hand the alteration of our chronographs to suit it would have been troublesome.

The last method I was already familiar with by description, as it is that generally used in America, and at Madras I had the opportunity of seeing it in practice in a small chronograph of Mr. Pogson's, the action of which was so very certain and satisfactory that I at once decided on adopting the principle if possible.

(17.) On examination of our chronographs I found the changes required would be very simple and easy, and our own apparatus contained the necessary parts of any importance, *viz.*, the electromagnets of the relays, which the adoption of the new method would throw out of use. I accordingly drew up a design which Mr. Doderet executed, with in some respects perfect success, and he has now in his hands an amended design, which I see no reason to doubt will prove quite satisfactory in every way.

(18.) The first attempt failed, because I was striving to obtain the double record of clock and observer (or two clocks) by means of only one pen, which would have had the great advantage of doing away with "style (or pen) equation".

After a good deal of experiment I was obliged to abandon this, finding that in order to obtain a satisfactory record, a somewhat radical change in our present means of producing the signals (breaking and making circuit) would be necessary, which I did not think the object justified me in attempting with the time and means at my disposal. The present design comprises two pens following each other on the paper, just as the styles did formerly.

My confidence in its being found to answer, is I think justified by the single record, already obtained from a similar pen, being as good as one could wish. The only change in the chronograph is, that the ebonite plate carrying the styles has been taken off the carriage, (see my last report para. 24) and a larger plate of wood substituted, on which are fitted two electro-magnets (taken from our old relays) and the pens, which project over the barrel just as the styles did, and trace exactly similar spiral lines.

(19.) This method does away with all the objectionable features of the old arrangement, and is as simple as can be easily imagined. There may be a slight loss of accuracy, but I doubt even this, and if it does occur it must be of the irregular kind which can cause no deterioration in the final results.

It has also the advantage of economy in saving expensive chemicals, as well as by reducing the amount of apparatus carried about. Lastly, a great deal may be often gained by the two observers exchanging telegraphic information, in doing which Captain Herschel and I constantly lost time by our inability and (common to all beginners in the art of signalling) to read as fast as we could signal.

With the pen recorder the message may be written on the chronograph and read off at comparative leisure.

(20.) There is another point in the equipment which has been much improved since our last field work, *viz.*, the collimators.

Those belonging to the Transits have only recently been received from England and are in every way superior to the ones formerly used, and they have an ingenious feature in their construction, by which any movement of the instrument on its pier (which must take place owing to difference of expansion and contraction under varying temperatures) is confined to the direction of the axis. This is likely to prove valuable, because with our field observatories the collimators are necessarily placed on pillars outside, without any adequate protection either from the heat of the sun or the cold at night.

(21.) The point is of importance chiefly with reference to the use of the collimators as meridional marks, which they never strictly are, because the deviation of the Transit instrument is determined independently every night. But if the collimators are appreciably stable, as I expect will prove to be the case (and as to which their mutual observations afford most searching evidence) they will provide the means of combining all the observations for deviation at a station, in order to get the error for each night. Our former experience shows that this, if obtainable, will prove a great advantage.

Extract from the Narrative Report—dated 23rd November 1875—of W. H. COLE, ESQ., M. A., Officiating Deputy Superintendent 3rd Grade, G. T. Survey, Officiating in charge Computing Office.

I have the honor to lay before you the report on the work performed by the Computing Office between the 1st May 1874—up to which date the last report details it—and the 1st October of this year, that is, for a period 5 months in excess of that usually reported on. This change is due to your having recently directed that Executive Officers should bring the narratives of their operations up to the end of the recess season, succeeding the field season to which they refer. I draw your attention to it, because were it not borne in mind, the out-turn of work I am about to detail would appear out of proportion to that of previous years.

CALCULATING BRANCH.

Final Reduction of the Triangulation.

(3.) The attention of this Branch has, whenever opportunity offered, been steadily directed to the final reduction of the triangulation of India and the publication of the results, and considerable progress has now been made. Of the five large sections into which you have divided the triangulation west of the Meridian of 89° three are now in hand, and I will endeavour to give you a general idea of the progress that has been made with each before stating the work of the Office in detail.

North-West Quadrilateral.

(4.) This division of the triangulation which extends over an area of about 475,000 square miles was in a very advanced state when reported on last year. All the principal triangulation had been reduced

Calculating Branch—(Continued).

and the results passed through the press, and one of the Synoptical Volumes—which give only such data of each series as are required for practical purposes—had been published, *viz.*, Volume I, or the Great Indus Series. Since that date four more Synoptical Volumes have been completed and published, *viz.*,

Vol. II. or the Great Arc Series, Section 24° to 30°.
Vol. III. „ Karáchi Longitudinal Series.
Vol. IV. „ Gurhágarh Meridional Series.
Vol. V. „ Rahún Meridional Series.

There still remain three series to complete this section of the triangulation, the Jogí-Tilá Meridional, Sutlej River and North-West Himalaya. The two former are in a very advanced state and will probably together form Volume VI of the Synoptical Volumes. I hope to send them to the binder in the course of two or three more weeks. The North-West Himalaya Series is ready for the press, but has to give place to other subjects more urgently required. It will be some months before it can be published; but nothing now remains to be done in connection with it by this branch of the office further than to superintend it through the press. It will be accompanied by several charts, most of which are drawn but have not yet been photozincographed.

South-East Quadrilateral.

(5.) This section of the triangulation of India, which is contained between the Meridians of 77° and 89° and the parallels of 17° and 24°, is that which you directed should be reduced second in order. Neglecting the two short triangulations of the South Párasnáth and South Malúncha Series, which were not executed with first class instruments, the Quadrilateral contains six chains of triangles forming three mutually dependent circuits. At its north-west corner it units with the N. W. Quadrilateral, the side Kámkhera to Bhaorása of the Sironj Base-line figure being common to both. The length and position of this side having been finally determined in the reduction of that Quadrilateral were considered invariable. At each of the other corners are base-lines, *viz.*, those of Calcutta, Vizagapatam and Bider. Its reduction necessitated finding the values of 831 unknown quantities, which should satisfy 292 equations of condition. 277 of the equations were however of such a form that an equal number of unknown quantities were readily eliminated and the undertaking was thus reduced to finding 554 unknown quantities to satisfy 15 equations, subject to the usual condition that the sum of the squares of the several quantities multiplied by their respective weights should be a minimum. Although the method of reduction was the same as that adopted for the North-West Quadrilateral, the experience gained from the latter has suggested many slight modifications in the details of the computations which have led to a considerable saving of labour. This has been further lightened to a very marked extent by the employment of Arithmometers, and I have now the satisfaction of reporting that not only has the principal triangulation been finally reduced and prepared for publication, but also that a large amount of secondary triangulation connected with it is in a far advanced state; that of the Great Arc, Section 18° to 24°, the Calcutta Longitudinal Series and the Coast Series is almost finished and only needs to be arranged for publication; that of the remaining series is in an advanced state. Thus in a few months nothing will remain but to pass the data through the press.

The following table contains the facts of computation of the Principal triangulation. In column (1) the 15 equations, which remained after the elimination of the unknown quantities above mentioned, are numbered in the order in which they were arranged for solution. Of these the first six are side equations, five of them being between base-lines, the measured lengths of which, have, for the purposes of reduction, been assumed as errorless. The sixth is a circuit equation. The remaining nine are all circuit equations in Latitude (λ) Longitude (L) and Azimuth (A). The circuits are shown by the letters in column (2) which have reference to the diagram. In column (3) are the absolute terms of the equations, or the errors which had to be dispersed between the base-lines or in the circuits. It should be stated that the terms in which the linear errors, *viz.*, those of the first six equations, are here expressed differ from those employed for the N. W. Quadrilateral which will be found tabulated on page 54—a of your report for 1870-71, the former being differences in the 7th place of logs and the latter similar differences divided by *Modulus* × *sin* 1″: the change is due to a simplification in the manner of expressing the co-efficients of the unknown quantities. The simultaneous solution of the equations involved finding the values of an equal number of indeterminate factors, and column (4) exhibits the accuracy with which this solution was performed, the quantities shown in it being obtained by substituting the deduced values of these factors in the normal equations. With the aid of the indeterminate factors, values of the angular errors involved in the equations of condition were found, at first to 5 places of decimals of seconds, and afterwards reduced to 3 places. These values being substituted in the equations produce the quantities given in columns (5) and (6), and their accordance with the quantities in

Calculating Branch—(Continued).

column (3) affords the second test which was applied to the accuracy of the calculation. These tests having been considered satisfactory the angular errors to 3 places were introduced into the computations and the corresponding corrections made: the last column exhibits the residual discrepancies which then remained.

With regard to the first six equations it should be stated that the calculations of the triangles have been made with tables of logarithms to 7 places of decimals only, an 8th place being obtained by interpolation, yet the discrepancies are at most only 4 in the 8th place of logs, and two of them cancel if the triangulation is considered continuous from the side Kámkhera to Bhaorasa *vid* Calcutta, to Vizagapatam. Furthermore, if a complete circuit is made starting from the side Kámkhera to Bhaorasa and carrying the calculation of the triangles round the whole periphery of the Quadrilateral, the value of the side of origin is reproduced identically to the eighth place of decimals of logs. The largest discrepancies in latitude and longitude still remaining are ″·005, or about 6 inches.

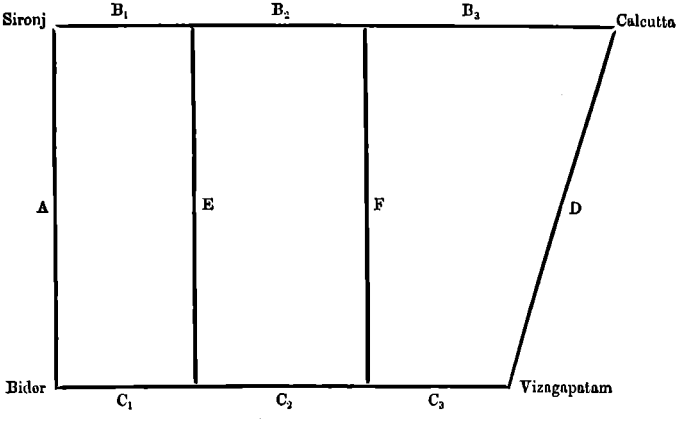


Table of the facts of computation.

No. of Equation	Triangulation involved		Value of circuit error: Before reduction	By substitution of "indeterminate factors"	By substitution of deduced angular errors: As computed to 5 decimals	By substitution of deduced angular errors: On contraction to 3 decimals	Residuals after correcting the angles
(1)	(2)		(3)	(4)	(5)	(6)	(7)
1	A	In 7th place of Logs.	− 16·44	− 16·439	− 16·441	− 16·439	0·0
2	$C_1-(B_1+E)$		− 54·86	− 54·860	− 54·859	− 54·864	+ 0·2
3	$B_1+B_2+B_3$		+ 42·5	+ 42·500	+ 42·500	+ 42·501	− 0·4
4	$C_1+C_2+C_3$		− 21·29	− 21·291	− 21·289	− 21·292	0·0
5	D		− 6·93	− 6·932	− 6·931	− 6·932	+ 0·4
6	$(E+C_2)-(B_2+F)$		+ 31·9	+ 31·900	+ 31·901	+ 31·902	+ 0·2
7 in λ	$(A+C_1)-(B_1+E)$	Natural Numbers	+ 0″·050	+ 0″·0500	+ 0″·0500	+ 0″·0500	− ″·002
8 „ L	Ditto		− 0·214	− 0·2140	− 0·2140	− 0·2139	− ·005
9 „ A	Ditto		+ 0·212	+ 0·2120	+ 0·2119	+ 0·2117	·000
10 „ λ	$(E+C_2)-(B_2+F)$		− 0·216	− 0·2160	− 0·2160	− 0·2160	− ·004
11 „ L	Ditto		+ 0·203	+ 0·2030	+ 0·2030	+ 0·2029	·000
12 „ A	Ditto		− 4·968	− 4·9680	− 4·9682	− 4·9682	+ ·008
13 „ λ	$(F+C_3)-(B_3+D)$		− 0·142	− 0·1420	− 0·1420	− 0·1419	− ·005
14 „ L	Ditto		+ 0·239	+ 0·2390	+ 0·2390	+ 0·2388	·000
15 „ A	Ditto		− 3·888	− 3·8880	− 3·8880	− 3·8881	− ·005

North-East Quadrilateral.

(6). As the reduction of the principal triangulation of the South-East Quadrilateral approached completion, I was enabled to make a commencement with the third section of the triangulation,

Calculating Branch—(Continued.)

known departmentally as the North-East Quadrilateral. It is bounded on the west by the Great Arc Series, Section 24° to 30°, on the south by the Calcutta Longitudinal Series and has in its eastern and northern periphery, the Calcutta Meridional and North-East Longitudinal Series. It contains twelve series, forming eleven circuits and its reduction will prove a more serious undertaking than that of any of the other divisions. At present only the circuit errors are in course of calculation, but this preliminary computation will shortly be complete and then the reduction itself can be taken in hand.

Other calculations.

(7). In addition to the calculations I have already described a good deal of assistance has been given to Captain Heaviside in preparing and passing through the press the results of the Pendulum Operations. Captain Trotter has also received much aid; the computation of the entire mass of the observations made by him, while he was attached to the Yárkand Mission having been performed by this Office and the results tabulated for publication in his report. A quantity of miscellaneous work has also been performed which is briefly summed up elsewhere.

Arithmometers.

(8). I noticed above the great advantage which had accrued from the use of Arithmometers, instruments which were introduced in to the office by yourself several months ago. Some of the computations which formerly occupied a pair of computers a fortnight or three weeks can with their aid be completed in four or five days. They are almost invaluable and would be quite so if more care was bestowed on their construction. They are of foreign manufacture and the several parts appear to be made in the gross, and then to be roughly put together; thus many of them soon get out of order and make mistakes. Were they carefully constructed as they would be by English mechanics, the principle on which they are designed is such that it seems impossible they should commit errors; as their manufacture is protected by a patent the desired improvement is not I fear likely to be effected.

Another aid to the computers, recently introduced into the office, is Crelle's Rechentafeln, a book of products of all numbers from 1 to 999. In this case foreign labour has the advantage over English; for it has produced at a cost of only sixteen shillings a most useful book, the labour of compiling which must have been enormous.

(9). The details of the ordinary calculations are as follows :—

Angle Books, indexed	467 vols.
Abstracts of Angles, copied and compared	600 angles.
Zero and general means computed	600 „

Computations in Duplicate.

Principal Triangulation	Weights computed	333
	Spherical Excesses computed	277
	Simple Quadrilaterals reduced	32
	„ Polygons „	32
	Compound Figures „	11
	Auxiliary reductions made	75
	Triangles computed	537
	Lats. Longs. Azimuths computed	750
	„ „ „ corrected (after S. E. Quadl. grinding)	140
	Heights computed	170
	„ examined, corrected and adjusted ...	630
Secondary Triangulation	Traverses computed	18
	Ray Traces computed	6
	Triangles adjusted and computed	2,400
	Heights computed	12
	Latitudes, Longitudes and Azimuths computed	1,100
Explorations	Latitudes	30
	Heights by Boiling Point	130

(10) The work performed in connection with the Typographic and Photozincographic presses, is detailed below.

Calculating Branch—(Continued).

For Typographic Office.

Synopses of the operations &c.	Pages compiled and printed.	Compiled, but not yet put to press.
Azimuth Table, Jogí-Tilá and Sutlej Series	14	
Alphabetical Lists of Gurhágarh, Rahún Sutlej and Jogí-Tilá Series	105	
Errata and Contents, Gurhágarh, Karáchi, Rahún, Great Arc (24°-30°)	11	
Note to Great Arc Final Chart	2	
Co-ordinates and Descriptions &c., of N. W. Himalaya Series, comprising 39 square degrees		The whole
Numerical and Alphabetical Lists of Principal Stations, Descriptions of Principal Stations of the Series comprised in the S. E. Quadrilateral	30	The remainder
Triangles Principal and Secondary of the Arc, Calcutta and Coast Series		About 80 pages which are half ready

For Vol. (S. E. Quadrilateral).

Lists, Descriptions of Stations, Observed Angles, Reduction of Figures and Principal Triangles

R. Calcutta Longitudinal Series	42 (to end of figs.)	To end of heights above Mean Sea Level
Great Arc (18°—24°)	18 („ Δs)	
Jabalpúr	56 („ figs.)	
Biláspúr	86 („ „)	
Coast	4 („ lists)	
Bider	40 (to near end of ∠s)	

Besides the above, the auxiliary reductions of the figures of the E. Coast Series and of a portion of the Biláspúr Series, including about 20 pages of printed matter, have been compiled but not yet put to press. Some progress has also been made in setting up the azimuthal observations appertaining to the South-East Quadrilateral for the press.

Other compilations for departmental and general use.	Compiled and printed.
Book of Routes in N.W.P., Himalayas &c., ...	34 pages
Data for Rangir Series Charts Nos. 1, 2, 3	13 „
Data for Biláspúr Series Chart, (S. Section) (1872-73)	8 „
Data for E. Frontier Series „ (1873-74)	1 „
Appendices to Vol. II	23 „

For Photozincographic Office.

Final Charts.	Compared or examined.
Karáchi Series	2
Great Arc Series (24° to 30°)	1
Gurhágarh „	2
Rahún „	2
N. W. Himalaya Series	2
Jogí-Tilá Series	1
Sutlej „	1
Total	11

Preliminary Charts.	
Madras Longitudinal and Mangalore Meridional Series (1871-73) ...	1
Biláspúr Series (S. Section) (1872-73)	1
Rangir „	3
Assam Valley Survey (1869-74)	1
„ „ „ (1873-74)	1
Bombay Island Survey	1
Total	8

For Office use.	
Triangulation of the South-East Quadrilateral	1

Calculating Branch—(Continued).

Instrumental Work.

(11.) Observations for time were taken on 20 occasions during the year for the purpose of shewing mean time and rating chronometers. Meteorological Observations were made in the Dehra Observatory on every day throughout the year, and the results were reduced and communicated month by month to the Reporter on Meteorology N. W. Provinces. A table of monthly means is as usual appended to this report. The large self-registering Anemometer referred to in last year's report was put into working order in January last, and a record has been since kept of the hourly velocity and direction of the wind. The winds in the Dún are so light that they often fail to turn the fans which move the direction pencil and this part of the record although it has been always tabulated, has not been made any use of at present. To do so would necessitate a careful weeding out of all hourly velocities below a certain fixed minimum. As yet only mean hourly velocities, irrespective of direction have been deduced for each month, an abstract of which follows that of the Meteorological Observations. It is remarkable how closely the curves formed from these data resemble one another.

Protection of Stations.

(12.) The preservation of the Principal Stations of this Survey has been as usual steadily kept in view, and much correspondence has in consequence been entailed. Replies to about 350 letters on this subject were drafted by Mr. C. Wood under your direction, and about 40 letters addressed to district officers who had failed to submit their annual reports on the stations placed under their charge. Modern changes in the boundaries of districts have caused some difficulty in ascertaining what stations fall within each. Since last reporting 16 more districts have been finally settled, making in all 307 districts of which the lists are now complete. The check lists now include 2,700 stations.

Miscellaneous.

(13.) Several duties of a miscellaneous character have also been performed by this branch of the office which may be briefly summarised as follows:—Reduction of barometer readings; computation of humidity and observed refractions on the Jogí-Tílá Series for Appendix No. 3 to Vol. II:—Preparation of Appendices Nos. 2, 4 and 5 to Vol. II:—Examination and arrangement of four Synoptical Vols. for the binder:—Translation of two Explorers' route survey field books:—Alphabetical lists of Indian proper names prepared for departmental issue:—New tables (Auxiliary) and a new form constructed to facilitate the computation of circumpolar star observations for azimuth:—Data collected for discussion as to the advisability of giving the observed azimuths in the S. E. Quadrilateral effect in the final reduction of the triangulation:—Circuit errors of the Kashmir triangulation and North-West Himalaya secondary triangulation determined and dispersed:—Effect of the difference in the values of the earth's axes as adopted by Everest and Clarke on differences of latitude, longitude and azimuth computed for arcs of various magnitude:—Elements of the Bombay Island Survey, executed in 1865-66, prepared for publication:—Differential latitudes and longitudes examined for the new edition of the Turkestan Map:—Captain McCullagh's and Lieutenant Harman's leveling records examined and reported on:—'Errors of mean square' of latitude, longitude and azimuth at the terminal stations of the right and left hand branches of the circuits of the N. W. Quadrilateral, computed from the origin of each circuit. Twenty-nine officers have been supplied with data. Forms for departmental use have been issued to 96 officers, and 776 parcels containing maps, charts, &c., were booked and despatched. Four candidates for employment in the Junior Branch were examined and three instructed in departmental computations; and papers supplied for the examination of six other candidates, besides several other duties which need not be enumerated here.

TYPOGRAPHIC BRANCH.

(14.) The work performed during the 4 years ending 1st May 1874, and the 17 months, 1st May 1874 to 1st October 1875, is concisely stated thus.

	1870-71	1871-72	1872-73	1873-74	1874-75 (17 months)
Pages composed, ...	819	1,143	1,420	1,220	1,868= 1,319 per annum.
Do. printed, ...	234,828	241,348	273,157	388,420	527,916=372,647 ,,

Typographic Branch—(Continued).

The total pages composed in the 17 months under report may be subdivided thus,

For volumes of the G. T. Survey, ...	1402
„ Route Book, ...	35
„ Charts, Memos, &c., ...	306
„ Annual Report, ...	125
Total ...	1868

DRAWING BRANCH.

The work executed by the Drawing Office is exhibited in the table which follows this report. Some very important maps have been prepared there during the past year; those of most general interest are the 3rd Edition of the map of Turkestan, compiled under your own superintendence; the map to illustrate the reports on Sir Douglas Forsyth's Mission to Yárkand and other maps relating to Trans Frontier explorations, the compilation of which is due to Captain Trotter.

PHOTO-ZINCOGRAPHIC BRANCH.

The work from 1st May 1874 to 30th September 1875 is shewn below under the heads of Maps, Charts, Diagrams and Forms.

Maps.

SUBJECT.	When published.	No. of parts.	No. of copies printed.
Prints of maps published in former years	...	40	1,341
Guzerat, sheet No. 8	May 1874	1	113
Ditto No. 9	„ „	1	105
Index to Dehra Dún Survey	September „	1	481
Kattywar Survey, degree sheet No. VI	October „	1	107
Ditto No. VII	„ „	1	150
Index to Kattywar Survey	„ „	1	468
Route map for the W. Himalayas &c., ...	„ „	1	473
Chamba Map	November „	4	22
Index to Kumaun and Garhwál Survey	„ „	1	460
„ Guzerat Survey	„ „	1	426
Kumaun and Garhwál, sheet No. 25, skeleton ...	„ „	1	105
Dehra Dún Tea Company's Plantation, sheet No. 1 ...	„ „	1	75
Ditto No. 2 ...	„ „	1	76
Guzerat Survey, sheet 80, section 3	December „	1	135
Jaunsár Map	„ „	1	22
Eastern Turkestan	„ „	2	478
Plan of Landour Bazar	January 1875	1	53
Map illustrating Trans-Himalayan Explorations during 1872	„ „	1	466
Index to Mussooree and Landour Survey	February „	1	28
Town and Cantonment of Rájkot	„ „	2	83
Map illustrating Trans-Himalayan Explorations during 1873	„ „	1	491
Kattywar Survey, sheet No. 35	March „	1	133
Guzerat „ „ 80, section 2	„ „	1	110
„ „ „ „ „ 11	April „	1	110
„ „ „ „ „ 9	„ „	1	135
„ „ „ „ „ 7	„ „	1	105
„ „ „ „ „ 1	„ „	1	127
Kattywar Survey, sheet No. 33	„ „	1	147
„ „ „ 32	May „	1	133
Mussooree and Landour Survey, sheet No. 15, skeleton	„ „	1	44
Turkestan Map, sheet No. 1 (3rd edition)	„ „	1	263
„ „ 2 „	June „	1	227
„ „ 3 „	„ „	1	284
„ „ 4 „	„ „	1	273
Kattywar Survey, sheet No. 34	July „	1	154
Kumaun and Garhwál, sheet No. 33, skeleton ...	August „	1	177
„ „ „ 12 „	„ „	1	156
„ „ „ 9 „	„ „	1	156
„ „ „ 22 „	September „	1	61
„ „ „ 38 „	„ „	1	167
„ „ „ 31 „	„ „	1	159
Guzerat Survey, sheet 80, section 13	„ „	1	107
„ „ 8	„ „	1	106
„ „ 5	„ „	1	105
Dehra Dún and Siwalik No. X } For Forest Department	„ „	1	132
„ „ „ XIX } For Forest Department	„ „	1	137
„ „ „ XX } For Forest Department	„ „	1	108
	Total ...	92	9,974

Photo-zincographic Branch—(Continued).

Charts.

Besides the foregoing 28 Blue prints were issued and several Silver prints were prepared on the scale of the Indian Atlas for the use of the Engravers.

SUBJECT.	When published.		No. of parts.	No. of copies printed.
Madras Longitudinal and Mangalore Meridional Series (1871-73) Numerical	July	1874	2	67
Assam Valley Triangulation (1872-73) Numerical	August	,,	2	67
Karáchí Longitudinal Series, Chart No. 1 Final ..	,,	,,	1	373
,, ,, 2 Final ...	,,	,,	1	371
Rangír Meridional Series, Chart No. 3 Numerical ...	,,	,,	1	65
,, ,, 1 ,, ...	September	,,	1	65
Biláspúr Series, season 1872-73 (S. section) ,, ...	,,	,,	1	65
Brahmaputra Series, season 1873-74 ,, ...	,,	,,	1	65
Great Arc Series, (Sec: 24°-30°)Final ...	,,	,,	1	384
Gurhágarh Meridional Series, Chart No. 1 Final ...	October	,,	1	367
Eastern Frontier Series, season 1873-74 Numerical ...	November	,,	1	65
Rangír Meridional Series, sheet No. 2 ,, ...	,,	,,	1	65
Gurhágarh Meridional Series, Chart No. 2 Final ...	December	,,	1	375
Malabar Minor Series, season 1873-74 Numerical ...	January	1875	1	65
Assam Valley Survey, season (1869-74) ,, ...	,,	,,	1	67
,, ,, (1873-74) ,, ...	,,	,,	1	65
Bangalore Meridional Series (Great Arc), season 1873-74 Numerical	February	,,	1	70
Bombay Island Survey Numerical ...	,,	,,	1	65
Rahún Meridional Series, Chart No. 1 Final ...	March	,,	1	361
N. W. Himalaya Series No. 1 Final ...	,,	,,	1	370
,, ,, 2 ,, ...	,,	,,	1	372
Rahún Meridional Series, Chart No. 2 Final ...	April	,,	1	372
Jodhpúr Series, season 1873-74, Numerical ...	,,	,,	1	70
	Total ...		25	4,271

Diagrams.

SUBJECT.	When published.		No. of copies printed.
Plates to illustrate Volumes II, III, IV, V, VI, of the G. T. Survey, and other diagrams.	July	1874	50
	August	,,	382
	October	,,	46
	November	,,	1156
	December	,,	680
	February	1875	4
	April	,,	390
	May	,,	370
	June	,,	190
	July	,,	736
	August	,,	402
	September	,,	837
	Total, ...		5,243
Professional and Office Forms.	1874-75 (17 months)		34,310

Photo-zincographic Branch—(Continued.)

7,536 Maps and 4,446 Charts were issued during the year. The forms are always expended as fast as printed. Contrasting the work performed since 1870-71 we have,

Year	Maps	Charts	Diagrams	Forms
1870-71	6,465	839	13,205	10,482
1871-72	10,131	1,375	4,937	13,655
1872-73	6,910	2,206	12,055	12,549
1873-74	9,207	2,027	3,557	28,125
1874-75 (17 Months)	9,974	4,271	25,43	34,310

An abstract of the work executed during the past five years stands as follows.

SUBJECT.	Number of Prints.				
	1870-71	1871-72	1872-73	1873-74	1874-75 (17 months)
Maps, Charts and Diagrams, ...	20,509	16,443	21,171	14,791	19,488
Forms, ...	10,482	13,655	12,549	28,125	34,310

In conclusion I must express my thanks to the several members of the office for their cordial co-operation in, and conscientious discharge of its duties. Where all have worked so well it seems almost invidious to single out any for especial commendation. I cannot however refrain from doing so in one instance at least. Mr. Wood has been associated with me in the same office for nearly nine years; but I have never hitherto had an opportunity, similar to the present, for placing on record my high opinion of his services and it is with pleasure that I now avail myself of it to state that I consider them very valuable. His duties are of a nature constantly requiring the exercise of no small patience and perseverance but his energies never seem to flag and his knowledge and experience are often of the greatest service.

Mr. Todd has done excellent work while attached to this office, and while congratulating him on his restored health, I cannot but regret that it necessitates his return to field duties and thus deprives the office of his services.

Mr. Peychers has proved himself exceedingly useful and deserves every commendation. Besides taking his regular share of the work, a good deal of the final supervision of press proofs has to be entrusted to him and in this he has been of much assistance to me.

Mr. Keating has become fairly well acquainted with the processes of computation and works industriously.

Baboo Gunga Pershad has discharged his duties in the same exemplary manner he always has done and deserves that I should add my testimony to that so frequently expressed by Mr. Hennessey as to his efficiency. Baboo Cally Mohun has also gained my approbation by the intelligent interest he takes in his work. On more than one occasion he has made suggestions with reference to the calculations which have led to a diminution of labour. Baboos Kally Coomar, Gopal Chunder and Tarapodo have worked with their accustomed diligence, and the other computers have given me every reason to be satisfied with them.

In the Drawing Office Mr. Atkinson has continued to conduct his duties as successfully as heretofore, and although the loss of his two best men, Sheik Saidudeen and Goormukh Sing, has for a time considerably diminished the power of his office, he is doing his best to train up others to supply their places.

In the Photo-zincographic Office Mr. Ollenbach is as hard working as ever. I am glad to observe that he now throws more of the manual labour on his subordinates, devoting his own attention to

supervision of their work, and the out-turn is very satisfactory. Mr. Dyson deserves great credit for the excellence of his negatives. I could wish that his assistants Dempster and Lloyd made more rapid progress under his instruction, but the art of Photography is not learnt in a day, and with more practice no doubt they will become more proficient.

Mr. O'Connor in the Printing Office has worked very industriously and the out-turn of work has been fully as great as the office was capable of. He was at one time somewhat lax in the discipline he maintained among his subordinates, I am glad that he has done his best to correct this fault.

Mean Velocity in miles of the winds which blew at Dehra during 8 months of 1875 for each hour of the day.

Civil Hours.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	2·27	3·13	3·75	3·14	2·67	1·41	0·59	0·90
1 „ 2	2·19	2·68	3·00	2·71	1·97	1·52	0·66	0·74
2 „ 3	2·39	2·23	2·54	2·36	2·03	1·48	0·66	1·10
3 „ 4	2·31	2·03	2·32	1·86	1·77	1·48	0·38	0·83
4 „ 5	1·96	1·97	2·11	1·71	1·63	1·00	0·14	0·57
5 „ 6	2·58	2·10	1·86	2·07	1·70	1·07	0·28	0·50
6 „ 7	2·08	1·87	1·75	1·79	1·33	0·62	0·14	0·43
7 „ 8	1·81	1·68	1·61	1·96	1·10	1·07	0·34	0·40
8 „ 9	1·96	1·67	1·86	2·68	1·00	1·00	0·69	0·70
9 „ 10	2·19	1·90	2·78	2·78	1·43	1·38	0·79	1·20
10 „ 11	2·46	2·72	3·96	3·11	2·17	1·52	1·21	1·53
11 „ 12	2·31	2·93	4·11	3·96	2·07	1·52	1·66	1·53
12 „ 13	3·11	3·85	4·86	3·79	2·33	1·83	1·33	2·03
13 „ 14	3·07	3·88	4·93	4·18	3·07	2·07	1·90	2·40
14 „ 15	3·22	4·23	5·28	4·89	3·00	1·59	1·57	2·33
15 „ 16	3·08	3·83	4·86	4·43	2·90	1·59	1·37	1·47
16 „ 17	2·50	3·32	4·59	3·89	2·20	1·34	1·20	0·97
17 „ 18	1·50	1·98	3·34	3·68	1·30	0·90	1·07	0·57
18 „ 19	1·12	1·19	1·72	3·25	0·70	0·28	0·66	0·47
19 „ 20	1·46	2·32	2·31	3·18	1·57	0·41	0·62	0·60
20 „ 21	2·54	2·94	3·14	3·75	2·47	0·45	0·76	0·90
21 „ 22	2·08	3·00	3·72	3·36	2·27	0·69	0·55	0·77
22 „ 23	2·42	3·10	3·72	3·57	2·47	1·17	0·90	0·87
23 „ 24	2·52	3·23	3·14	3·50	2·27	1·03	0·86	1·07
Sums, ...	55·13	63·78	77·26	75·60	47·42	28·42	20·33	24·88
Averages, ...	2·30	2·66	3·22	3·15	1·98	1·18	0·85	1·04

MONTHLY Meteorological results taken from the Register kept at the Office of the Superintendent G. T. Survey of India, Dehra Dún.

YEAR & MONTH.	BAROMETER.						HYGROMETER.				THERMOMETER.								RAIN.		WIND.	CLOUD.	
	h. m. At 9 30 A.M.			h. m. At 3 30 P.M.			h. m. At 9 30 A.M.		h. m. At 3 30 P.M.		Dry Bulb.					Wet Bulb.						h. m. At 9 30 A.M.	h. m. At 3 30 P.M.
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean Temperature of Dew point.	Monthly mean Humidity.	Monthly mean Temperature of Dew point.	Monthly mean Humidity.	Max: in Sun's rays.	Min: on grass.	Max: in air.	Min: in air.	Monthly mean in air.	Max: wet.	Min: wet.	Monthly mean wet.	No. of days it fell.	Fall in inches.	Average direction.		
1874.	in.	in.	in.	in.	in.	in.	°		°		°	°	°	°	°	°	°	°					
January	27·989	27·681	27·814	27·883	27·617	27·730	43·2	·716	44·3	·531	84·5	28·8	71·2	31·8	53·3	63·5	27·5	44·5	4	1·46	W.	5	5
February	·873	·417	·736	·784	·329	·656	45·4	·676	43·8	·456	87·7	34·3	77·2	37·9	57·3	64·6	25·9	46·2	6	3·77	S.	3	4
March	·832	·489	·653	·754	·389	·579	48·9	·602	47·5	·449	98·1	36·9	85·1	39·1	62·9	63·8	27·0	48·5	7	3·48	N.	4	4
April	·758	·495	·616	·677	·407	·531	53·4	·402	49·0	·262	109·8	46·7	96·7	51·3	76·8	71·5	49·5	61·2	1	0·02	W.	2	4
May	·582	·370	·460	·512	·279	·362	56·4	·365	52·7	·248	115·9	60·1	103·0	63·9	84·6	80·0	52·2	64·9	3	0·57	N.	1	1
June	·635	·199	·427	·552	·160	·350	73·3	·769	74·1	·713	113·6	65·3	101·4	65·1	81·9	80·5	59·0	72·0	21	18·73	N. & E.	7	7
July	·561	·279	·429	·473	·237	·359	75·3	·876	76·3	·845	104·8	69·0	90·2	70·1	79·0	82·1	63·9	72·9	30	34·57	S. W.	8	8
August	·562	319	·440	·489	·270	·370	75·1	·877	76·4	·841	105·4	70·4	89·9	71·8	79·1	81·4	65·0	73·0	27	25·72	N. & W.	8	7
September	·616	·455	·541	·500	·375	·451	71·5	·811	72·7	·730	103·9	61·0	88·0	63·5	77·5	79·0	53·6	69·8	13	7·82	N.	5	5
October	·760	·510	·672	·678	·446	·582	59·1	·593	59·7	·474	100·8	52·1	86·2	55·7	71·8	74·0	48·4	60·2	0	0·00	N.	0	1
November	·888	·739	·818	·791	·671	·727	48·5	·581	49·0	·424	94·8	40·4	82·6	45·0	62·5	66·2	31·6	51·3	0	0·00	S.	0	0
December	·900	·685	·836	·812	·604	·751	42·7	·620	43·6	·425	81·5	32·0	71·4	38·0	56·5	58·1	34·3	47·2	0	0·00	N.	2	2
1875.																							
January	27·937	27·589	27·730	27·850	27·507	27·648	41·4	·670	41·2	·453	77·1	31·9	72·1	35·2	54·1	58·7	32·3	45·9	3	0·62	E.	2	4
February	·863	·598	·747	·781	·515	·683	47·4	·731	47·9	·545	86·0	32·5	75·4	38·5	57·6	63·2	33·2	48·9	7	6·10	W.	5	5
March	·808	·519	·649	·722	·453	·568	52·5	·513	50·1	·329	103·0	44·0	90·1	48·1	70·4	71·2	41·7	55·8	0	0·00	S.	2	3
April	·666	·410	·553	·601	·306	·465	56·2	·414	54·4	·289	109·3	56·7	97·5	60·4	79·7	75·7	46·5	60·7	1	0·01	W.	1	2
May	·662	·403	·533	·588	·318	·448	63·7	·563	62·4	·448	112·0	58·9	100·1	60·8	79·9	76·1	42·4	63·9	12	4·57	S. E.	4	5
June	·545	·255	·375	·419	·188	·292	71·4	·627	71·1	·530	115·0	61·3	100·8	69·0	84·2	81·2	52·1	70·6	10	10·39	N.	4	6
July	·523	·242	·380	·473	·207	·313	75·3	·864	77·3	·778	104·9	69·4	90·2	71·0	80·4	85·0	58·8	73·3	28	22·91	S.	8	8
August	·596	·342	·448	·530	·283	·382	74·7	·891	76·0	·838	101·4	68·8	87·6	69·3	78·4	80·4	64·2	73·1	28	22·99	E.	8	8
September	·668	·378	·555	·589	·302	·468	72·6	·837	73·5	·807	106·3	64·7	88·5	67·2	77·3	83·0	61·0	71·1	22	12·85	N.	5	7

NOTE.—The height of the Barometer Cistern above Mean Sea Level at Karáchí is 2232·41 feet.

Annual Return of work executed in the Drawing Branch of the Computing Office from 1st May 1874 to 1st October 1875.

DESCRIPTION OF WORK.	Number of sheets or diagrams. Finished	In hand	Scale 1 inch =	REMARKS.
Compilation.			Miles.	
Sheets Nos. 1, 2, 3 and 4 Turkestan Map, (3rd edition) with hill shading.	4		32	For Photo-zincography.
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Miscellaneous.				
Examined and reported on 19 fair Maps of Kumaun and Garhwál, Kattywar, Guzerat and Dehra Dún and Siwaliks Surveys.				
Examined 148 proofs of Maps and Charts.				
Colored 7,503 Maps.				
Prepared 24 professional and Office forms on drawing and transfer paper.				For Photo-zincography and Zincography.
Prepared plans of cities of Khotan, Yárkand and Kashghar. ...				
Do. map to show the connection of triangulation of India and Ceylon.				
Corrected Sheet No. 14 of Mussooree and Landour Survey, and inserted numbers of boundary pillars on the several sheets of this survey.				

GENERAL REPORT

ON THE OPERATIONS

OF THE

GREAT TRIGONOMETRICAL SURVEY OF INDIA,

DURING

1874-75,

Prepared for submission to the Government of India.

BY

COLONEL J. T. WALKER, R.E., F.R.S., &C.,

SUPERINTENDENT OF THE SURVEY.

Dehra Dun:

PRINTED AT THE OFFICE OF THE SUPERINTENDENT G. T. SURVEY.

M. J. O'CONNOR.

1876.