

GENERAL REPORT
ON THE OPERATIONS
OF THE
GREAT TRIGONOMETRICAL SURVEY OF INDIA,
DURING
1871-72,

Prepared for submission to the Government of India.

BY
MAJOR T. G. MONTGOMERIE, R.E., F.R.S., &C.,
OFFG. SUPERINTENDENT G. T. SURVEY.



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M. J. O'CONNOR.
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- (1.) The operations of the Great Trigonometrical Survey during 1871-72 have been much the same as during the previous year, and have produced the following

Out-turn of Final Work.

out-turn; viz., of Principal Triangles with great theodolites 64 triangles, covering an area of 10,310 square miles with a total direct length of 396 miles, and observations for 3 azimuths of verification; of secondary triangulation with smaller theodolites an area of 13,530 square miles on which the positions of a large number of points were fixed and the heights of 783 were determined; of Topographical Surveying on the scale of two inches to the mile 3,418 square miles, on the one inch to the mile scale 1,279 square miles; of boundary lines and check lines 1,608 miles; of main lines of double leveling 245 miles, by means of which the heights of 190 points of reference were finally determined; by Astronomical Latitude observations the Latitudes of 25 points were determined; of geographical explorations 844 miles of Route Survey have been reduced, by which the geography of an area of about 7,650 square miles of *terra incognita* has been unravelled.

- (2.) The observations have been made with the usual care; and the precision reached in former years has been fully maintained as shown in the table given in the margin, the average probable error being only ± 0.21 of a second.

Observations.

the usual care; and the precision reached in former years has been fully maintained as shown in the table given in the margin, the average probable error being only ± 0.21 of a second.

Series.	Probable Errors of Observed Angles.		Errors of Triangles.	
	Number.	Amount.	Number.	Amount.
I ...	54	$\pm 0''.28$	18	$0''.62$
III ...	57	$.17$	19	$.59$
IV ...	33	$.14$	11	$.33$
VI ...	33	$.25$	11	$.39$
Averages, ...		± 0.21	...	0.48

- (3.) Besides the finished work enumerated above, there has been the usual

Out-turn of Approximate Work.

out-turn of approximate work for the ensuing season's operations, including the selection and building of 35 new stations in extension over a total distance of 241 miles, clearing of hill tops of forest, cutting of rays &c., so as to prevent any delay in the steady advance of the operations at the opening of the next field season.

- (4.) The amount of data supplied to the Topographical and Revenue branches of the Survey and to the other departments of Government has increased very much.

Data supplied.

- (5.) Considerable progress has been made in preparing the materials for the 2nd Volume of the "Account of the Operations of the Great Trigonometrical Survey," and

Publication of Observations &c.

for the publication of the observations; and with the increased means placed last year at the disposal of the Computing Office, steady progress will be made in this important work, which once accomplished will place these very valuable records beyond all accidents and at the same time make them readily accessible for all general purposes.

- (6.) The increased means placed at the disposal of the Drawing Office has not only admitted of the publication of nearly all charts of the present year that have been

Triangulation Charts.

received up to date, but has also enabled this office to publish by photo-zincography a considerable number of the Triangulation Charts of the earlier operations, of which up to this time nothing had been published, owing to there being no establishment for preparing them. There is now a prospect that the mass of these valuable compilations of condensed data will be forthcoming, in a form readily available, to all who may require to use them.

- (7.) The preservation of the records has as usual been carefully attended to. Those in the Head Quarters Office of the

Records.

G. T. Survey at Delhra are all in proper order, and the Officer in charge of the Surveyor General's Office *Calcutta, reports that the duplicates there are also in thorough preservation.

(8.) Steady progress has been made with the reduction and preparation of the Level Charts for Upper India. A large addition has been made to the Tables of Heights with descriptions of the G. T. Survey Bench-marks, and the publication of them has been brought up to date. The demand for these tables continues to increase.

Charts of Levels.
 (9.) The main leveling operations have been continued on the original plan, and arrangements have been made to extend them through the *Bombay Presidency and ultimately through *Madras. An index chart showing the proposed sheets of Level Charts in *Bengal and Northern India, has been prepared and circulated to all Departments and Officers likely to require them. The co-operation of all concerned has been asked for; and Officers will, with the Index, be at once able to see whether they can in any way contribute materials for this work, to which the Government of India attaches so much importance. Materials for a number of new sheets have already been collected, and will be gradually made use of as the strength of the Drawing Office is developed; the means of doing this having been placed at my disposal.

Leveling operations.
 (10.) The measures prescribed by the Government of India for the protection of the principal stations of observation have been carefully carried out. During the year 155 stations scattered over 33 districts have been repaired and taken over by the local authorities. Besides the above, almost all of those previously handed over have been reported on, and where necessary have been repaired, a duty which involves a great deal of labour; as, after the rains, many require petty repairs in order to prevent extensive damage. All the marks of the present year have been handed over to the local officials, with the exception of some in Madras which will be handed over before the end of this year.

Preservation of Stations.
 (11.) An abstract of the operations of the various Survey Parties and Offices is given below. Further details will be found in the extracts from the Narrative Reports of the various Executive Officers, including my usual report on the Trans-Himalayan explorations, which have as before been carried out under my personal direction.

T. G. MONTGOMERIE, MAJOR, R.E.,
Offg. Supdt. Great Trigonometrical Survey of India.

NO. I.—TRIGONOMETRICAL.

THE BIDER LONGITUDINAL SERIES, ON PARALLEL 18°.

(12.) The operations of this Series were continued by Mr. Rossenrode who took charge of the party on the 6th November 1871 and marched into the field on the 20th December. The country traversed being very unhealthy, the party could not start earlier; pack-bullocks were the only

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 H. Beverley, Esq., Surveyor 1st Grade.
 Mr. E. P. Wrixon, Asst. Surveyor 3rd Grade.

means available for carriage; and, as the country was throughout both hilly and intricate, marching and arranging for supplies was a matter of very great difficulty, provisions having to be brought from great distances: but few villages occurring on the line of the series, great delay necessarily occurred in marching from station to station.

(13.) Whilst the atmosphere continued to be clear great progress was made; but the jungle fires commenced in the middle of February, as is usual in such countries, and from that time forward the progress was slow, depending as it did upon occasional showers to make the atmosphere sufficiently clear to enable the observer to see his signals on surrounding stations.

Wild animals were very numerous; the tigers were especially troublesome, as in that part of the country they infest the footpaths in order to seize unwary travellers.

(14.) Mr. Rossenrode overcame these difficulties with his usual energy, though he himself and the whole of the camp suffered from repeated attacks of fever. Fortunately Mr. Beverley was in camp when Mr. Rossenrode was first attacked with fever, and was able to relieve him from a portion of the work which would inevitably have come to a stand-still had Mr. Rossenrode been alone.

Towards the end of April Mr. Rossenrode had finished the Bider Longitudinal Series, closing on Káp and Dhár Hill Stations and effecting a junction with the Coast Series, thus completing a very difficult piece of work which, owing to the extreme unhealthiness of the tract of country traversed by the Series, had been more than usually trying to all engaged on it.

(15.) In addition to the above Mr. Rossenrode was able to observe at 4 stations of the Biláspur Meridional Series, the southern section of which will form the scene of the future operations of this party, starting from the stations Munas and Báli.

(16.) In spite of all the difficulties Mr. Rossenrode made very good progress, the principal triangulation covering an area of 3,041 square miles having made a direct advance of 128 miles. At the same time the approximate series was carried forward 115 miles more, by means of which arrangements have been made for effecting a junction with the northern section of the Biláspur Series.

(17.) The secondary triangulation covers an area of 2,109 square miles in addition to the principal work; more secondary work and greater detail in that triangulated would have been effected had it not been for the sickness which crippled every one in camp.

(18.) Fortunately during the ensuing season the work will be in the Bastar and Jaipur states where it is believed the country will improve as the party advances to the north; the country generally rising to a considerable altitude above the sea, it is hoped that the party will suffer less from sickness.

No. II.—TRIGONOMETRICAL.

THE ASSAM VALLEY TRIANGULATION.

- (19.) This triangulation, under Mr. W. G. Beverley, was continued to the East up the Assám valley. Owing to the Lushai expedition being in progress, the civil authorities had come to the conclusion that the wild tribes on the low hills adjoining the valley would be hostile, and the district officers

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 Mr. G. A. Ineris, Asst. Surveyor 1st Grade.
 " W. J. O'Sullivan, ditto 1st Grade.
 " C. Bryson, ditto 3rd Grade.

had consequently been directed to erect stockades to prevent the tribes from entering the Assam valley. This being the state of affairs it was quite impossible that the triangulation could be carried over even the outermost portion of the hills, without a very much stronger guard than the civil authorities could supply at such a time. The officer in charge was consequently reluctantly compelled to alter all his arrangements in order to carry the Series through the plains. This in itself was the source of great delay, which was much enhanced by the very diffi-

cult nature of the country which, where not covered with forest, is clothed with gigantic tropical grass and reeds, the latter so thick that in clearing a ray they had to be cut one by one as if they were small trees.

(20.) The district officers did not give any assistance, and consequently the party had to struggle against a dearth of local labour, though the villages met with would have been able to supply all that was required without any inconvenience.

(21.) After a careful reconnoissance of the ground, Mr. Beverley came to the conclusion that the only chance of progressing would be got by carrying the Series along the great river, whereby much heavy jungle cutting would be avoided on the one hand, whilst on the other he would escape the excessive demands for compensation which Tea planters and other private owners would have exacted had he kept clear of the river; previous experience had proved that such owners have exaggerated ideas as to the value of their property.

(22.) The heavy smoke from the jungle fires was as troublesome as in previous seasons; and after the middle of January none of the distant peaks were visible even after a sharp shower of rain.

(23.) With a view to assist the party in overcoming the various difficulties that it had to encounter, I restricted the Bráhmáputra Series operations as much as possible, transferring Mr. Harris of that Series temporarily, and devoting all spare men, elephants and funds that were available in order to carry on the work of the Assám Triangulation.

(24.) Though so much delayed by having to change all the arrangements of the Series, owing to the impossibility of making use of the hills, Mr. Beverley was able to complete 420 square miles of principal triangulation by a direct advance of 40 miles, the secondary triangulation covering an area of 2,300 square miles.

(25.) One important advantage has been secured by adhering to the course of the river, as Mr. Beverley has thereby been able to fix four (4) of the Revenue Survey Stations, which was satisfactorily accomplished by means of careful observations to heliostopes. This will meet the wants of the Surveyor General who was anxious to have some of the Revenue Survey points in Assám fixed with a view to compiling the Revenue Survey work, which can be now carried out.

(26.) The health of the party was fair and it suffered less from insects than during the previous season.

(27.) Arrangements have been made to strengthen the Assám party still further, and as the Series has now reached the Sílságar district, one of the healthiest in Upper Assám, it is hoped that the triangulation will progress rapidly during the ensuing seasons.

NO. III.—TRIGONOMETRICAL.

NORTHERN SECTION OF THE BANGALOR MERIDIONAL SERIES.

(28.) This party under Lieutenant Rogers took the field early in November, and complete arrangements having been made in the previous season he was able to carry on the observations without intermission until a junction was effected with Sir Andrew Waugh's Southern section of the Great Arc which extends North to Dehra Dun. This junction was effected by the 1st of March.

PERSONNEL.

Lieut. M. W. Rogers, R.E., Offg. Deputy Suptl.	
3rd Grade.	
Mr. W. C. Price, Assistant Surveyor	2nd Grade.
" J. Bond,	ditto 3rd Grade.
" C. P. Torrens,	ditto 4th Grade.
" W. Oldham,	ditto 4th Grade.

Lieutenant Rogers then took up a Minor Series by means of which he connected Haidarabad and Sikandrabad with the Principal Series. He succeeded in fixing both of these important places.

(29.) The country traversed by the Series is hilly and very rocky; 20 miles north of the Kistna a range of hills occurs beyond which the country has a mean elevation of 1,800 feet, and towards Bider the whole country rises again and forms a plateau with an elevation of about 2,000 feet. The greater part of the country is without roads, and the villages appear to be in a state of decay owing, it is said, to the failure of the rains for some years past, but more probably to the conditions upon which the land has hitherto been held—a state of affairs which the Nizam's Minister has fortunately already begun to improve and as the new Haidarabad State Railway passes through it, there is now some hope that this hitherto but little known portion of the peninsula will rapidly advance in civilization. Considerable delay was caused by thick jungle in some portions, and from the ground being generally all at nearly the same elevation. In spite of this Lieutenant Rogers made very good progress, completing the Series by a direct advance of 86 miles with 16 principal stations, covering an area of 3,099 square miles. The secondary triangulation covers a further area of 2,136 square miles, a large amount of work which is the more satisfactory as all the points, both those visited and intersected, have had their heights as well as their positions determined.

(30.) In addition to the above Lieutenant Rogers was able to determine by means of Aneroid barometers the heights of a large number of places visited by the party in marching from station to station. These heights were taken by simultaneous observations with two Aneroids from Bangalor to Gutti, Lieutenant Rogers marching in advance with one aneroid and an assistant with another aneroid marching one stage behind him, whereby daily simultaneous differences were determined between the ends of each stage, the aneroid barometers being compared every evening. This is the only system by means of which it is likely that really reliable heights can be obtained from these instruments.

The heights determined are published in the Appendix, and form a valuable addition to the geography of this portion of the country which has hitherto been but little known.

(31.) The assistants suffered from ill health; smallpox broke out in one of the detached camps, and I much regret to record that the wife of one assistant fell a victim to it.

NO. IV—TRIGONOMETRICAL.

MANGALUR LONGITUDINAL SERIES, PARALLEL 13°.

(32.) The Madras Party under Major Branfill, though still suffering from the effects of the previous unhealthy season, took the field early in November. The operations were pushed on with great energy and though there were delays, arising from the approximate series requiring alteration, the very difficult nature of the country and the early setting in of the haze, yet in

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Lieut. J. R. McCullagh,	Assr. Supdt.	1st Grade.
Mr. J. W. Mitchell,	Asst. Surveyor	1st Grade.
" O. V. Norris,	ditto	2nd Grade.
" C. D. Potter,	ditto	3rd Grade.
" E. W. Lasseron,	ditto	4th Grade.

spite of every thing, very good progress was made. Fifteen principal stations were observed from and the Series was advanced over a direct distance of more than 100 miles. The principal triangulation covering an area of 3,239 square miles and the secondary triangulation a further area of 2,053 square miles. The Series was thus carried over the Western Ghâts, a most difficult range, being, as it is, rugged and in parts so densely covered with forest and jungle.

(33.) The Tidal operations at Tutukudi (Tutikorin) were completed in a very satisfactory manner. An attempt was made to take another set of Tidal observations at Mangalur, but although Major Branfill devoted a great deal of labor and tried every expedient, he was unable to make any permanent arrangements owing to the nature of the coast which is very exposed; during the

ensuing season a more protected site will be searched for.

(34.) The party suffered severely from fever more especially towards the end of the season.

(35.) From the computations of the previous season's work, it appears that the Aneimudi Peak in the Aneimalli Range has an altitude of 8,837 feet above the Sea, nearly 200 feet higher than the Dodabetta Peak in the Nilgiri Hills, which has hitherto been supposed to be the highest peak in Southern India. In determining the heights of the peaks in the Aneimalli Range a very valuable addition has been made to the geography of India, large portions of that part having hitherto been all but *terra incognita*. A further important addition has moreover been made in the same quarter by means of a Secondary Series extending about 120 miles along the Coast to the south of Mangalur, thus bridging the gap left at this place in Colonel Lambton's triangulation.

(36.) So little being known as to the general levels of the country, arrangements were made for taking a large number of aneroid observations at as many places as possible. Leaving Bangalur the party marched in two portions, for the sake of observing Barometric differences between each stage by means of corresponding simultaneous observations with two pairs of aneroids, the result of which proved highly satisfactory, the closing error being only 7 feet. Barometric observations were also taken daily throughout the season, at 10 A.M. and 4 P.M., by the main party and by two of the Assistants who were working separately: a system which is likely to lead to good results, more especially when any one of the observers happens to be at a point whose height has been trigonometrically determined, as in that case great reliance can be placed on the heights derived from the observations made by the other observers.

(37.) The heights determined from the above will be published as soon as Major Branfill is able to compute them.

NO. V.—GEODETTIC.

THE PENDULUM OBSERVATIONS.

(38.) On the death of Captain Basevi, R.E., the Pendulum party was put

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 Captain W. J. Heaviside, R.E., Offg. Dy. Supdt. 3rd
 Grade.
 Mr. J. W. Macdougall, Asst. Surveyor 2nd Grade.

temporarily under the charge of Mr. J. B. N. Hennessey, and although the observations were necessarily suspended, a great deal of extra work devolved on Mr. Hennessey, as to arranging the affairs of the party, sorting the papers of Captain Basevi, examining the instruments and carefully packing them so that they might not suffer in any way from damp, &c.

(39.) It was necessary that every record, which could throw any light on the smallest detail of Captain Basevi's valuable operations, should be preserved, not only as a guide for his successor but also that none of his hard earned results should be lost to posterity: my best thanks are due to Mr. Hennessey by whom this difficult task was most skilfully and satisfactorily carried out. When this most urgent work was accomplished the Assistant with the party under Mr. Hennessey's instructions, took up the reduction of some of the last pendulum observations.

(40.) Subsequently Captain Heaviside was given the charge of the party which he joined on the 20th of April. During the recess he has been diligently occupied in arranging the papers under separate headings, and in making himself acquainted with the methods followed by Captain Basevi in observing and computing out the results. Captain Heaviside has also practised as much as possible

in taking observations and has already attained sufficient knowledge of the work to enable him to commence a regular set of Pendulum observations: in this he has throughout been greatly assisted by Mr. Hennessey. Judging from the progress that Captain Heaviside has made I feel every confidence that he will be successful in taking the farther observations that are required to complete Captain Basevi's work.

NO. VI.—TRIGONOMETRICAL.

BILASPUR MERIDIONAL SERIES.

- (41.) This series was extended southwards for a distance of 42 miles by means of one pentagon and two quadrilaterals with one set of Azimuth observations taken at Pathaidi. But little secondary triangulation was done owing partly to the almost total absence of all permanent buildings; the

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 Mr. L. H. Clarke, Surveyor 3rd Grade.
 „ H. E. T. Keelan, Surveyor 3rd Grade.
 „ H. Healy, Assistant Surveyor 4th Grade.

inhabitants in this wild, jungle country being chiefly aborigines living in the rudest huts. Some signs of a more civilized people were seen in the shape of ruined temples &c. supposed to be Buddhist, most of them hidden in dense forest, and none of them being sufficiently conspicuous to be seen from the Survey Stations. The position of the Civil Station of Ráipur was fixed.

- (42.) The Approximate series was advanced about 60 miles, and a junction was effected with the southern section.

- (43.) The party generally suffered a good deal from malarious fever.

NO. VII.—LEVELING OPERATIONS.

DETERMINATIONS OF ALTITUDE BY THE SPIRIT LEVEL.

- (44.) The leveling operations were resumed from the last point laid down at the end of the previous season, *viz.* from Parsoni; and the main line was carried from thence *viâ* Sáhilganj (Náthpur) to Purniah with a branch line to the small Civil Station of

PERSONNEL.

Captain T. T. Carter, R. E., Dy. Supdt. 2nd Grade.
 Mr. A. W. Donnelly, Surveyor 2nd Grade.

Madahpur, and another branch to Kotgauwah and thence by two lines to the G. T. S. marks of Dighi and Rámnagar.

- (45.) A number of permanent points were established near Purniah, at the request of the Collector, in order to serve as checks on proposed leveling operations that are to be carried out by the municipal authorities. A chart showing the points fixed and a memorandum as to their heights was given to the Collector. From Purniah the main line was carried down to Karágholaghát, and thence across the *Ganges to the G. T. Survey Bench-mark at the Pipanti Railway Station, fixed in 1864 by the main line which passes on to *Calcutta. The junction thus effected shows a total difference of 0.78 of a foot.

- (46.) After completing the above, the main line was carried on from Purniah to the G. T. Survey towers at Sonákhoda and Rámganj with which a connection was effected by the end of the field season; this is a most important determination as the two towers mark the ends of one of the initial bases of the Trigonometrical Survey.

(47.) Considerable delay was caused by the want of roads, in one portion the line having to be carried through high grass. There was also a difficulty as to the crossing of the Kosi river and still more as to the Ganges, which was so broad that special arrangements had to be made before the leveling staves could be read off.

(48.) The out-turn of work has altogether been very good, embracing as it does 245 miles of double leveling, during which 7 trigonometrical stations were connected with and 16 bench-marks were laid down with a very much larger proportion of marks on permanent points than usual. I had specially directed Captain Carter to fix more bench-marks, and he has very satisfactorily carried out my instructions. The bench-marks and permanent points are always most valuable as points of reference and checks for local works such as canals, drainage &c., and in the last season's work done by his predecessor there were some unnecessarily large gaps without any permanent mark of the main line of levels.

(49.) Mr. Donnelly held temporary charge of the party until Captain Carter's return from furlough. The arrangements made by Mr. Donnelly were very satisfactory and the work done by him has turned out very good.

(50.) The health of the party was on the whole good.

No. VIII.—TOPOGRAPHICAL.

THE SURVEY OF GUZRAT.

(51.) Major Haig R.E., took over charge of this party on the 23rd September and started for the field on the 23rd of October; operations commencing near Súrat as soon as arrangements were completed.

PERSONNEL.

Major C. T. Haig, R.E., Offg. Dy. Supdt.	1st Grade.
Captain A. Pullan, S.C.	3rd "
Mr. A. D'Souza, Surveyor	3rd Grade.
" A. Christie, Asst. Surveyor	1st Grade.
" C. H. McA'Fee, Asst. Surveyor	2nd Grade.
" E. J. Connor, " "	3rd "
" J. Hickie, " "	3rd "
" G. D. Cusson, " "	3rd "

(52.) The topographical operations were diligently pushed on; and the area mapped, *viz.*, 1382 square miles, shows a marked increase on that of the previous season. Every endeavour was made to execute

a large area of triangulation for the ensuing season as well as to supply extra points for use during the current season. In all 1036 square miles were triangulated including the Minor series along the River Mahi. The Mahi triangulation had previously progressed very slowly owing to the dense forest and jungle on both banks, which made it very difficult to get long sides; but by adopting smaller sides, and making as much use as possible of the open space of the river itself, the work was brought to a satisfactory conclusion by the end of June. A number of stations of the Súrat city survey were fixed by the triangulation; and Major Haig consequently anticipates that he will be able to prepare a very accurate map of Súrat without much extra labour.

(53.) Many portions of the country being thickly wooded, I directed that a larger amount of traversing should be carried out in such places, the main traverses to start from and close on trigonometrical stations. The necessity for adopting more traversing was evident, because a complete network of triangulation would be very expensive, and even if executed could never supply so many points as a number of main and minor lines of traverses which in their progress would besides determine numerous topographical features which could not be got from a triangulation.

(54.) Major Haig reports favorably of his Assistants who have now all had a good share of experience, and with strict attention to each particular opera-

tion I have no doubt but that a full amount of first-class work will be turned out during ensuing seasons. The training of the native Sub-Surveyors has also received due attention and several of them have already completed a fair share of work.

(55.) Major Haig has shown great tact in dealing with the Baroda Darbár, and by conciliation has prevented all obstruction in the progress of the Survey which is a matter of congratulation, as at one time the opposition of the Native officials seemed likely to seriously retard the operations.

(56.) Altogether, considering that the party is a new one, very good progress has been made, and I feel sure, if it is possible, the general out-turn will be again increased during the ensuing field season, though the party has to work in a very difficult flat country, in parts densely wooded.

(57.) The health of the party has been fairly good, only 2 or 3 members suffering from fever &c., and as Major Haig is well acquainted with the climate of the country I hope the health of the party will be as good in future seasons.

No. IX.—ASTRONOMICAL.

LATITUDE OBSERVATIONS ON THE MERIDIAN OF 75°.

(58.) This party resumed operations to the south of Kem H. S. in Lat. 18° 11'. The party started on the 9th of November but observations were not commenced till about 20th December; from the latter date to the 17th of May 7 stations had been selected and observed from, including a second set of observations at one of them, the party during this period having travelled 450 miles by land and 100 by sea.

Captain W. M. Campbell, R. E., Offg. Dy. Suptd.
2nd Grade.

Mr. A. H. Bryson, Asst. Surveyor 4th Grade.

(59.) The selection of the stations was satisfactorily made, and on the whole they are likely to be as free from disturbance of the plumb line as is possible in such a country.

(60.) The observations were taken with the new Zenith Sector which has worked very satisfactorily; though there is, as in its sister instrument, a tendency to instability shown by gradual change of the zero of levels and microscopes and level of transit axis, a tendency which it is hoped means will be devised to correct: for although it is not likely to affect the observations, as the time occupied in taking a double observation is but 5 minutes, yet it would be as well to perfect the instrument in this respect.

(61.) The capability which this instrument has of changing the zero on its limb in a great measure removed the necessity for taking exact pairs of north and south Stars, as a fresh set of graduations is used for every observation whether of the same Star or not. I accordingly sanctioned Captain Campbell's dispensing with Stars in pairs, though he was directed to use an equal number of Stars north and south of the Zenith and to endeavour to maintain an equality between the mean zenith distance north and south, making it his first object to use Stars depending on the greatest number of observations.

(62.) Hitherto the labor of reversing the Zenith Sectors bodily, has prevented the observers from trying the experiment as it involved taking the instrument entirely to pieces; but Captain Herschel R.E., devised the means of revolving it, all standing, as described in his report and found that it had such a decided effect on the results that it was evidently essential and Captain Campbell accordingly adopted the plan as soon as it was communicated to him.

(63.) The plan of changing the order of position (East and West) of observation with alternate stars, was found to be preferable to doing the same on alternate nights. Throughout the season the Zenith Sector was carried on spring carts constructed by Captain Campbell for that purpose, whereby a considerable saving has been made in the pay of bearers, and not a little delay avoided, as bearers are always difficult to get and keep. The carts have answered their purpose admirably; the instrument having passed safely over some very bad, rough tracks not worthy the name of road.

(64.) Altogether the progress of the party and the use made of the instrument has been very satisfactory.

NO. X.—TRIGONOMETRICAL.

THE BRAHMAPUTRA SERIES.

(65.) The field operations of this party under Mr. Beverley were entirely confined to the approximate operations, as

PERSONNEL.
 W. G. Beverley, Esq., Assist. Supdt. 2nd Grade.
 Mr. C. J. Neuville, Surveyor 2nd Grade.
 „ G. A. Harris, Assist. Surveyor 1st Grade.

as much of the strength of the party as possible being devoted to the Assam triangulation. Five rays were finally cleared; three towers were completed, and a commencement was made with a minor triangulation for the purpose of fixing the station of Maimansinh.

(66.) As much progress has been made as the means available admitted of, and the whole of the approximate series has been completed with the exception of the building of 4 towers and 5 platform stations.

(67.) More than sufficient stations have been prepared for the ensuing season's operations, and the remainder, noted above, can be built while those to the south are being observed from.

(68.) About 20 per cent of the establishment were generally ill with fever.

NO. XI.—TOPOGRAPHICAL.

THE SURVEY OF KATTYWAR.

(69.) The progress made by this party under Captain Trotter has continued to be very good, though the south portion of the ground surveyed topographically was

PERSONNEL.
 Captain H. Trotter, R.E., Depy. Supdt. 3rd Grade.
 Lieut. A. W. Baird, Asst. „ 1st „
 Mr. J. McGill, Assistant Supdt. „ 2nd „
 „ F. Rynall, Surveyor „ 4th „
 „ J. Wood, „ „ 4th „
 „ N. C. Gynno, Assistant Surveyor „ 2nd „
 „ T. Rendell, „ „ 2nd „
 „ E. N. Wyatt, „ „ 2nd „
 „ W. Fielding, „ „ 3rd „

mostly flat, while in that to the north there was a large amount of detail. Had there not being so much detail in the latter, the party might have turned out even a larger area than it has. It is satisfactory to be able to report that the tilluka boundaries of the ground surveyed were found to have been properly demarcated by the time the party took the field. This is a point which this Department has had the greatest difficulty in getting carried out, not only in Kattywar but in all parts of India. The Civil, Forest Departments &c., ask to have boundaries laid down, but forget that it is quite impossible for this Department to do anything until the boundaries are demarcated in some permanent

manner, as by pillars, &c. The consequence of neglecting this essential preliminary, is endless trouble and expense: and, in the Survey reported on, it was necessary in previous seasons to send in maps disfigured by undemarcated boundaries.

(70.) The necessity for new maps of Kattywar has been fully proved, and in fact become even more obvious than it was when the work first commenced. On comparing the old maps with the new corrected ones, differences of 1 mile in 5 and even of 1 mile in less distances were found to exist; the lines of watershed and drainage were also found to be entirely incorrect, the old maps being positively misleading. For instance an examination of our new original maps induced the the Agent of the Bombay, Baroda and C. I. Railway to lay out for detail survey an entirely different line from what he originally intended when he had the old maps only to judge from. Colonel Anderson, the Political Agent of Kattywar, is very urgent to get the maps of the country round Rájkot. It is gratifying to learn from these and many other instances that the Surveys of Kattywar and Guzrát are fully appreciated.

(71.) The out-turn of the field season has been 2,036 square miles on the scale of 2 inches to the mile; 1,940 square miles of country have also been triangulated preparatory to being surveyed topographically during the ensuing season; traverses amounting to 779 miles were carried along tálluka boundaries with theodolite and chain, and 156 miles more were executed for the purpose of testing the accuracy of the detail survey.

(72.) The season was a healthy one in Kattywar and there was consequently comparatively little sickness in the field.

(73.) Captain Trotter was fortunate enough to shoot four of the lions that haunt the country: judging from the details given in the Appendix they appear to be formidable animals, though not nearly so troublesome to men as tigers are.

(74.) The material collected for final maps will enable the party to prepare a further instalment of them on the scale of 4 miles to the inch, for incorporation in the sheets of the Atlas of India.

The average number of plane table points fixed in each square mile is a little over ten (10).

(75.) In the area triangulated for next season a point has been fixed in every 2½ square miles, and a height in every 8½ square miles, which is ample to secure all desirable accuracy in the detail and at the same time to illustrate the differences of level.

NO. XII.—TOPOGRAPHICAL.

HIMALAYAN SURVEYS IN KUMAON AND GURHWAL.

(76.) During the recess this party was chiefly employed on the fair maps of the Kosi Valley Survey, which comprise 8 large shaded sheets and the same number of skeleton sheets without shading.

PERSONNEL.

Lieut. J. Hill, R.E.,	Offg. Depy. Supdt.	3rd Grade.
" H. M. Chambers, R.E.,	Asst. Supdt.	2nd Grade.
Mr. F. C. Ryall,	Surveyor	1st Grade.
" J. Peyton,	ditto	2nd Grade.
" W. Todd,	ditto	3rd Grade (on Furlough).
" J. Low,	ditto	3rd Grade.
" L. Peacock,	Asst. Surveyor	1st Grade.
" H. Todd,	ditto	2nd Grade.
" T. Kinney,	ditto	3rd Grade.
" E. F. Litchfield,	ditto	4th Grade.

(77.) A second edition of the Guide Map for Masúri and Landaur was also prepared containing all the changes that have taken place in the Sanatarium since the original maps were prepared. A table of distances, an index to all the houses &c., and

a number of new heights were added to the map, making this new edition very complete.

(78.) The drawing of the Kosi Valley Maps was necessarily laborious, and several of the Surveyors had to be kept in later than usual, and the party was in consequence not able to finish so large an area as it would have done if a complete season had been available.

(79.) The field work began with an extension of the triangulation of the Mána and Níti valleys that drain into the Alaknanda branch of the *Ganges, a most difficult piece of work, as all the stations of observation were necessarily above the limit of forest, and some were 17,000 feet above the sea. The triangulation in the Mána valley was extended from the Badrináth Temple to the village of Ghastoli, and the triangulation of the Níti valley was carried up to the Níti Pass on the great Himalayan watershed.

(80.) Three stations were established close to the Níti Pass from which a good view of the Trans-Himalayan range, generally known as the Kailás snowy range, was obtained. In this range 8 lofty peaks were satisfactorily fixed and their heights were also determined; one of these peaks is the sacred Kailás Parbat which has various appellations such as Gang-ri, Garingboche, &c. This celebrated peak had been formerly fixed by Lieutenant (now General) R. Strachey, R.E. from similar points near the Níti Pass, and the present operations by which it has been directly connected with the triangulation of India, prove that his results were nearly correct; the height now established being 22,028 feet, just 28 feet in excess of General Strachey's, and the position given by him requiring no material alteration. The determination of these 8 Trans-Himalayan peaks will be excessively useful in testing and compiling the work of my explorers, who have at various times passed near them and have taken numerous bearings to the most conspicuous, in some cases from points very far to the north and east, beyond the Kailás range where I was naturally anxious to have some check upon their longitudes.

(81.) I have previously dwelt on the difficulties which surveying in the upper valleys of the Himalayas involves; they were as formidable as usual in the present instance, and the success of the Surveyors in overcoming them was not a little due to the cordial assistance rendered to them by Captain Garstin who has the Civil charge of this very wild and elevated tract of British Territory.

(82.) The field work of the season comprised the triangulation of the country east of Naini-Tal, including the hills, as well as the flat portion at their foot known as the Bhábar, up to the Nepal Frontier on the Sardah river. The Topographical work covers a number of mountainous districts north and east of Almorah up to the Nepal Frontier, and also a part of the Bhábar to the south of Naini-Tal. A small portion of very intricate, hilly ground opposite Harwar was triangulated and sketched. This tract had not hitherto been surveyed as it was originally beyond the boundary of Gurhwal, with which it has subsequently been incorporated. A map of it was required in order to prevent there being a gap between the survey of the hills and that of the plains.

(83.) The triangulation covers an area of 1,862 square miles with a trigonometrical point fixed in every four (4) square miles, and one height in every 5½ square miles, a very liberal proportion for the scale of survey.

(84.) The topographical surveying covers an area of 1,279 square miles including a very large amount of intricate, forest-clad mountains with only one-tenth part actually under cultivation. In addition to this 93 square miles of Nepal were sketched from stations in Kumaon.

(85.) The topographical work was examined and tested in various parts and was found to be accurately delineated and in many cases the rendering is most artistic.

(86.) Four large sheets of the fair maps have been prepared during the

recess and will be published by the end of the year. They are capital specimens of drawing both as regards the hill shading and general execution; the style of the work has undoubtedly been much improved by the experience gained on the large scale surveys of Ránikhet and of the Kosi Valley.

(87.) The party has altogether made very good progress and Lieutenant Hill has fully provided for the ensuing season, there being, with previous years triangulation, ample points for all the topographical work that can be taken up next season.

(88.) The health of the party was good during the field season, but after its return to quarters Lieutenant H. M. Chambers, R.E., died at Masúri; he was a most promising young officer and his untimely death was much regretted by all who knew him.

NO. XIII.—ASTRONOMICAL.

LATITUDE OBSERVATIONS ON THE MERIDIAN OF 78°.

(89.) Captain Herschel after the recess was employed in taking observations connected with the Solar Eclipse of 11-12 December 1871, and his Latitude observations were resumed as soon as he could get away from the work connected with the eclipse observations. Though delayed by this

PERSONNEL.

Capt. J. Herschel, R.E., Offg. Depy. Supdt. 1st Grade.
Mr. G. Belcham, Asst. Surveyor 1st Grade.

extra duty Captain Herschel was able, by extreme economy of the time available, and by staying out late in intense heat, to complete all the observations that were required up to Elichpur, his most northerly station being in Lat. $20^{\circ} 44'$. This involved a direct advance of 550 miles, which was largely exceeded by wanderings in the Haidarabad territories where roads are unknown, the country traversed being in most places unutterably stony and unsuited for wheeled carts of any description. In spite of the great distances to be traversed and the small time available, Latitude observations were taken at 18 stations, forming four groups as detailed in Appendix. These groups are at intervals in latitude of from about 1° to 2° , but in several instances observations at intermediate points are available from Colonel Lambton's work, some of which Captain Herschel has reduced and has reason to believe that, apart from constant errors, they are good enough to be included. The Latitude observations for the Arc from Cape *Comorin in lat. $8^{\circ} 13'$ to Kaliánpur lat. $24^{\circ} 7'$ may be considered complete, as all that is now necessary is to get the geodetic values of the stations of the last two groups which will be completed early in the next field season.

(90.) The principal stations at 3 of the new groups, were also stations of the late Captain Basevi for his Pendulum observations for the determination of the local force of gravity.

(91.) As stated in Captain Herschel's report for last year, he had reason to think that a peculiar source of error existed in the levels of the Zenith Sector; being unable to account for it, he devised a method for reversing the instrument bodily. This was ingeniously effected by introducing a small metal button under the centre of the instrument after prizing the latter up on one side with a lever. On lowering the instrument on the button a condition of unstable equilibrium was obtained in which this heavy instrument could be turned round, so to speak with a finger, with perfect safety, the feet just grazing the stone slab on which the instrument stands—a method which proved very satisfactory and was as before stated subsequently put into practice by Captain Campbell with the other sister Zenith Sector. At first Captain Herschel thought that this reversal would eliminate

a constant error, which was apparent in the first case, but subsequent experience shows that the effect is barely traceable, and there now seems to be little doubt but that the errors detected are due to the position of the bubbles in the levels. These errors on the whole are insufficient to justify any alteration of previous results; but the system of reversal will be continued, and in order to neutralize the irregularity in the levels, their readings will be purposely and frequently altered during the course of the work, and a re-adjustment of level will be made, say every hour, as a part of the routine.

(92.) The results as far as computed, give farther evidence as to the great uncertainty of local attraction. Between the Honúr group in lat. $14^{\circ} 54'$ and the Darúr group in lat. $16^{\circ} 12'$, being a difference of only $1^{\circ} 18'$ in latitude and $35'$ in longitude, *i.e.*, 98 miles, the change in the local disturbance is no less than 8 seconds; and, as the errors of measurement cannot possibly account for more than a small fraction of this amount, there seems no doubt but that the attraction is disturbed in a very irregular way. The Honúr and Darúr groups appeared to be both as free from apparent abnormal causes for irregularity of attraction as they well could be, and yet the change in disturbance shows the largest deflection that has hitherto been observed in India, which may not be directly attributed to mountain masses.

(93.) The amount of work done has been very large and is highly creditable to Captain Herschel. As a rule from 30 to 35 stars were observed each night; and, bearing in mind that at every station and indeed every night almost the meridional direction had to be sought out by transits, and adjustments had to be repeated, before the regular work was commenced, it is easy to understand how harassing the work must have been with the temperature at from 98° to 105° . Notwithstanding the hard work and the exposure towards the end of the field season the health of the party was on the whole very good.

(94.) Captain Herschel's detailed report contains various other particulars that will be interesting to all who study questions into which the variations of density in the crust of the earth enter.

NO. XIV

THE COMPUTING OFFICE.

(95.) In the computing office Mr. Hennessey has continued the calculations of the Sironj-Chach Quadrilateral so as

PERSONNEL.
 J. B. N. Hennessey, Esq., Depy. Supdt 1st Grade.
 W. H. Cole, Esq., M. A., Asst. Supdt. 1st Grade.

Computing Branch.

Mr. C. Wood, Surveyor 3rd Grade.
 " H. W. Pechers, Asst. Surveyor 1st Grade.
 Bábu Ganza Pershad.
 " Gally Mohun Ghose.
 " Kally Coomur and 9 other native computers.

Printing Office.

Mr. M. J. O'Connor.

to complete the triangulation; this involved a large amount of computation, chiefly in connection with the auxiliary principal stations, no less than 268 triangles entering, (in groups of 2 and upwards), into 110 figures were made consistent by the method of least squares. So that the whole mass of this extensive work, which forms the basis of the Geodesy and Geography of northern India, has now been reduced by the most accurate of modern processes. Besides the above special work a very large amount of ordinary computations were performed as detailed in para. 3 of Mr. Hennessey's Report.

(96.) A general plan for reducing the secondary triangulation has been prepared in accordance with what has been done for the principal work in the Sironj-Chach Quadrilateral; care has been taken to elaborate a scheme which avoids redundant calculations while securing the full utility of the secondary work, which is becoming more valuable every year for new large scale surveys required for railways, roads, canals &c. Experiments have been made with the new plan and it promises to do what is required with a minimum amount of labour.

(97.) A large amount of the computed results have been compiled for the press, sufficient to cover about 450 quarto pages. In addition a great quantity of data has been compiled and examined for the numerical charts, of which no less than 30 large sheets were prepared, involving months of laborious work which requires the exercise of the greatest vigilance in order to prevent errors.

(98.) The measures for the protection of stations have been steadily persevered with, a reference to Mr. Hennessey's report shows what a large amount of work this involves.

(99.) Besides the above regular work of the office, various other important duties have been discharged by Mr. Hennessey, amongst which may be mentioned the preparation for the press of 1,143 pages of printed matter, mostly quarto size, including 517 pages for the new volumes of the "Account of the Great Trigonometrical Survey"; also the supply of special data to 23 officers.

(100.) Mr. Hennessey also superintended the Photo-zincographic and Drawing branches, the operations of which are detailed below.

I have elsewhere referred to the valuable services of Mr. Hennessey with the Pendulum Party.

(101.) Mr. Hennessey was selected to assist in the observations of the Total Eclipse of the Sun, 11-12th December 1871. Total Eclipse of the sun which occurred on the 11-12th December 1871. There he rendered very efficient aid and was more especially successful in photographing the eclipse, securing no less than 6 excellent photographs during totality. These photographs have met with deserved commendation from competent authorities in England, and it is not too much to say that they are on the whole superior to any that have hitherto been produced in any part of the world. This was due to Mr. Hennessey's skilful arrangements and to the judgment he exercised in varying his programme on finding what a peculiar state of atmosphere he had to deal with, mist of a varying density having unfortunately prevailed during the whole eclipse.

(102.) Mr. Hennessey gives various interesting extracts from his own report as to the eclipse and also some from Colonel Tennant's report as to the observations generally.

(103.) Altogether Mr. Hennessey has been very fully employed and very great credit is due to him for the efficiency to which the various branches under his orders have attained owing to his skilful and unwearied supervision in all matters.

(104.) Mr. Hennessey has been ably seconded by Mr. W. H. Cole, M.A. who is now competent to assist in all matters, and also to originate valuable projects for the prosecution of the work, whereby his assistance has become doubly valuable.

NO. XV.

CARTOGRAPHY, PHOTO-ZINCOGRAPHY &c.,

(105.) The Drawing Office has, as before, been chiefly occupied with the preliminary charts of triangulation and the charts of levels, the following charts having been prepared for photo-zincography, viz., 23 preliminary charts of triangulation, of which the majority have already been published, besides various other triangulation charts which have been prepared in manuscript only for

Drawing Office.

Mr. G. W. F. Atkinson, Surveyor 4th Grade,
6 Native Draftsmen and 23 Apprentices.

Photo-zincographic Office.

Mr. C. G. Ollenbach,
" C. Dyson.

the use of government officials; 4 sheets of charts of levels have been completed and many more are in course of preparation. An index to the level sheets has also been published, so that officials may at once be able to see whether the materials in their offices can in any way assist the completion of these most useful charts. Numerous maps and reductions have been prepared for incorporation with the level sheets and various others for the use of the Irrigation Department.

(104.) A map of the country round Dehli was compiled with various plans of the city and fortifications on a larger scale for the use of the Camp of Exercise during

1871-72. Experiments were made as to the most convenient form for issuing such maps for use with troops in the field; some copies were printed on water-proof india rubber cloth, on white cloth, and on several kinds of paper, printing being applied on both sides. These were put up in various forms and the conclusion arrived at was that a roll with a couple of elastics attached was the most handy, as it could be carried in the holster. The white cloth promises to be the most serviceable for although the maps on India rubber came out beautifully and were all but indestructible, they were too heavy for general use, and it is probable that they might be unpleasant to handle during great heat. As to paper, some on ordinary thick and thin drawing paper will always be required for office use, with an army, but the maps on bank-post paper were found to be very clear and to stand a large amount of rough handling, though of such nice light material, and on the whole this is probably the most serviceable paper that has hitherto been tried: some farther experiments are being made and I hope that an indigenous material will be found suitable. The results of the experiment will be published hereafter. The printing on both sides of the cloth or paper answered very well even with the thinnest, viz., the bank-post, the maps being as clear as could be wished. Experiments were, however, made by printing the subordinate map at the back in blue or brown, and I think some small advantage was thereby gained on the thinner material. When the portability of the maps is so desirable as during a campaign the advantage of using both sides of the material is obvious and I think should be adopted in future. It may be noted here that cloth maps are perhaps better adapted for use on horseback, many horses objecting to the rustling of paper. Probably a few copies on water-proof cloth would be found useful for an expedition during the rains when every other material is apt to be damaged by the damp. This map was drawn and printed in little more than six weeks, and I need hardly point out how advantageous it is to be able to print a map so quickly; a similar map during the Mutiny would have been of immense advantage but this office had not then got the means of doing anything of the kind.

(107.) Three sheets of the Maps of Routes in northern India were completed and the 4th was commenced; this compilation has involved a very great amount of close examination and careful selection so as to include every thing useful that the scale would admit of without overcrowding. The maps include my former Kashmir Route Map, with considerable extensions and additions on both sides of the frontier. The additions in *Kumaon and *Gurhwal are more numerous than in any other part. Details as to the routes in the Western Himalayas have been printed to accompany these Route Maps, these details give the distances, heights &c., for the use of travellers who are constantly applying to this office for such information, and it is hoped that with the polymetrical tables attached to them they will supply all that is required.

(108.) A commencement has been made with a series of Trans-Frontier Maps based on the operations of the Great Trigonometrical Survey and on the explorations made by British and Asiatic explorers from the side of India, more especially on those recently made in connection with this survey by Asiatic explorers. These maps it is hoped will prove useful in studying questions connected with any part of our extensive frontier or with any of the foreign territories lying beyond it. One sheet is now ready for the press and 3 others are in course of preparation.

(109.) A few other original maps and compilations of general interest have been prepared and published, and the Drawing Office has been busily occupied; the amount of work turned out, under Mr. Atkinson who has supervised it, is very satisfactory. The quality of the work has been steadily improving and I am hopeful that with more experience Mr. Atkinson will fully maintain the reputation of the office.

(110.) By the photo-zincographic process 16443 copies of charts, maps and diagrams have been printed of which 4703 have been coloured by hand, for issue to government officials and for sale to the public, and 13655 copies of forms for calculation and office work have been printed by zincography for the use of this department. Though the total number of prints of all sorts is about the same as last year a far larger amount of the elaborate kinds of work—maps and charts—has been performed, both these sorts of works are photo-zincographed.

(111.) Mr. Duhan resumed charge of his office as personal assistant in September 71, and has discharged his various duties entirely to my satisfaction.

Mr. H. Duhan, Surveyor 1st Grade.
Personal Assistant.

NO. XVI GEOGRAPHICAL.

TRANS-HIMALAYAN AND TRANS-FRONTIER EXPLORATIONS.

(112.) Explorations have been continued in various directions on our western, northern and north-eastern frontiers. On the whole great progress has been made and one continuous line of explorations beyond the frontier has been carried right round India. The route traversed, starting from Sindh, goes to Khelát in Belúchistán and thence by Kandahár to Kábul. From Kábul it crosses the Hindu Kush mountains to Badukshán and thence up the head waters of the Oxus and across the great Pámir Steppe to Káshgar and Yárkand in Eastern Turkestan. From Yárkand the explorations follow the route to the Kárákoram pass, and thence the connection is continued by the regular operations of this survey to the Pangong lake, and south to the Indus, where that river first enters Ladák near Demchok. From Demchok the line of the explorations is carried up the Indus and its large branch the Gartung-chu to Gartok and thence across the Kailás range to the Mánsarowar lake. From the Mánsarowar the line is continued across the *Himalayas, then down the course of the great Nári-Chu or Sang-po river (the Bráhmáputra) to Shigatze and thence to Lhása the capital of Great Tibet. This line with its branches is about 5000 miles in length and is connected with British India by numerous cross lines, the details of which have from time to time been published in the reports of the Great Trigonometrical Survey. It must be remarked that these routes were all at great elevations above the sea, more than half being at over 12,000 feet, a fact which has of course added very much to the difficulties of exploration.

(113.) Very great progress has been made with a second line, inside the above line, in such places as it is required, the results of which will be published before long, though it is not convenient to do more than refer to it until the work is completed.

(114.) A commencement has been made with a third line of explorations exterior to the first line referred to, and at a very considerable distance beyond it; some progress has already been made with it, the first link being that from Yárkand to Khotan, determined by Mr. Johnson's exploration, and thence across the lofty Lingzitháng plateau to the Pangong lake. From the Pangong our explorers have extended the line by a traverse to Rudok, the capital of the Chinese districts of Pangong &c., and thence, over the very elevated plateaux north of the great Aling-Gangri peaks, to the Thok-Jálung gold field, passing through a succession

of gold and borax fields. From Thok-Jálung the line has been extended south-east through Májín to the Shellifuk lake, north-east of the Great Kailás Parbat over the most elevated plateaux in the world; the explorers having been for months at over 15,000 feet above the sea. This portion of the outer line is connected with the Mánсарowar lake. Farther extensions have been made to the west and north of Lhása, and I trust eventually that a junction will be effected between this and the portion near Shellifuk and thus open out a large portion of the geography of Central Tibet. On the west some extension has already been made with this outer line beyond the Oxus and I am hopeful that more will be forthcoming. In this report details are given with respect to one of the connecting lines between the inner and middle line of explorations, *viz.*, between Dárjiling and Shigatze in Great Tibet on the one side, and between Shigatze and Nepal on the other. These lines of exploration open out the geography of a very large tract of country as to which we previously had but the vaguest conjectural indications. The routes may be described as going right round the great Mount Everest, penetrating on the north, to the Sang-po or Bráhnáputra River and thence south-west over the well-known Tingri maidán, the most extensive plateau on the south of the *Himalaya watershed that is drained by streams which flow direct into India.

(115.) From Tingri the line passes to the west of Mount Everest, and again connects with the work brought up from India.

(116.) The greater part of this work was done by one explorer; on a reference to the map it will be seen that his route for some distance corresponds at points with Doctor (Sir Wm.) Hooker's route west of Dárjiling, the new ground commencing from his most north-westerly points near the Wallanchun and Kanglachem passes, embraces a portion of the great eastern branch of the Arun river, then passes a large lake of which we had previously heard though its position has never, as far as I know, even been indicated on any map. The position of a number of peaks, north of those which are visible from the side of India, have been determined. The country has of course been crossed previously by the Ghurkas, Niwars and other natives of the adjacent countries, but as far as I know has never been even seen by an European. Amongst other places this route has fixed the position of the celebrated Sakya monastery second only to that of Tashi Lumbo. The route traversed is 844 miles in length of which 550 miles may be said to be over entirely new ground and the remainder, though close to a line which at least one European has gone along, has never been regularly surveyed before. This exploration with its bearings &c., opens out the geography of nearly 30,000 square miles of what has hitherto been all but *terra incognita*, it more especially elucidates the geography of the basin of the Arun or Arun Kosi river, the largest feeder of the great Kosi river, which drains the whole of Eastern Nepal. The courses of its upper feeders have been hitherto a puzzle to geographers.

(117.) The routes give an independent determination of the longitude of Shigatze and prove that the value which I adopted for that town, based on Turner's Route Survey, was a very close approximation. This point was fully discussed in my Trans-Himalayan report for 1865-67 on the Chief Pandit's exploration from the Mánсарowar lake to Lhása at page x, and it is gratifying to find that my reliance on Turner's work was not misplaced.

(118.) The explorer took latitude observations at 11 points upon which the work depends, and he determined the height of 31 places. His work has stood all the usual tests of comparison satisfactorily, and as it includes a considerable number of peaks &c., on both sides of his route: I think it will prove a valuable addition to the trans-frontier geography of India.

DEHRA DUN, }
November 1872. }

T. G. MONTGOMERIE, MAJOR R.E.,
Offg. Supdt. Great Trigonometrical Survey of India.

Abstract of the out-turn of work executed by the Great Trigonometrical Survey Parties, during the Official year 1871-72.

DESCRIPTION OF DETAILS.	1									TOTAL.
	Birdhmaputra Series, 24-inch Theodolite.	Eastern Frontier Series 14-inch Theodolite.	Bider Longl. Series, 36-inch Theodolite.	Bilaspur Moll. Series, 24-inch Theodolite.	*Bombay Party, 24-inch Theodolite.	*Madras Party, 24-inch Theodolite.	Guzrat Survey, (Topographical.)	*Kadywar Survey, (Topographical.)	*Kumaon & Gurhwal Survey, (Topographical.)	
Number of Principal Stations, newly fixed,	5	13	8	15	10	...	...	...	51
Number of Principal Triangles, completed,	5	18	11	19	11	...	...	...	64
Area of Principal Triangulation, in square miles,	420	3041	611	3099	3239	...	...	...	10,310
Lengths of Principal Series, in miles,	40	128	42	86	100	...	...	...	396
Average Triangular error, in seconds,	2.88	0.62	0.30	0.59	0.33	...	...	...	...
Average Probable errors of Angles, in seconds, ±	...	0.78	0.23	0.25	0.17	0.14	...	...	...	...
Azimuths of verification,	1	...	1	1	...	...	...	3
Number of Secondary Stations whose positions and heights have been fixed,	35	7	13	23	55	142	221	287	783
Do. of Secondary Stations whose positions only have been fixed,	5	...	...	...	739	111	655
Do. of Secondary Triangles of which all 3 angles have been observed,	4	1	15	26	6	213	188	80	533
Area of Secondary and Minor Triangulation, in square miles,	2300	2109	134	2136	2053	1036	1900	†1862	†13,530
Number of Points fixed by intersection, but not visited,	47	22	6	74	49	535	?	302	?
Length of boundary lines and check lines surveyed, in miles,	595	935	78	1608
Area Topographically surveyed on scale of 1 inch = 1 mile, in square miles,	†1279	†1279
„ Topographically surveyed on scale of 2 inch = 1 mile, in square miles,	1382	2036	...	3418
Number of Revenue Survey Stations and boundary pillars, fixed,	4	...	1	...	...	...	...	15	20
Do. of Principal Stations selected in advance, ...	2	6	18	6	...	3	...	...	...	35
Lengths of Approximate Series, Principal, in miles,	115	60	38	28	...	...	...	241
Number of Towers, constructed, ...	3	...	...	6	2	1	...	...	...	12
Do. Platforms constructed for Principal Stations,	14	4	9	11	...	...	...	38
Do. Platforms constructed for Secondary Stations,	12	8	...	...	...	...	20
Do. Miles of Rays cleared, ...	62	40	...	113	18	5	149	...	...	367
Do. Miles of path-way made,	99	...	5	24	...	...	...	129
Do. Hill tops cleared of forest and jungle, ...	6	2	15	9	11	10	...	...	...	53
Do. Principal Stations whose elements were computed,	5	...	...	11	7	...	...	...	23
Do. Secondary Stations whose elements were computed,	61	...	...	42	48	?	...	533	...
Do. Preliminary Charts of Triangulation,	1	...	...	1	1	...	...	...	3
Do. Principal Stations placed under official protection, ...	3	...	...	8	9	8	...	...	...	28
Do. Stations protected and closed, ...	3	...	...	9	10	8	...	...	...	30
Length of Line by double leveling, in miles,	245
Number of points whose heights were determined by Spirit Levels,	190
Number of points whose Latitudes have been determined Astronomically,	25
Length of Route Survey, in miles,
Number of Stations at which complete Tidal observations, have been made,	1
Area of unknown territory explored, in square miles,

† Including 302 Square miles of Trans-Sutlej Minor Triangulation.

† Excluding 93 Square miles of the Nepal border sketched from Kumaon.

APPENDIX.

EXTRACTS FROM THE NARRATIVE REPORTS

OF THE

EXECUTIVE OFFICERS IN CHARGE

OF THE

SURVEY PARTIES AND OPERATIONS.

Rules for pronouncing Indian proper names ; *a* has a variable sound as in *woman*, *rural*, *paltry* ; *á* as in *tartan* ; *i* as in *clique* ; *í* as in *ravine* ; *u* as in *bull* ; *ú* as in *rural* ; *o* as in *note* ; *e* as *a* in *say* ; *au* as *ou* in *cloud* ; *ai* as *i* in *ride* ; *g* as in *gong* ; *abad* as *ábád* ; *bazar* as *bázár*. Exceptions to spelling by rule are indicated thus **Calcutta*, **Calicut*, &c

**Extract from the Narrative Report—dated 16th July 1872—of W. C. ROSSEN-
RODE, ESQ., Deputy Superintendent 3rd Grade, in charge Bider
Longitudinal Series.**

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(2.) In compliance with Departmental Order No. 39, dated 31st August 1871, I assumed charge of the Bider Longitudinal Series, G. T. Survey, on the 6th November and the party took the field on the 20th December 1871.

(3.) During the recess of 1871 the party was engaged in the following computations which, owing to the continued illness of Messrs. Bell and Wrixon, progressed very slowly,—

|                                                                                                    |    |
|----------------------------------------------------------------------------------------------------|----|
| Spheroidal Excesses computed in duplicate .. .. .                                                  | 5  |
| Weights and Reciprocals of Observed Angles in duplicate .. .. .                                    | 17 |
| Computed angular corrections to Pentagon in duplicate .. .. .                                      | 1  |
| Number of Principal Triangles computed in duplicate .. .. .                                        | 5  |
| Number of deductions Latitudes, Longitudes and Azimuths of Principal Stations in duplicate .. .. . | 10 |
| Number of deductions of Heights of Principal Stations in duplicate .. .. .                         | 10 |
| Number of Secondary Triangles determining 14 intersected points in duplicate .. .. .               | 26 |
| Number of Latitudes, Longitudes and Azimuths of Secondary Stations in duplicate .. .. .            | 28 |
| Number of Heights of Secondary Stations in duplicate .. .. .                                       | 1  |
| The Preliminary Charts of the Bider Longitudinal Series for seasons 1869-70 and 1870-71 .. .. .    | 2  |

(4.) The country through which the operations were carried on was hilly throughout, very wild, difficult and unhealthy. The jungle was dense, the passes lengthy, tedious, steep and stony. In ascending and descending them, the pack bullocks (the only available carriage in this district) were mostly disabled in the early part of the season and were completely unserviceable on closing work. From sore feet and sore backs many died and others being unable to follow the camp were abandoned. The scarcity of rain and the failure of the crops greatly enhanced the difficulties; for supplies of every description had to accompany the camp and provisions had to be collected and brought from long distances. A depôt was established at each station for the use of the camp during its stay there, and the remainder sufficed for the stages between it and the next station. The arrangements for provisioning the party were good and no inconvenience was experienced during the whole of the field season. Owing to the drought, the streams which were abundant the previous season were found dry in many places.

(5.) Mr. Henry Beverley has in his Narrative Report of last season, 1870-71, described the country so carefully and minutely that I can add nothing more to it, for the country in which he worked was similar to that in which I was employed,—in fact, it was a part of the same country presenting the same features and peculiarities of configuration.

(6.) The sides of the triangles were mostly long. During favorable weather no detention occurred. I completed one station in December and five stations, including an Azimuth, in January. Marching was tedious and trying, and much time was lost in crossing over the hills through the (ghats) passes. It occupied my camp 8 days to reach Páncha Hill Station from Kauráribiding Hill Station, the direct distance being only 29·3 miles; each stage was from 12 to 16 miles and two of these were of greater length. The tortuous paths strewn with stones over the roughest ground traversed by man and beast was most trying to all in camp and more especially to the carriers of the great Theodolite, who although assisted by coolies could barely make much progress in ascending and descending these stony hill paths. To clear these paths of stones and rocks would cost immense sums of moucy and occupy months of labor. They were therefore merely widened for the great Theodolite by the jungle being cleared and by the removal of large rocks, or, if these could not be removed, by avoiding them.

(7.) The great Theodolite could not on two occasions come up, and the men had to bivouac in the jungles and join camp the next day. As has already been said much time was lost in marching from station to station owing to the circuitous routes we had to adopt to take advantage of the easiest known passes to cross over these mountain ranges. These delays would have been greater had not Mr. Beverley furnished me with the routes from station to station, and how they should be visited with reference to one another. He had been over the country and was able to give me the most direct routes to each station of each figure and all unnecessary detours were thus avoided by visiting each station according to the programme provided by him.

(8.) About the middle of February the jungle was fired in all directions and smoke spread gradually. The haze set in about the same time and the atmosphere became daily more unfavorable for observations, until the whole country was enveloped in haze and smoke, and nothing could be seen. Our luminous day and night signals could not penetrate this thick atmosphere.

(9.) From the 23rd February to the 24th March, I was detained at Munas Hill Station for the observations which were completed in a month during occasional breaks of favorable weather. At the above station not a single angle to lamps was observed. At the next station, Báli, I was again detained for nearly a month: a few showers of rain accompanied by storms, two of which were very severe, enabled me to complete my observations and released me from this station.

(10.) The above two stations furnished the base for the Southern Section of the Biláspur Meridional Series; and on completing them the junction with the Coast Series was accomplished.

(11.) I proceeded to Tuli Hill Station, the centre of the first pentagon of the Biláspur Meridional Series Southern Section. Occasional showers of rain enabled me to progress rapidly with the final observations which terminated at Bárdwár Hill Station on the 4th May 1872. There was sickness during the whole field season, but at Bárdwár 10 and 12 men were daily prostrated with fever; I therefore closed work and returned to recess quarters. My second attack of fever occurred here and I returned to Wálter by dák and was seriously indisposed on the journey; since my arrival I have had frequent returns of fever.

(12.) There was very great sickness in camp this field season, not a single man in the whole party escaped from fever. My first attack occurred at Kálingkonda Hill Station, my third Station in January, while observing an Azimuth there. I persevered with the observations notwithstanding my daily bouts of fever. Fortunately Mr. Beverley was in camp and assisted me both in the observatory and office, and I am greatly indebted to him, for had he not been present, the star could not have been observed by me single-handed owing to the bad state of health I was in at the time.

(13.) Sickness reduced the strength of my native establishment considerably, and so crippled me that I had to carry the stand and telescope of the great Theodolite and most of the Government property on coolies. Some of the sick men were useless during the whole field season and were sent home when I returned to recess quarters. Those men who returned with me comparatively well have, since coming in, had frequent relapses of fever, and most of them have enlarged spleens and are still in hospital under treatment. There were no casualties in the field, but since returning to Wálter 5 deaths have occurred, 4 from fever and 1 from dysentery.

(14.) The operations have entered the Bastar and Jaipur states, and I believe the country will improve as we proceed northwards, and there will not be so much sickness during the ensuing season in the more open country through which the operations will be carried on.

(15.) Wild animals are very numerous in the tract triangulated last season, and tigers are most destructive: villages have been deserted and some of the passes have been closed owing to their depredations. While engaged in observations at Kaurálbiding Hill Station, I ordered a good portion of my camp to proceed to the first stage *en route* to Páncha Hill Station and to await my arrival there. These men were kept at bay for hours by a tiger which I was informed took possession of the road that had been cut for the great Theodolite. The camp moved on in a body when he had retreated into the jungles after the men had yelled and shouted for hours. Often the villagers cautioned us not to proceed by paths which were in possession of these man-eating tigers, which, waiting their opportunity, carried off numbers of people as they, unsuspecting of danger, travelled on the path.

(16.) The inhabitants are few and the hamlets very distant from one another. Very few large villages were met with. Frequently a single large hut was seen; its occupants consisted of fathers, sons, and grandsons with their wives and children. A spring of water or a stream, a small cleared patch of ground for cultivation of grain, with a few lime, orange, jack and mango trees were sufficient to satisfy the wants of the family. The inhabitants are steeped in ignorance and vice: men, women and children drink toddy from the sago palm, or distil spirits from the Mau flowers which they also dry and retain for food. They drink to excess, are very poor and wear a rag 4 inches wide and two feet long to hide their nakedness. Among some of the hill tribes nude figures are the rule and not the exception. The authorities have tried to civilize them by distributing cloth among them but they will not clothe themselves.

(17.) Owing to the party being short-handed, by the absence of Mr. Bell on furlough and the crippled state of my native establishment during the entire field season from sickness, very little secondary work has been done: what has been accomplished has been executed by me

with the great Theodolite. A great deal more could have been done had I men to renew the hill marks of the Topographical Survey which were consumed by fire and had the weather been favorable. Many of the poles of the Topographical Survey, indicating their stations, were observed from one station only, the weather becoming unfavorable they could not be seen from Munas and Báli Hill Stations when the jungle was fired and the haze set in.

(18.) I was not unmindful of the importance and value of Secondary work in connection with our principal operations. I trained Mr. Wrixon for the work and detached him on the 24th February to lay down Jaipur, but want of experience and bad weather prevented his completing the Secondary work I assigned to him.

(19.) Mr. Henry Beverley, Surveyor 1st Grade, was detached on the 17th January after the Azimuth observations at Kálingkonda Hill Station to extend the Approximate operations. He revisited Bárdwár and Saikárpan Hill Stations which he had fixed the previous season, and continued his operations and connected with the stations of the Northern Section Biláspur Meridional Series Malewa and Bannai. The fruits of his labors are 16 stations selected, the hills cleared of jungle and platform's constructed. His zeal and energy have been most conspicuous, for notwithstanding the great sickness among his men he pushed on until he completed his portion of the work and effected a satisfactory connection with Mr. Clarke who carried on the Approximate Series of the Northern Section. Mr. Beverley was delayed by bad weather, and as the season was far advanced and the men of his establishment were prostrated with fever he could not undertake Secondary work. He joined me at Tulsi Hill Station and remained in camp assisting me at two more stations Pothdongri and Saikárpan; he was again detached to alter a compound figure into two single ones. As the whole of the Approximate work has been completed, Mr. Beverley can, the next season, be employed uninterruptedly on Secondary operations.

(20.) Mr. E. P. Wrixon, Assistant Surveyor 2nd Grade, was employed in recording observations and in current office duties until the 23rd February. He was detached on the 24th of the same month to lay down the town of Jaipur by a series of Minor Triangulation, and after that to lay down the town of Bastar. Owing to the hazy weather during the latter part of February, the whole of March and the first week in April, he was unable to do any work as he was aiming to connect Jaipur with large triangles. This is the first time Mr. Wrixon has been detached on Secondary Triangulation, I trust his want of experience combined with the unfavorable weather which set in immediately after he was detached will plead for him for the small out-turn of work. Mr. Wrixon twice suffered from fever in the field and his detachment suffered greatly from repeated attacks of fever.

(21.) In conclusion I have to refer to the Hospital Assistants who were with me during the last field season. The first-class Hospital Assistant who accompanied me from Wálder was an experienced, attentive man and fully competent to take charge of a large camp. He was however old and infirm and was very soon disabled from repeated attacks of fever. A second-class Hospital Assistant succeeded him; this man had been employed under Colonel Saxton, Deputy Superintendent Topographical Survey, in charge No. 3 Party. He was acquainted with the country and he could not help joining when posted to the Bider Longitudinal Series, but he was so intimidated that shortly after joining he complained of illness. He travelled in a dǔli and was of very little use during the remainder of the season. He was always complaining of his own illness and the sickness in camp, and was continually urging me to close work after the 1st April. On the plea of ill health he was inattentive and careless. He went to hospital shortly after my arrival at Wálder, and has obtained leave on Medical certificate for 7 months. The third-class Hospital Assistant doing duty at present with me promises well.

(22.) The following is the out-turn of work executed during the field season:—

|                                                                                                                                   |      |
|-----------------------------------------------------------------------------------------------------------------------------------|------|
| Principal stations newly fixed .. .. .                                                                                            | 13   |
| No. of Principal Triangles completed .. .. .                                                                                      | 18   |
| Area of Principal Triangles in square miles completed .. .. .                                                                     | 3041 |
| Length of Principal Series in miles .. .. .                                                                                       | 128  |
| Azimuth of verification .. .. .                                                                                                   | 1    |
| No. of Secondary Stations whose positions and heights have been fixed .. .. .                                                     | 7    |
| No. of Secondary Triangles of which all three angles have been observed .. .. .                                                   | 1    |
| Area of Secondary Triangles exterior of Principal Triangulation, square miles .. .. .                                             | 2109 |
| No. of points fixed by intersection but not visited .. .. .                                                                       | 22   |
| No. of Principal Stations selected in advance including Malewa and Bannai of Northern Section, Biláspur Meridional Series .. .. . | 18   |
| Length of Approximate Series in miles .. .. .                                                                                     | 115  |
| No. of Platforms constructed for Principal Stations .. .. .                                                                       | 14   |
| No. of miles of pathway made .. .. .                                                                                              | 99   |
| No. of hill tops cleared of forest and jungle .. .. .                                                                             | 15   |
| No. of Stations protected and closed .. .. .                                                                                      | none |

The area of the Principal and Secondary Triangles completed during the field season 1871-72 is 5150 square miles, at a cost of Rupees 34,768-12-8, which gives a rate of Rupees 6-12-6 per square mile.

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**Extract from the Narrative Report—dated 12th July 1872—of W. G. BEVERLEY, ESQ., Assistant Superintendent 2nd Grade, in charge of the Eastern Frontier Series (Assam Valley Triangulation).**

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(2.) The party marched from Gowhatty on the 17th December via Naugong, and proceeded on to Kankochan Hill Station where I arrived on the 2nd January.

(4.) At the close of last season there were only two stations selected and built in advance, and although Mr. O'Sullivan had laid out the Khelibúishon pentagon, he was doubtful whether the stations of Cheniábúishon H. S. and Sapanajung H. S. as then selected, were mutually visible, as he had not been able to determine that point finally the previous season from the very unfavorable weather at its close. The rejection of one of these points and the conversion of the figure into a series of simple triangles seemed also probable. I therefore waited at Kankochan H. S. until Mr. O'Sullivan had decided on the position of the forward station Cheniábúishon H. S. which he did by the 9th. The principal observations at this station being completed I marched on to Khelibúishon H. S. and having taken all the observations there, I proceeded to Chenghchishon H. S. where I arrived on the 24th January. I was detained here four days waiting for the signal at Sapanajung H. S. On the evening of the 27th I received a letter from Mr. O'Sullivan informing me that he had at last been compelled to reject that point and I closed at this station and left on the 28th January.

(5.) I had desired Mr. O'Sullivan to reject Sapanajung H. S. in case he should not be able to see it from Cheniábúishon H. S. as the best part of the field season had already gone and much time had already been lost. The station of Cheniábúishon H. S. is situated on the outermost of a series of parallel ridges of uniform height and densely wooded, the site selected was the only one which could command a view of the plains to the North and East and also be visible from the back stations, hence it was not considered advisable to remove it, as it would not only have created delay, but involved re-observing the angles at two stations, but above all made it difficult to carry the series into the plains which it had now become necessary to do.

(6.) Mr. O'Sullivan had reported on his return to recess quarters at the close of the field season of 1870-71, that he had received reliable information that the Lotha Nágás across the Dhunsiri River would prevent the entry of any Survey parties into their district. As this information had not been alluded to in the General Report, nor in the instructions for next season's work, the method of procedure for carrying the triangulation into the plains and other considerations involved, were not discussed by me at Head Quarters with yourself. I was informed by the Commissioner of Assam when I requested his opinion as to entering the Lotha Nága hills, that no Survey operations could for the present, be carried on in the tract in question, as the tribes were hostile.

(7.) I was in hopes however that it might have been possible to carry on a series, with alternate stations in the plains and in the outermost low range, which from the maps, appeared to lie in and along British boundary and were uninhabited, and I communicated with the District Officers on the subject and was informed, after considerable delay, that the Sibságar District had been closed to the Hill tribes and stockades erected to prevent their ingress into Assam; that no Survey party could enter into the Hill Districts without a very strong body of police, which could not then be furnished, and that the maps were quite untrustworthy, as the British boundary was at least 7 or 8 miles from the foot of the hills.

(8.) My plans for continuing the triangulation along the hills having thus been baffled in every way, I was compelled to resort to the plains and the triangulation was carried down on the side Kankochan H. S. to Cheniábúishon H. S. With the hope of being able to obtain peaks on the outer range, the station of Golághát had been selected by Mr. O'Sullivan and a platform and pillar built. As the hills were no longer available, Mr. O'Sullivan was directed to carry the series by symmetrical, single triangles through the plains of Sibságar.

(9.) It was some time before I could decide on the most suitable course the series should take; proceeding in a direct line was inadmissible as the centre and southern portion of the District is studded with tea plantations and grants, the owners of which were not at all disposed to have lines run through their estates, or their property injured, even on payment of compensation, which was given in one instance last season, and was excessive in regard to the damage sustained. This was a consideration of the utmost importance as the means at the disposal of the party would not admit of such heavy compensation as would be demanded, while the progress of the work would probably be delayed by opposition and litigation. I therefore decided on carrying the series along the course of the river by which means very heavy jungle cutting, as well as tea plantations would be avoided and the height of the towers would be reduced, and there would be little or no compensation to be paid, thus making it the most economical course to adopt; at the same time the triangulation was not intended to be restricted to the river, but to deviate therefrom whenever it should be found necessary.

(10.) When the direction of the series had been decided upon I returned to the hills and visited Cheniábúishon H. S. and took the observations there, including those to Golághát T. S. and Bor-Chapri T. S. at the latter of which stations Mr. O'Sullivan had now built a masonry pillar. Observations at Cheniábúishon H. S. were completed on the 23rd February, at Bor-Chapri T. S. on the 26th and at Golághát T. S. by the 7th March. After this I took up the Approximate work until the beginning of April, returning to Kankochan H. S. to complete the observations to Bor-Chapri T. S.

(11.) The Approximate work during the past season has been carried only a very short distance owing to the lateness of the season, the nature of the country, the scarcity of local labor and the continued unfavorable weather. The out-turn of work is small but no energy has been spared, nor means untried to overcome the difficulties which had to be encountered and which are in my opinion greater than in any other part of India. The difficulties experienced in the selection of stations in the plains of Assam are manifold.

(12.) The country does not slope down gradually from the foot of the hills to the Bráhmáputra River, but consists of a succession of low ridges frequently covered with almost impenetrable jungle, not running parallel to the streams which generally flow down from the mountains at right angles to the river, as may be naturally supposed, but in most instances at right angles to those streams, with an abrupt fall into the basin of the Bráhmáputra. It is difficult in such undulating tracts with wide level bits of country, to fix upon any particular length of side, and it was found imperative to have the side Golághát T. S. to Madaigáon T. S. 10.4 miles, while the height of the tower at the latter place, it will be necessary to build over 30 feet to ensure mutual visibility. The series carried along the course of the river will render so great a height unnecessary for future stations.

(13.) Frequently extensive patches of tall grass and reed jungle were met with, which elephants were employed, by Mr. O'Sullivan, to crush down on the rays, by means of heavy logs dragged by them. In some places the rays have been carried through boggy and swampy ground with thick tall reeds which had to be cut one by one. Occasionally belts of jungle had to be traversed, the trees in which, with few exceptions, were of no great diameter, but were so interlaced with canes and bamboos, and had so heavy an undergrowth, that it was a most arduous and tedious undertaking to carry a narrow gap through. Between Bor-Chapri T. S. and Nikori Chapri T. S. Mr. O'Sullivan was occupied nearly three weeks in carrying a ray, the undergrowth on which was not only very heavy, but hid from view high mounds raised by earth-worms. In ground of this nature prambulators were useless and Mr. O'Sullivan adopted a rope 132 feet long made impervious to wet by means of wax and oil, and which was tested every morning.

(14.) Local labor was rarely procurable in Assam and the District Officers scarcely gave us any assistance whatever, although the villages occasionally met with were able to furnish a large number of coolies, and with proper parwáns the mauzádárs would have readily provided them. The difficulty of obtaining supplies for the camp was also a source of delay. These difficulties are however likely to be very much diminished next season, and with a better knowledge of the country and our requirements, an establishment now trained to plain's work, the progress in the ensuing season may be confidently expected to be more rapid and satisfactory.

(16.) The triangulation in the hills traversed the country of the Míkir and Ringmáh Nága Tribes whose characteristics have been already described by Mr Rosseirode, as well as the various insect annoyances, to which the party was also subjected during the last field season, though not to the same extent. No annoyance was experienced from tigers and wild elephants.

(17.) Very little Secondary work has been obtained, smoke and haze obscured the atmosphere from about the middle of January, and though occasional sharp showers cleared the air for a day or two, the distant peaks were invariably enveloped in haze and fog. Throughout the season, the weather has been very unfavorable, there had hardly been a week of uninterrupted dry weather, and at the beginning of April the rains were so heavy, that, in two days the plains were completely submerged.

(18.) The district of Sibságar in Upper Assam is one of the healthiest in the province and unless the rains are protracted, field work can be resumed early in November with safety. The atmosphere is generally very clear throughout that month and up to the middle of December, and I have hopes of being able to get a large amount of Secondary work early next season, soon after taking the field, which I purpose doing in the beginning of November. The health of the establishment was on the whole pretty fair. Four deaths occurred during the season, two of which were from complaints of long standing. The party arrived in recess quarters in the first week of May.

(19.) Mr. O'Sullivan accompanied me from Gowhatty. Before taking the field he was employed in equipping and organizing the Native Establishment and in training men in the use of the heliotope. As soon as Mr. O'Sullivan had fixed the station of Cheniáúishon H. S. he descended into the plains and was employed on the Approximate Series. He selected 4 stations, built masonry pillars at two, carried about 55 miles of trial and 30 miles of final rays, and was compelled to close work on the 20th of April from want of supplies. Mr. O'Sullivan's progress, in spite of the great difficulties and hardships he had met with, is very good. His thorough knowledge of Assam and its people, his determination and energy, and zeal for his duties, combined with professional aptitude, render him the best fitted for conducting so difficult and troublesome an operation as the Approximate series in the Assam Valley.

(20.) Mr. Bryson accompanied me to Kankochan H. S. as observatory recorder and also took part in the principal observations at two or three stations. On Mr. O'Sullivan's taking up the Approximate work in the plains, he was at first employed to superintend the building of one station and to carry a ray from Golághát T. S. to Madnigáon T. S. Subsequently he was deputed to Secondary work chiefly with a view of fixing all the Revenue Survey paka pillars on either side of the Bráhmáputra River. Mr. Bryson from an utter want of energy and interest in his duties, has repeatedly failed to carry out my instructions, or to complete the work allotted to him.

(21.) Mr. Harris was transferred temporarily from the Bráhmáputra Series for the purpose of building the pillars required on the Eastern Frontier Series. He was much delayed by the unusual detention of the Assam steamer and joined the party on the 17th March. He took up the work assigned to him at once, and although new to the country and the language, was able to make his arrangements with his usual judgment and prudence. The continued heavy rain throughout the time he was engaged on his work threw him back considerably, and he could only complete two pillars and build the foundation of a third to a height of 1 foot, besides preparing materials &c., for a fourth station. Mr. Harris returned to recess quarters some time after the rest of the party, on the 28th May.

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**Extract from the Narrative Report—dated 15th July 1872—of Lieutenant M. W. RO-  
GERS, R.E., Officiating Deputy Superintendent 3rd Grade, in charge  
Bombay Party.**

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(1.) The Head Quarters left Bangalore on the 6th November and marched to Gutti and thence by train to Raichure, reaching the first station of the season, a few miles north of the river Kistna, on the 26th November. I at once commenced observations and continued them without intermission until the series was brought up to the sides Shilapali-Goraegat-Topkonda of Sir Andrew Waugh's Great Arc. This was completed on the 1st March.

(2.) The country, through which the series passed this season, belongs to H. H. the Nizám and is apparently little known or visited. About 20 miles north of the Kistna, a range of hills runs from east to west, parallel to the river, which is about 1200 feet above the sea;

on ascending this range the country is hilly and very stony in parts, and with a mean elevation of 1800 feet. There are no roads and the villages &c. seem to be generally in a state of decay, owing, I was told, to the failure of the rains for some years past. The greatest portion of the country traversed was Jágír-land, held by noblemen who reside in Haidarabad, and have apparently no care whatever for their dependents. In most of these Jágírs the Nizám's authority seems only nominal; the present Minister, Sir Salár Jáng, is however improving this state of things and is resuming all the Jágírs which were held for military service and are not family possessions. This has been done in several cases under my own notice, and the result to us has generally been—that where, under the Jágírdár, my assistant last year complained of hindrance and incivility, I have been agreeably surprised at the difference under the new *régime*. The new state railway runs across this tract of country and will probably bring roads and a better state of things in its wake.

(3.) The country to the west of the series is very stony; slate of a rough description is plentiful and is used in many places for roofing, and all the villages are built of a whitish stone which gives them a neat and clean appearance at a distance.

(4.) Towards Bider the whole country rises again and forms a second plateau, with an elevation of about 2000 feet. Along the southern portion it is covered with thick jungle, which, together with the flatness of the ground, caused considerable delay and trouble in effecting a junction with the old work which itself appears to have been carried out of the meridian in order to avoid that portion of the country. The soil about Bider is red, and ironstone abounds, and at Koyer and many other villages a good deal of iron is smelted; they do not, however, quarry very much, but use the ironstone gravel which seems very rich in metal.

(5.) On the completion of the Principal Series, I took up a Minor Series to fix the city of Haidarabad, and the cantonment of Sikandrabad. I used the 24-inch Theodolite in all cases save one, where I was obliged to choose a very rocky and difficult hill, in place of the hill of Golkonda, which I had reckoned upon occupying. At the instance of the Resident, my signaller was allowed to make a mark and shew his heliotrope from the fort, but when I arrived near the city myself, I was informed that no European was allowed into the fort or ever had been, so I was obliged to select a new point. Save the Chár Minár, a large building at the junction of the main streets, there are no prominent buildings in the city itself; the Mecca Masjid, though a well built handsome building, having no minarets of any size. This Series was finished on the 6th April. The next portion of the revision was 100 miles north and the weather had by this time become very hazy and hot, so I determined to march back to Gulbargah which I reached on the 14th.

(6.) I there placed the theodolite, tents &c. in safety and proceeded by train to Bangalor, which I reached on the 20th April.

(7.) The principal work of the field season has been as under;—

The series has been advanced 86 miles and completed. 56 angles have been observed at 16 Principal Stations forming the northern portion of a double polygon, one double polygon and the larger portion of a double polygon and compound figure, which forms the junction of the two series; the whole covers an area of 3099 square miles. An Azimuth was observed at Kodangal S., and 4 Zenith distance stations fixed around for Captain Herschel. 34 Secondary angles at 2 principal and 8 secondary stations were observed, on the Haidarabad Series, with the 24-inch Theodolite, covering an area of 832 square miles. (All Secondary and Intersected points, observed by the party, were fixed in height as well as position.)

(8.) Aneroid Barometer observations for height have been carried on regularly throughout this and the last field season whereby the heights of all the hills on which the stations are, and halting grounds, have been fixed. This season the heights of hills have been taken by simultaneous observations with two aneroids, a method of very fair accuracy. I have the honor to forward herewith a list of heights in the series from Bangalor to Bider and Haidarabad, containing two lines of road and numerous places in the districts. The heights from Bangalor to Gutti, were determined by simultaneous observations. Captain Herschel arranged to place his assistant and barometer at my disposal and I marched to Gutti, myself one stage in advance, whereby daily simultaneous differences were taken, the barometers being compared every evening. This arrangement when practicable should be very fairly correct. I shall be obliged, should this table of heights be printed, if a few copies of the table be printed separately and forwarded to me, as myself and Major Brauffill often receive applications for heights in Mysor &c.



(9.) At the instance of the Resident, Mamsabdárs were appointed by H. H. the Nizám's Government to accompany the camp of myself and Mr. Price. The one for the latter gentleman did not appear, but to Mamsabdár Muhammad Faiyázuddín Khán and his sepoys who accompanied me I am much indebted; without their aid, I should inevitably have been delayed, and possibly have been brought into unpleasant collision with the employes of the Jágirdárs; as it was, I had very little trouble. My best thanks are due to the Resident and H. H. the Nizám's Minister for the help they rendered to me.

(10.) Mr. Price was employed in selecting and building stations on the Approximate Series; he selected 6 and built 13, besides selecting 8 Zenith distance stations for Captain Herschel. I have alluded to the difficulties of the junction figure, which necessitated a high perforated pillar station with a wooden platform for the observatory tent. Whilst selecting and building near Nander on the Sironj-Bider section of the Arc, his camp was attacked by small-pox and I am sorry to say he lost his wife; he himself suffered severely at the same time from fever, and I therefore directed him to rejoin me at Gulbargah whence he proceeded to Bangalor with the Head Quarters. As usual his work has been good and he has spared himself no exertion to carry it on; he is a very praiseworthy and able assistant. He has had the entire selection of the Series, and I trust that on the completion of his 9 years service he may be promoted.

(11.) Mr. Bond worked at and completed the Kadapa (Cuddapah) Minor Series, he triangulated a direct distance of 90 miles by 11 triangles covering an area of 1124 square miles, his instrument was a 10-inch Theodolite and his average triangular error 1.36 seconds. In addition he fixed 33 intersected points and closed all the stations of his initial sides. After finishing at Kaddapa he marched to Karnúl and began a short series to connect that place, but his health gave way under the exertion and great heat and he was ordered by the Surgeon of Karnúl to return to Bangalor. I have already communicated with you on the state of his health, which has been severely tried in the department. The quality of his work speaks for itself and I am entirely satisfied with it and that he has worked to the utmost of his power.

(12.) Mr. Torrens accompanied me as recorder for the first six weeks, during which time he instructed Mr. Oldham in his work; he then went with Mr. Price and selected and built a principal station, after this he prepared the Haidarabad Series; I then sent him to Captain Herschel under whose directions he marched north and selected 3 stations for Zenith distance observations and also reconnoitered the country with a view to choosing stations for doubling the Great Arc at that point. This year has been his first at any independent work and I see no reason to alter my favourable opinion of him. He has now served his time for promotion which I trust he will get when a vacancy occurs.

(13.) Mr. W. Oldham joined the department in October, from Bishop Cotton's School at Bangalor where he had been acting as under Master; he has been with me as recorder during the season and worked well and obtained all the necessary knowledge in departmental forms. At the end of the season he closed 3 stations independently and has altogether given me satisfaction.

(14.) During the last recess, one double Polygon, one Pentagon and one Azimuth were computed, together with all the Secondary work, bringing up the Series to date.

*Heights in Mysor, Ballári (Belary), Kadapa (Cuddapah) and the Nizám's Dominions.  
\* Bombay Party. Seasons 1869-70-71-72.*

| Name of Placc.                 | Ancroid Height. | Trigonometrical Height. | Remarks and Descriptions.                                                                                   |
|--------------------------------|-----------------|-------------------------|-------------------------------------------------------------------------------------------------------------|
| Bangalor ... ..                |                 | 2989                    | Barometer Cistern in Civil Hospital.                                                                        |
| Nellamangalam ... ..           |                 | 2905                    | Ground level at Traveller's Bungalow.                                                                       |
| Sompur ... ..                  |                 | 3050                    | Ditto           ditto.                                                                                      |
| Tumkur ... ..                  |                 | 2681                    | Ditto           ditto.                                                                                      |
| Rámádeverabetta H.S.           |                 | 3883                    | Trigonometrical mark on hill near Tumkur.                                                                   |
| Agraharam village ... ..       | 2530            |                         | By bridge over Surnamuky River South bank.                                                                  |
| Maddagiri village ... ..       |                 | 2462                    | Road outside gate on Sirah road.                                                                            |
| Do. H. S. ... ..               |                 | 3935                    | On corner tower of highest fort on drug.                                                                    |
| Maddágaisi village ... ..      |                 | 2452                    | On Paugarh road opposite Police thánah.                                                                     |
| Do. Drug ... ..                |                 | 3376                    | Highest point of hill.                                                                                      |
| Maddak Sira village ... ..     |                 | 2173                    | On Paugarh road in tope beyond Town.                                                                        |
| Do. Drug ... ..                |                 | 2936                    | Col. Lambton's old station mark.                                                                            |
| Raddam village ... ..          | 1902            |                         | In tope S. of village.                                                                                      |
| Pennakonda ... ..              | 1862            |                         | In tope outside walls close to Bangalor road.                                                               |
| Do. H.S. ... ..                |                 | 3091                    | On stone on the highest portion of fort.                                                                    |
| Hindupur ... ..                |                 | 2068                    | ⊙ on Temple N. of Town.                                                                                     |
| Yerrakonda H.S. ... ..         |                 | 2820                    | 2 miles West of Gutti road at 69th milestone.                                                               |
| Innagur H.S. ... ..            |                 | 2900                    | Kadapa District. ⊙ on side of hill.                                                                         |
| Mitiapalli village ... ..      |                 | 1929                    | Village West of Innagur, in tamarind tope.                                                                  |
| Halsurbetta H.S. ... ..        |                 | 3341                    | A little West of Gutti road at 16th milestone from Bangalor.                                                |
| Do. village ... ..             |                 | 2994                    |                                                                                                             |
| Ambaji Drug H.S. ... ..        |                 | 4339                    | ⊙ on high hill 2½ miles W. of Chintamanipet.                                                                |
| Do. village ... ..             |                 | 2989                    | Tope N. of village at foot of hill.                                                                         |
| Maunkli Drug H.S. ... ..       |                 | 3610                    | On road from Pedda Ballapur to Hindupur.                                                                    |
| Do. camp ... ..                |                 | 2562                    | At 11th milestone from Pedda Ballapur.                                                                      |
| Suntapur village ... ..        |                 | 2663                    | 3½ miles N.N.W. of Doduirnanga.                                                                             |
| Paugarh H.S. ... ..            |                 | 3026                    | On Sultán's Battery in Drug.                                                                                |
| Do. village ... ..             |                 | 2062                    | On high road below the drug ; outside village.                                                              |
| Chikápilli village ... ..      | 1848            |                         | 14 miles from Paugarh on road to Ráidrug.                                                                   |
| Kamakonda Drug ... ..          |                 | 3537                    | High hill ½ mile East of road.                                                                              |
| Kumbadúr village ... ..        | 1781            |                         | 18 miles from Paugarh on road.                                                                              |
| Dasranpilli village ... ..     | 1807            |                         | 27   ditto ditto ditto.                                                                                     |
| Kallían Drug H.S. ... ..       |                 | 2383                    | ⊙ on platform in fort, E. of village.                                                                       |
| Do. village ... ..             | 1838            |                         | 35 miles from Paugarh. Tope E. of village.                                                                  |
| Davandelbetta H.S. ... ..      | 2395            | 2434                    | 2 miles N. W. of Kallían village.                                                                           |
| Urakonda H.S. ... ..           |                 | 2193                    | ½ mile East of Gutti-Bangalor Road at the 105th milestone ; near Chinna Kotapilli village.                  |
| Kaunagaunpalli village ... ..  | 1384            |                         | 17 miles from Chinna Kotapilli on the road from Darnaveram to Kallían Drug.                                 |
| Kondapilli village ... ..      | 1582            |                         | Camp between Hill and Village.                                                                              |
| Do. H.S. ... ..                | 2286            | 2259                    |                                                                                                             |
| Hahnúr village ... ..          | 1175            |                         | Camp S. of village.                                                                                         |
| Davarkonda H.S. ... ..         | 1824            | 1840                    | Near tank E. of Hundi Anantápúr.                                                                            |
| Do. camp ... ..                | 1163            |                         | On side of tank E. of hill.                                                                                 |
| Kudligi village ... ..         | 1332            |                         | 13 miles from Anantápúr on Ballári Road.                                                                    |
| Uderpi Drug village ... ..     | 1298            |                         | Camp S. of village on Ballári Road.                                                                         |
| Do. H.S. ... ..                | 1731            | 1725                    |                                                                                                             |
| Zenith distance station ... .. |                 | 1570                    | 2 miles S. W. of village.                                                                                   |
| Honúr H.S. ... ..              |                 | 1583                    | 1 mile N. E. of village on old Ballári Road.                                                                |
| Gaddakal village ... ..        | 1429            |                         | Camp N. of village in tamarind tope 22 miles from Ballári on the Gutti Road ⊙ General Cullen's height 1420. |
| Do. H.S. ... ..                | 1790            | 1823                    |                                                                                                             |
| Aminapalli village ... ..      | 1270            |                         | Camp on road S. of tank.                                                                                    |
| Gundakul ... ..                |                 | 1432                    | ⊙ on roof of railway station. Genl. Cullen's 1500.                                                          |
| Ballári Fort ... ..            |                 | 1976                    | Base of Flagstaff in chief battery. ⊙                                                                       |
| Do. Railway Station ... ..     |                 | 1484                    | Railway levels.                                                                                             |
| Gutti ... ..                   | 1238            |                         | Town ; at cemetery foot of drug.                                                                            |
| Do. Drug ... ..                | 2136            | 2101                    | Highest point.                                                                                              |
| Namthahad S. ... ..            |                 | 1173                    | Trigonometrical station 3 miles S. of Gutti.                                                                |
| Kadrápilli village ... ..      | 1175            |                         | Camp ¼ miles N. of Nágasamudra village.                                                                     |

*Heights in Mysor, Ballári, Kadapa and the Nizám's Dominions.*  
 \* *Bombay Party. Seasons 1869-70-71-72—(Continued.)*

| Name of Place.           | Aneroid Height. | Trigonometrical Height. | Remarks and Descriptions.                                     |
|--------------------------|-----------------|-------------------------|---------------------------------------------------------------|
| Boglemarkonda H.S. ...   | ...             | 2350                    | ⊙ on top of hill.                                             |
| Kondántur village ...    | 1024            |                         | Camp in tope N. of village $\frac{1}{2}$ mile W. of road.     |
| Paumdi H.S. ...          | ...             | 1680                    | Flat topped hill close to Bangalor-Gutti Road.                |
| Yainigamarri village ... | 1634            |                         | $\frac{1}{2}$ mile N. of village and E. of Karnúl-Gutti road. |
| Sudápalli village ...    | 1155            |                         | Camp by tank 2 miles E. of Karnúl road.                       |
| Kottúr village ...       | 1357            |                         | Camp E. of village.                                           |
| Katomoraj H.S. ...       | 2052            | 2053                    |                                                               |
| Shítabanda village ...   | 1373            |                         |                                                               |
| Bandimaddagu village ... | 1457            |                         |                                                               |
| Pulíkonda H.S. ...       | 1811            | 1802                    | ⊙ on solid tower 16 feet high.                                |
| Hospetta village ...     | 1321            |                         |                                                               |
| Gongondla village ...    | ...             | 1354                    | Highest point of low rocky hill.                              |
| Kerra Bellágal H.S. ...  | ...             | 1423                    | Hill S. E. of village of Kerra Bellágal.                      |
| Krishnadodi village ...  | 1055            |                         | Camp on bank of tank W. of village.                           |
| Adoni Drug H.S. ...      | 1997            | 2000                    | Trigonometrical ⊙                                             |
| Malliabad H.S. ...       | ...             | 1771                    | Hill 4 miles S. of Ráichur. Nizám's country.                  |
| Do. village ...          | 1372            |                         | Camp on a knoll E. of village.                                |
| Darrur H.S. ...          | ...             | 1805                    | In Geddáwal Rája's territory.                                 |
| Do. camp ...             | 1257            |                         | N. foot of hill ditto.                                        |
| Nandinia village ...     | 1210            |                         | Camp in palmyra tope E. of village.                           |
| Kottápalli H.S. ...      | 1576            | 1579                    | 4 miles N. of Kistna River.                                   |
| Do. camp ...             | 1285            |                         | Half way between hill and village.                            |
| Chintalíkinta H.S. ...   | ...             | 1759                    | In Deodrug táluk 8 miles S. of the Kistna.                    |
| Do. village ...          | 1285            |                         |                                                               |
| Janikalu H.S. ...        | ...             | 1555                    | In Manwi táluk 9 miles N. of the Tongábudra.                  |
| Do. camp ...             | 1292            |                         | Close to hill, opposite side to village.                      |
| Kinkerray village ...    | 1251            |                         |                                                               |
| Yedagiri village ...     | 1225            |                         | G. I. P. Railway Station is $1\frac{1}{2}$ miles W.           |
| Bima River ...           | 1164            |                         | Naikal Ferry. Water level in December.                        |
| Ditto ...                | 1189            |                         | Ditto on West bank.                                           |
| Naikal H.S. ...          | ...             | 1611                    |                                                               |
| Do. village ...          | 1207            |                         |                                                               |
| Yedagiri Drug ...        | ...             | 1792                    | Highest Tower.                                                |
| Gannápur village ...     | 1328            |                         | $\frac{1}{2}$ mile E. of village.                             |
| Narúnpet village ...     | 1454            |                         | Rája's garden N. of Town.                                     |
| Muktul village ...       | ...             | 1295                    | Roof of highest house.                                        |
| Ípáhgat H.S. ...         | 2308            | 2340                    |                                                               |
| Do. camp ...             | 1758            |                         | $\frac{1}{2}$ mile S. of Trivallapur village.                 |
| Yeddalapuram village ... | 1960            |                         | $\frac{1}{2}$ mile E. of village above the ghát.              |
| Undurke village ...      | 1732            |                         | $\frac{1}{2}$ mile S. W. of village.                          |
| Korlah village ...       | 1565            |                         | $\frac{1}{2}$ mile S. of village.                             |
| Hudngi S. ...            | 1440            | 1438                    | Trigl. Station in field 1 mile N. of village.                 |
| Andaki ...               | 1445            |                         | Camp close to North of village.                               |
| Nellagat H.S. ...        | 2048            | 2036                    |                                                               |
| Rabbanpalli village ...  | 1892            |                         | Camp half way between hill and village.                       |
| Chittapalli village ...  | 1862            |                         | In tope on road S. of village.                                |
| Kodungal S. ...          | 1907            | 1914                    | On rising ground 2 miles N. of village.                       |
| Kushgi ...               | 1706            |                         | Tope N. of Town on road from Kodungal.                        |
| Worval ...               | 1739            |                         | $\frac{1}{2}$ mile W. of large tank and N. of road.           |
| Antawaram ...            | 1825            |                         | N. E. of village.                                             |
| Pochanagat H.S. ...      | 2371            | 2358                    |                                                               |
| Kusmasamudram ...        | 2008            |                         | Close to village on S. side.                                  |
| Tandúr ...               | 1508            |                         | East of village near tombs of Nizám's officers.               |
| Gannápur H.S. ...        | 1584            | 1606                    |                                                               |
| Índúr village ...        | 1658            |                         | Close to West side.                                           |
| Daravid ...              | 1738            |                         | Tope E. of village.                                           |
| Anantagiri H.S. ...      | 2311            | 2311                    |                                                               |
| Keravalli ...            | 1934            |                         | $\frac{1}{2}$ mile N. close to hill.                          |
| Koatpalli ...            | ...             | 1728                    | Foot of high Tower in village.                                |
| Mothakapalli H.S. ...    | 2284            | 2282                    |                                                               |
| Do. camp ...             | 1965            |                         |                                                               |
| Bachinapalli ...         | 2090            |                         | N. E. of village.                                             |

*Heights in Mysor, Ballári, Kadapa and the Nizám's Dominions.*  
 \* *Bombay Party. Seasons 1869-70-71-72—(Continued.)*

| Name of Place.           | Aneroid Height. | Trigonometrical Height. | Remarks and Descriptions.                             |
|--------------------------|-----------------|-------------------------|-------------------------------------------------------|
| Kandenmarrei T.S. ...    | 2227            | 2240                    | Lower mark, ground level.                             |
| Bihilpur ...             | 2162            |                         | Large tope 1 mile S. of village.                      |
| Womekonda H.S. ...       | 2196            | 2178                    |                                                       |
| Do. camp ...             | 1987            |                         | S. of hill.                                           |
| Kúpánagar ...            | 2080            |                         | ¼ mile E. of village on Bider Road.                   |
| Shilapali H.S. ...       | 2229            | 2199                    |                                                       |
| Pedda Chilmaira ...      | 2103            |                         | Tope E. of village and N. of road.                    |
| Goraegat H.S. ...        | 2052            | 2071                    |                                                       |
| Do. village ...          | 1963            |                         | Foot of hill, village side.                           |
| Topkonda H.S. ...        | 2185            | 2182                    |                                                       |
| Gazulgúda ...            | 2046            |                         | Camp N. of village.                                   |
| Kothapalli ...           | 1973            |                         | By stream in tope E. of village.                      |
| Cheballah H.S. ...       | 2201            | 2187                    | ⊙ on low hill W. of temple.                           |
| Bakawaram ...            | 1799            |                         | In plantation E. of village.                          |
| Gaganpahár H.S. ...      | 1995            | 2016                    |                                                       |
| Do. camp ...             | 1814            |                         | In tope near road 6 miles from Haidarabad.            |
| Husainsavalli Dargáh ... | 1830            |                         | In tope, N. of road near Golkonda tombs.              |
| Golkonda Fort ...        |                 | 2024                    | ⊙ on rock in fort.                                    |
| Durgápahár H.S. ...      |                 | 2089                    | On range of low hills N. of Golkonda.                 |
| Naubatpahár H.S. ...     |                 | 1867                    | Small hill between Haidarabad and Sikandrabad.        |
| Do. camp ...             | 1719            |                         | S. End of Husain Ságar tank.                          |
| Mulkagiri H.S. ...       |                 | 2007                    | Low hill 1½ miles N. E. of Lancer lines Sikan-drabad. |
| Chár Minár ...           |                 | 1739                    | Balustrade; top of minaret about 65 feet higher.      |
| Chaddarghát Ch. ...      |                 | 1736                    | Basement of pinnacle.                                 |
| Balárám ...              |                 | 1977                    | Resident's flagstaff, lower cross piece.              |
| Kishara H.S. ...         |                 | 2089                    |                                                       |
| Do. camp ...             | 1786            |                         | N. of village halfway to hill.                        |
| Lechmápur H.S. ...       |                 | 2115                    |                                                       |
| Nizámpet village ...     | 1930            |                         | Tope S. of village.                                   |
| Sadulnagar ...           | 1724            |                         | In tope W. of road and S. E. of village.              |
| Suldapur H.S. ...        | 2089            | 2088                    |                                                       |
| Umdanagar ...            | 1732            |                         | East of village.                                      |
| Undol ...                | 1637            |                         | Tope S. of Town. General Cullen 1709.                 |
| Tadmanúr H.S. ...        | 1864            | 1851                    |                                                       |

*The High road from Bangalor viâ Gutti-Adoni-Ráichur.*

|                      |      |      |                                                                                              |
|----------------------|------|------|----------------------------------------------------------------------------------------------|
| Bangalor ...         |      | 3131 | Roof of observatory at S. E. end of Base-Line on Gutti road.                                 |
| Davanhalli ...       | 2950 | 2956 | Ground level of bungalow compound.                                                           |
| Chota Ballapur ...   | 3023 |      | Ditto.                                                                                       |
| Patasamudram ...     | 2713 |      | Ditto.                                                                                       |
| Gantwarpalli ...     | 2359 |      | Varanda level.                                                                               |
| Palsamudram ...      |      | 2237 | Ground level.                                                                                |
| Pennakonda ...       | 1862 |      | In tope near old dák bungalow.                                                               |
| Chinna Kotapilli ... | 1433 | 1444 | Bungalow compound.                                                                           |
| (Darmaveram) ...     |      | 1201 | Level of ground at old palace. (Old road.)                                                   |
| Marúr ...            | 1269 |      | Bungalow compound. New road.                                                                 |
| Hundi Anantapur ...  | 1156 | 1152 | ⊙ on *tehseldar's house in town.                                                             |
| Garuldinni ...       | 1080 |      | In tope close to old bungalow.                                                               |
| Yeggawopalli ...     | 1068 |      | Road bridge parapet 15½ miles from Gutti.                                                    |
| Gutti ...            | 1220 |      | ¼ mile S. E. of railway station.                                                             |
| Jonagiri ...         | 1361 |      |                                                                                              |
| Pattikonda ...       | 1548 |      | Camp close to fort wall on N. side.                                                          |
| Adoni ...            | 1418 |      | Camp in tope close to foot of drug. Genl. Cullen 1395.                                       |
| Hulikanáva ...       | 1201 |      | 15 miles from Adoni.                                                                         |
| Tongábudra ...       | 1046 |      | On N. bank E. of road. Haidarabad State. Genl. Cullen's height of Madaveram on S. bank 1089. |

*Heights in Mysor, Ballári, Kadapa and the Nizám's Dominions.*  
*\*Bombay Party, Seasons 1869-70-71-72—(Continued.)*

| Name of Place.                                 | Aneroid Height. | Trigonometrical Height. | Remarks and Descriptions.                                                 |
|------------------------------------------------|-----------------|-------------------------|---------------------------------------------------------------------------|
| Ráichur ... ..                                 | 1326            |                         | In Rája's tope between rail and ford.<br>South bank. General Cullen 1129. |
| Kistna River ... ..                            | 1116            |                         |                                                                           |
| <i>The Road from Sikandrabad to Gulbargah.</i> |                 |                         |                                                                           |
| Sikandrabad ... ..                             |                 | 1791                    | Cistern of Barometerin Meteorological observatory.                        |
| Pattancherru ... ..                            | 1791            |                         | Bungalow compound. Genl. Cullen 2062. ? error                             |
| Kundi ... ..                                   | 1757            |                         | Ditto.                                                                    |
| Sedáshipet ... ..                              | 1757            | 1758                    | Ditto. Genl. Cullen 1825.                                                 |
| Kumkoal ... ..                                 | 2054            |                         | Ditto.                                                                    |
| Burra Yekali ... ..                            | 2035            |                         | Ditto.                                                                    |
| Cherrakpilli ... ..                            | 1980            |                         | Ditto.                                                                    |
| Mungulghi ... ..                               | 1943            |                         | Ditto.                                                                    |
| Hominabad ... ..                               | 2030            |                         | Ditto Road branches off from Sholapur road.                               |
| Kini ... ..                                    | 1864            |                         | Ditto Close to Mulámari River.                                            |
| Korkotah ... ..                                | 1439            |                         | Ditto do. Binathora River.                                                |
| Gulbargah ... ..                               | 1456            |                         | Camp at 135th milestone.                                                  |

*Aneroid Levels taken in the train from Gulbargah to Gutti, compared with Madras Railway values, the latter being level of rail.*

| Name of place.           | Aneroid Height. | Railway Height. | Remarks.                                                      |
|--------------------------|-----------------|-----------------|---------------------------------------------------------------|
| Gulbargah Station ... .. |                 | 1488            |                                                               |
| Sháhabad ... ..          |                 | 1306            |                                                               |
| Yedagiri ... ..          | 1351            | 1194            |                                                               |
| Kistna River ... ..      | 1171            | 1139            | G.I.P. Level 1143. G. T. Survey height 1146.<br>Bed of river. |
| Ditto ... ..             | 1104            |                 |                                                               |
| Chikéúgúr Station ... .. | 1044            |                 |                                                               |
| Ráichur ... ..           | 1130            | 1171            |                                                               |
| Matmarri ... ..          | 1281            | 1311            |                                                               |
| Matmarri ... ..          | 1185            | 1206            |                                                               |
| Tongábudra River ... ..  | 1050            | 1081            | Bridge level.                                                 |
| Do. Station ... ..       | 1061            |                 |                                                               |
| Kusgi ... ..             | 1211            | 1236            |                                                               |
| Adoni ... ..             | 1350            | 1364            |                                                               |
| Nuncherlah ... ..        | 1550            | 1553            |                                                               |
| Gundukal ... ..          | 1412            | 1411            | Trigonometrical height of station roof 1432.                  |
| Gutti ... ..             | 1193            | 1203            |                                                               |

The Aneroid Heights of Trigonometrical points, though given for the sake of comparison, have not been used. Each Aneroid Height, (except in the railway heights) is a mean derived from two adjacent Trigonometrical Stations.

All these heights are derived from observations taken with two gold band Aneroid Barometers (by Cooke and sons) at 9-30 A.M. and 3-30 P.M.

The observations were corrected for instrumental errors and also for daily variation; this latter quantity being derived from the fixed Mercurial Barometers at Bangalor, Karnúl and Sikandrabad Meteorological Observatories.

E.g. To obtain the height of Kudligi village  
 Height of Uderpi Drug H.S., 1725  
 Observed difference of height — 399

Height of Daverkonda H.S., 1840  
 Observed difference of height — 510

1st result 1335

2nd result 1330

Mean height 1333

The railway heights were taken at all hours of the day and night, and hourly variations applied.

**Extract from the Narrative Report—dated 15th July 1872—of Major B. R. BRAN-FILL, Deputy Superintendent 2nd Grade, in charge of the Madras Party.**

(1.) The Madras Party under my charge had not entirely recovered from the previous unhealthy field season, when, the first burst of the N.E. monsoon being over and the computations complete, it was possible to take the field on the 1st November 1871, but bad weather detained us till the 10th of that month.

(2.) I may here mention that the computations of the previous field season's work shewed that the point Ancimudi (a high peak in the Ancimallei hills) was no less than 8,837 feet above the sea, 195 feet higher than Dodabetta in the Nilgiri hills, hitherto supposed to be the highest point in Southern India.

(3.) My instructions were to leave the Southernmost Section of the Great Arc on which this party had been engaged for three or four seasons previously, and to take up the remaining triangulation of the Mangalur Longitudinal and Meridional Series, about 110 to 120 miles on each—probably two season's work.

(4.) The Approximate Series of the whole was stated to be complete, with the exception of two stations about the point of junction near Mangalur; but only five stations in advance of the side Nughalli-Naráyan Drug (observed in 1867-68) were built. I was furnished with charts of the approximate series, and descriptions of the five stations built.

(5.) As soon as the weather permitted, on the 10th November, the party left Bangalur, and reached Nughalli on the 17th and 18th marching in two parties for the sake of observing a Barometric Levelling traverse, by means of corresponding simultaneous observations with two pairs of Aneroids—the result of which, notwithstanding the unfavorable state of the weather, proved highly satisfactory, the closing error being only about 7 feet. Barometric observations were also taken daily throughout the season at 10 A.M. and 4 P.M. by the main party, and by two of the assistants detached.

(6.) At the commencement of the field season I made the following disposition of the party.

I myself remained with the main or observing party to take the Principal observations until Lieutenant McCullagh should become sufficiently practised with the 24-Inch Theodolite to conduct the work alone. I then purposed examining the Approximate Series in advance, and after that to set up the self-registering Tide-Gauge at Mangalur, which had been named as a Tidal station, leaving Lieutenant McCullagh to complete the final observations with the 24-Inch Theodolite.

Mr. Mitchell was directed to complete the Ammedikal polygon, of which two stations remained for selection, and then, in accordance with my instructions to select and observe a series of triangles extending along the coast south of Mangalur as far Ponnáni in latitude 10° 48'.

Mr. Norris, whose health was still bad and unable to bear the trying weather we now experienced, viz., cold wet nights with strong dry and hot N. E. winds by day, I directed to take up the station building in the low country to the west of the Gháts, and afterwards to assist me at Mangalur, whilst Mr. Potter was sent to build the stations above the Gháts and northward up the Meridional (Approximate) Series, and Mr. Laceron remained as Office assistant and Observatory recorder with the main party.

(7.) At Nughalli H. S. I observed an Azimuth to  $\delta$  Ursæ Minoris at Western Elongation; and 51 (Ilev.) Cephei at Eastern Elongation; which, owing to rainy and cloudy weather caused a delay of four days. The result of the observations shews the computed Azimuth as brought down from the Calcutta Base to be 3° 77.4 too great, or the observed Azimuth in defect 3° 77.4, the difference being in the same direction as, but greater in amount than that previously obtained on this Series.

(8.) A further delay of several days occurred, by the signal party sent to occupy the great Pushpagiri H.S. (the "Soobramunny Hill" of Atlas Sheet No. 43) being misled, and attempting to ascend from its inaccessible side.

(9.) But a more serious delay was met with at Sâtanhalli H.S. the central station of the first polygon, where, after some days fruitless efforts to obtain a signal from Dâsâni H.S., the N. flank station, the ray proved impracticable, being obstructed by a large portion of the top of an intervening hill. I selected a new point on the Dâsâni group of hills, fortunately without much difficulty, leaving Lieutenant McCullagh, who by this time was quite able to carry on the observations alone, to measure the new angles; but this failure of the Approximate Series cost us no less than 10 days of the best weather for observing.

(11.) The principal observations were carried on without further hindrance than that caused by the forests and mountainous country of the Malnâd and Western Ghâts, in which clouds and heavy mists frequently obscured the signals, and the distances traversed between each station were very great, occupying eight days on the average, and as many as eleven and twelve days in two cases.

(12.) About the end of January whilst observing at Pushpagiri H. S., Mr. Potter reported that the Approximate Series had again failed in Kudurei-Mukh H. S., the first point common to the Longitudinal and Meridional Series, and that his station building was at a standstill until he should receive fresh instructions how to proceed. These I sent him immediately but owing to the great distances, nearly three weeks elapsed before he could resume his duties.

(14.) In view of the somewhat small and ill-conditioned figures provided, and thinking that the number of the stations must be reduced to ensure the completion of this triangulation next season, I determined to remodel the series in advance, by throwing back (eastward) the side of junction and selecting a figure to the North-East of Kudurei-Mukh above the Ghâts, that should as it were, "cut off the corner," leaving Mangalur to be fixed by an independent quadrilateral figure, which (latter) however had to be abandoned during the observations for two single triangles, the greater diagonal being too long for observation at that season of the year. The country being rugged and roadless, I proceeded on foot from Kudurei-Mukh to examine it to the N. E., and succeeded, with Mr. Potter's assistance, in selecting three new points of a figure by which I hope the series will be improved and abridged, and rendered capable of completion next season.

(15.) As the season was now (at the end of February) far advanced I suspended the Approximate Series operations ended. Approximate Series work, and, having directed Mr. Potter to build the remaining stations, and to close and deliver to the civil authorities those visited and finally observed at this season, I proceeded to Mangalur for the Tidal operations, after satisfying myself regarding the connection of Mangalur pillar station with the main Series.

(16.) Meanwhile and till the end of the season, Lieutenant McCullagh with the main party had been greatly impeded in his observations with the 24-inch theodolite by the hazy weather setting in. At Ballamallei, the southwesternmost flank station, he was detained 15 days, at Ammedikal (central station) 18 days, and at Kudurei-Mukh 25 days, until the 10th May, when, as there was no hope of completing the observations before the beginning of the monsoon, he closed the season's observing and marched to Bangalur, where the party arrived on the 28th May, having suffered much latterly from fever.

(17.) I had instructions to set up one of the new self registering Tide-Gauges by Adie London, at Mangalur, which I accordingly proceeded to do. I found the river (Netravati) which runs northward past the town of Mangalur, separated from the open sea for several miles, by a spit of sand varying in width from 100 to 400 yards, and 10 or 12 feet above sea level in the highest parts. I learnt that this spit had been extending northwards steadily for many years, driving the river mouth and bar continually before it. The older parts of the sand spit were covered with a growth of sea pink and many other plants, and were apparently very firm and not liable to shift. Some years since, a breach was cut in the spit to allow the river to enter the sea a mile or so short of its mouth at that time, and rather above (south of) the town: but a very few tides sufficed to fill up the gap, of which now there is scarcely a trace to be found. From this and other local information, there seemed good reason to suppose that the sand spit might be considered more than sufficiently permanent for a year's tidal operations.

- (18.) As I could hear of no better place on the coast nearer than Kárvár (or Sadáshghar) which is beyond the limits of the triangulation remaining to be done, I determined to make the attempt to establish a Tidal observatory here, although there was some room to doubt of success; and accordingly I sank a masonry well in the highest part or ridge of the sand spit, where it was 12 feet above sea level and 30 yards away from high water mark on the beach, about a mile south of the river mouth, and nearly opposite the town of Mangalur.

A Tidal observatory decided on and begun, and a masonry well sunk.

- (19.) The sand was very firm at a small depth below the surface where it was slightly moist, but exceedingly "quick" at the permanent water level below, which I saw reason to believe to be considerably higher than mean sea level. The well was begun a little above this, and sunk by emptying the sand continually from its bottom, and adding to its height, until there was always a depth of 6 feet of water or more in it, and 10 feet of masonry above high water mark.

- (20.) Communication with the open sea was now established by means of wrought iron gas piping, of one inch bore, with a copper perforated nozzle, extending 40 or 50 feet beyond

Communication with open sea established.

extreme low water mark of spring tides into 4 or 5 feet of water, the other end being introduced into the well at about the mean level of the sea, which was the lowest that could be managed even at low water, owing to the wash of the waves and the persistent high level of the water standing in the sand spit. A syphon end extending to the bottom of the well having been added to the inner end of the pipe, it was found that although the communication with the sea was apparently free enough about high water, at low water the pipe was inadequate to empty the well more rapidly than it filled by percolation from the sand below. It was necessary therefore to introduce a watertight case or cistern that should only admit or deliver the sea water by means of the pipe. This proved an exceedingly difficult task, more especially so as the season of perpetual rollers from the South-Westward and a heavy surf on the coast had set in by this time, (the beginning of April) and prevented the removal of the pipe in order to let down the case entire.

- (21.) After one or two trials I succeeded in securing a water-tight case of wood

A watertight cistern or case of wood introduced.

(10) ten feet in depth in the required position with the pipe standing. This occupied the time till the end of April, and the result appeared to be satisfactory, but being near the time of neap tides the range of the tide was too small to test the efficiency of the arrangement thoroughly, when, rather suddenly, the free communication with the sea ceased; the water having shoaled and covered the sea end of the pipe with about a foot of sand.

I found that water would still flow out of the cistern freely, but that even with a considerable head of water outside it would scarcely flow in at all.

The pipe choked by deposit of sand.

- (22.) By this time a masonry platform with deep foundations had been built to support

Masonry platform completed and self-registering Tide-Gauge set up.

the iron bedplate of the self-registering Tide-Gauge to be set up, a small thatched hut or observatory erected, and the instrument with clock put in position ready to start.

- (23.) The severe gale of wind from the W to N. W. doubtless connected with the devastating storm which occurred at Madras about the same

Damage by severe gale of 1st and 2nd May 1872.

time (1st and 2nd May,) now took place and considerably altered the shore line, washing away much of the sandspit almost up to the observatory and well, and shoaling the water for some distance out to sea.

- (24.) The season of high surf was now too far advanced to do anything further, and notwithstanding the statement that the alteration

Tidal operations closed.

of shore line and sea bed was very unusual, it seemed best to pack away the instrument safely and defer further operations till the close of the monsoon.

- (25.) I regret to add that the unusual violence of the monsoon has made further encroachments, and the Executive Engineer to make sure of

Further damage and removal of observatory hut.

saving the materials from being lost has removed the observatory hut, but not before much damage and loss had occurred from the violence of the waves.

- (26.) To set up a Tidal observatory and maintain it in operation for a twelvemonth on

Considerations against success at Mangalur.

the sandy shore of an open coast, like that of the Indian Peninsula, is an affair of such difficulty and



expense, and at best so uncertain of success, that it can hardly be recommended; and I greatly fear that Mangalur must be abandoned as a Tidal Station, and a protected spot sought for. If the pipe of communication with the sea be made long enough to be beyond the line of surf and shifting bottom, the bore must probably be enlarged beyond a practicable limit, to ensure rapidity of action; and I doubt if any manageable length of tube will secure it from the liability to be buried or shifted on the sandy shore of the Western Coast.

(27.) I attribute the success of the Tuticorin Tidal operations just completed, (see para 37) to the protection of the harbour and the fact that the end of the tube could always be got at and examined.

Reason for success at Tutukudi (Tutikorin)

(28.) During the progress of the Tidal observatory, three new permanent stone Bench-marks were marked in the usual manner and connected by Spirit leveling with each other and with Captain Basevi's points leveled in December 1869, (the results agreeing well with his), and a double line of levels was carried by Mr. Norris to the new G. T. Survey pillar Station at the Lighthouse recently built and observed at, about a mile or more distant.

Permanent Bench-marks fixed and levels determined.

(29.) On the 7th May I left the instruments &c. in charge of the Executive Engineer at Mangalur and proceeded to Bangalor where I arrived on the 1st June.

Return to Bangalor.

(30.) The following is a brief statement of the field season's work:—(15) Fifteen Principal Stations were visited and (40) forty angles observed, fixing (10) ten new principal stations, by (11) eleven triangles embracing an area of 3239 square miles, executed at a cost of Rs. 14 per square mile, and extending the Series above (100) one hundred miles from East to West across the mountain range of the Western Gháts, besides a good proportion of Secondary and incidental work; 55 Secondary points fixed, spread over 2053 square miles beyond the principal triangulation; also a year's series of Tidal curves secured, with hourly readings made and tabulated. Also a connection made by Spirit leveling between the closing station of the Series at Mangalur and several Tidal Bench-marks.

Brief statement of Season's work.

(31.) I trust that you will endorse my belief that the amount of work done and progress made, has been satisfactory in spite of unusual hindrances.

(32.) I beg to point out to you that a large share of the Principal observations was done by Lieutenant McCullagh alone, and that although this is his first season's practice, with the 24-Inch Theodolite, the results, tested by the computed errors, weights, and corrections, appear to be very good, and compare very well with the results of other observers in the Department. Thus the mean triangular error, usually large (about 0'·5) with the theodolite in use with this party (No. 1 Troughton and Simms-altered) is only 0'·33, whilst the mean probable error of the (40) forty angles is only  $\pm 0'·14$ , the mean of the 7 previous seasons being  $\pm 0'·18$ . I consider these good results are due in a great measure to Lieutenant McCullagh's extreme care and aptitude for the work. This officer was attached to this (the Madras) party in October, just before taking the field, in a bad state of health from which he recovered but slowly: during November, December and January he took a large share of the office and observatory work, the details of which he soon mastered, and from 1st February he had sole charge of the main or observing party which he conducted to my satisfaction to the end of the Field season.

I am greatly obliged to Lieutenant McCullagh for the very willing and able manner in which he carried out my wishes, and I have much pleasure in stating that I consider him in every way fit for the sole charge of a Trigonometrical party.

(33.) Mr. Mitchell's outturn of work is as follows:—Two Principal stations selected and eleven Minor Series stations, forming a single Series of eleven triangles, extending about one hundred and twenty miles along the coast to the South of Mangalur and bridging the gap left at this place in the chart of Colonel Lambton's triangulation. He observed the angles at five of the southernmost stations. The mean error of the two triangles observed is 7"·3. So large an error must be attributed to the extremely unfavorable state of the weather during the observations. Mr. Mitchell also finally closed one Principal station and kept up a series of Barometric observations throughout the season, and only reached Bangalor on the 8th June suffering much from sickness.

Mr. J. W. Mitchell, Assistant Surveyor 1st Grade.

(34.) Mr. Norris has built three Principal stations with ordinary platforms, one masonry

pillar (11½ feet high), two wooden observatory platforms (10 and 12 feet high), cleared some two miles of rays, executed one or two miles of Leveling, and finally closed two of the Principal stations. Mr. Norris was ill when he took the field, and frequently suffered from fever. It was on this account that I sent him at once to the low country near the sea, in the hope that his health would improve, and I believe it did so, but he was very frequently unfit for work and unable to bear much exposure in the forenoon and middle of the day.

(35.) Mr. Potter has done a good season's work in spite of unusual difficulties. He has

built, and well built, seven platform stations all on the top of high hills or mountains, finally closed five, and has selected one principal and six secondary stations, clearing and making 12 miles of pathway. Nearly all his work being in the mountainous country of the Western Gháts and Malnad of Mysor, labor and materials were only procurable with much difficulty and delay. Mr. Potter took a series of Barometric observations throughout the season, and his weekly diaries, reports with sketch-charts, observations and monthly papers were always well done, and sent in with regularity and in a workmanlike style. He and his party suffered very severely from fever in the Field. I have much reason to be pleased with Mr. Potter's conduct and beg to bring his name to your notice for favorable consideration.

(36.) Mr. Laseron as Office assistant and Observatory recorder has worked well, and

I have every reason to be satisfied with him. The Mr. E.W. Laseron, Assistant Surveyor 4th Grade. angle books, field computations, and office records, have been duly kept up with neatness and regularity. Mr. Laseron's capacity, attainments and willingness are greater than the mere performance of his duty requires, and his conduct is as already often reported, unexceptionable. He has served well for more than three years in the Department and I therefore beg to recommend him for promotion on the first opportunity occurring.

(37.) In addition to the Trigonometrical work detailed above, I have to report the

completion of a year's Tidal Observations at Tutukudi. The Tutukudi Tidal Observations completed.

In May 1871, I set up a self-registering Tide-Gauge (No. 1 by Adie, London), checked its performance by means of a temporary Gauge and connected it with the permanent Benchmarks previously provided for the purpose.

Captain G. A. Phipps, Master Attendant for the port of Tutukudi most kindly undertook the duties of tidal observer, daily dating the curves traced, winding the clock weekly and keeping it right, and, changing the sheet of paper on the drum every fortnight, whilst the services of a native writer were retained for the daily register of anemometer, barometer, and thermometer readings, and a copy of the meteorological notes made in the Master Attendant's office. The level of the instrument was re-tested in November 1871, and again at the end of the year's work in June 1872 when Lieutenant McCullagh was deputed to examine, test, dismantle and pack up the instrument. This duty he carried out to my entire satisfaction, thus closing what I trust will prove a most valuable and accurate register of the sea level. I have taken hourly readings of the registered curves, as well as readings of every high and low tide through the entire period. A special report will be sent in as soon as the preliminary reductions have been made and tabulated, but I take this opportunity to express my great obligations to Captain Phipps for his uniformly ready assistance, and for his constant attention so freely accorded.

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**Extract from the Narrative Report—dated 29th August 1872—of Captain W. J. Heavyside, R. E. Officiating Deputy Superintendent 3rd Grade, in charge  
No. 4 Extra Party.**

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(1.) The Party reached Head Quarters, Dehra Dun, from Tibet on the 19th of September 1871. Mr. J. B. N. Hennessey, Deputy Superintendent 1st Grade, was then in charge.

(2.) For some six weeks after the arrival of the party in Dehra, Mr. Hennessey, with Mr. Macdougall's assistance, was occupied in arranging the affairs, and sorting the papers of the late Captain Basevi. This was no light task.

Owing to the sudden nature of Captain Basevis' death, in a place where the facilities for carriage were most limited, and where he had none of the conveniences afforded by an office; it was but to be expected that his private and professional papers would not be sorted. Moreover, he alone, in India, was thoroughly conversant with the pendulum operations: and the computations for the last stations at which he observed had not been completed. It was, therefore, most essential that every record which could throw any light on the smallest detail of his delicate and valuable operations should be preserved: not only as a guide for his successor, but, also, that none of the hard earned results connected with his memory, should be lost to posterity. With this end in view Major G. H. Basevi kindly permitted all the properties, both public and private, which Captain Basevi had with him at the time of his death, to be brought to Dehra intact. There were also other books, papers &c., which had been left at Dehra. These were all carefully gone through by Mr. Hennessey who was thus enabled to collect all records and notes which Captain Basevi had preserved in the course of the operations from 1865.

(3.) After the papers had been sorted, the instruments were examined. The knife edges of the Pendulums were well oiled, and the whole apparatus carefully packed away.

(4.) Mr. Macdougall then took up the reduction of some of the pendulum observations. He afterwards assisted in the Computing Office for about 2 months.

(5.) At the time of Captain Basevi's death I was in England on furlough. Being offered the charge of the party, with a view to completing the pendulum operations, I left England and arrived in Dehra on the 11th of April.

(6.) I took over charge of the party from Mr. Hennessey and on the 20th of April the party moved up to Masúri.

(7.) The pendulum observatory at Masúri had been recently used for base-line bar comparisons. The removal of frame-works and pillars from the observatory, as also filling up the pits into which the bars had been lowered, occupied some days. During this time the vacuum cylinder was opened out, cleaned, painted, and made as air tight as possible. It was then found that the frame-work and arrangement of the apparatus, as used in the plains of India, had been somewhat modified by Captain Basevi to meet his requirements in the high table lands of Tibet. A certain amount of reconstruction was therefore necessary. Captain Basevi has left a detailed account of the methods he employed in observing, and, also, drawings of the different parts of the apparatus. But there are many little details connected with the work which are only to be learnt by experience. For instance, the large air pump was not taken to Tibet and had lain by some time; it required thorough cleaning, when put together and set to work it was some days before the proper size of the piston wads: the right length of the stroke: and the correct adjustment of the valves was hit upon, so as to reduce the pressure in the cylinder below one Inch. There were similar delays with other parts of the apparatus and eventually the rains commenced before every thing had been got into thorough working adjustment.

So long as the fine nights lasted, I occupied myself in comparing clocks and chronometers, and in taking transits of stars.

(8.) During the recess, I have been engaged in arranging my predecessor's papers under headings; and in becoming acquainted with the methods he followed in observing and in computing out his results. I have also practised clock comparisons, observing coincidences with the pendulums, and other details connected with the work. I think I have now attained sufficient knowledge of the operations, to enable me to commence a regular set of observations at Masúri, so soon as the rains cease.

(9.) Mr. Macdougall has been chiefly employed during the recess in making duplicates of the Pendulum computations. He has afforded me assistance by his knowledge of the forms of computation and of the places in Captain Basevi's books, where tables &c., are to be found.

(10.) I am greatly indebted to Mr. Hennessey for the cordial assistance, and for the many useful hints he has given me in the course of my work. Mr. Hennessey was associated with Captain Basevi, in determining many important matters connected with the Pendulum experiments, and his knowledge has, therefore, been to me invaluable.

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**Extract from the Narrative Report—dated 15th August 1872—of H. KEELAN, ESQ.,  
 Officiating Deputy Superintendent 2nd Grade, in charge  
 Bilaspur Meridional Series.**

(2.) The party left Chanár (Chunar) on the 19th of November to resume the operations on the Biláspur Series; and arrived at the Tower Station of Pathaidi on the 17th December, where it was required to observe the verificatory Azimuth, which could not be obtained at the close of the operations of 1870-71, owing to unfavorable weather.

(3.) On the following day the 18th the thatch roofing was removed, and the tower found in excellent preservation. On the 20th the observations to  $\delta$  Ursæ Minoris were begun, and finished on the 26th of December.

(4.) Immediately on my arrival at Pathaidi station, I instructed Mr. Surveyor L. H. Clarke to proceed without delay to the stations of the pentagon formed round the station of Charkádi, to clear all the rays and commence the preparation of materials for the construction of the towers of the figure, during the absence of, and whilst I retained the services of Mr. H. E. T. Keelan to assist in the star observations at Pathaidi, in consequence of the inexperience of Mr. Probationary Assistant Surveyor H. Healy in observatory duties: he having recently joined the department.

(5.) On the completion of the Azimuthal Observations, I instructed Mr. Surveyor H. E. T. Keelan to relieve Mr. L. H. Clarke of the work entrusted to him; whilst I proceeded myself, to the stations on the eastern flank of the series to build the platforms and cut the roads to them: Mr. Clarke meanwhile, was ordered to clear the rays and prepare materials for the tower stations forming the two quadrilaterals with the hill points.

(6.) After finishing the platforms at the hill stations of Silighát, Chapora and Khalári, I retraced my steps northward to begin the final observations; but, owing to numberless difficulties to be surmounted, the towers of the Charkádi pentagon were not ready before the 20th of February, when observations were commenced; and by the end of the month were completed at the tower stations of Bardha, Latúa, and Gúma.

(7.) During the month of March, final observations were completed at the tower stations of Charkádi and Jerwa, at the hill station of Silighát, and a few zeros at the hill station of Chapora.

(8.) During the month of April, final observations were completed at the hill stations of Chapora and Khalári, and the tower stations of Achola and Mahásamand; after which, I proceeded to erect the rectangular pillars, and transfer the care of the hill station platforms of Silighát, Chapora and Khalári, to the village officials. I then erected a substantial thatching over the tower of Mahásamand, and marched with the camp to Jabalpur to recess the establishment.

(9.) The season's final work consists of one pentagon and two quadrilaterals. The Approximate Series, extending about 60 miles from the North, on the base Mahásamand to Khalári, consists of 4 quadrilaterals, and completes the junction with the triangulation brought up from the South, on the base Pendra H.S. to Decpahár H.S. of the Biláspur Series. And lastly, the Minor Triangulation to determine the position of the Civil Station of Ráipur.

(10.) In the prosecution of the season's work, it was found, that owing to the character of the Chattísghar district, through which the Biláspur Series passes, being of a wild nature, there existed no buildings or temples or other permanent objects to fix. The inhabitants, who are chiefly aborigines are content to dwell in huts huddled together, in smaller or larger groups bearing a name. Occasionally may be seen a demolished Budhist temple in the depths of a dense forest, on sites where in some remote period existed a large brick, or stone built town; so that there are no objects in the country to observe to, and therefore, no secondary points were determined from the principal stations of the series, except one building, the large modern temple of Bandhár—erected recently by a sect who emigrated from the north into these provinces about a hundred or more years ago. On this account, I detached Mr. Surveyor H. E. T. Keelan into the more open part of the district to the westward, to determine the position of the Civil Station of Ráipur, as well as to fix as many buildings, temples, &c., as he could manage to see along the course of the Minor Triangulation. But even here, the country was quite devoid of buildings.

(11.) Mr. Surveyor L. H. Clarke was, as already mentioned, detached from the station of Pathaidi with instructions to clear the rays and prepare materials for towers of the Charkádi pentagon; when on the 30th of December he was relieved by Mr. Surveyor H. E. T. Keelan, and ordered to proceed upon similar work connected with the stations of the 2 following quadrilaterals, all of which he did satisfactorily; and by the 20th of February completed the towers of Achola and Mahásamand, when he received fresh orders to proceed without delay and extend the Approximate Series southward, on the base Mahásamand T.S. to Khalári H.S., as directed in the following extract of my letter of instructions to him on the subject, dated 22nd February 1872.

“The series will be composed of polygons; and it will be advisable to select at least two figures in advance in the direction of the parallel lines indicated in the plan furnished you; so as to form a satisfactory junction, if practicable, during the present season, with the approximate series now being carried up by Mr. Surveyor H. Beverley from the south, and with whom you must put yourself in communication and exchange plans of figures selected from north and south.”

(12.) Mr. Clarke lost no time in this undertaking, and I was glad to find that by the end of March he had formed the desired junction upon the base Pendra H.S. and Deopahár H.S. by means of 4 quadrilaterals. On the whole Mr. Clarke has done a good season's work; and I deem it necessary to bring the same to your favorable notice.

(13.) Mr. Surveyor H. E. T. Keelan was first of all employed in assisting at the circumpolar star observations at Pathaidi Tower Station, on the completion of which, I directed him to relieve Mr. Surveyor L. H. Clarke of the duties on the Charkádi polygon; and notwithstanding the great difficulties he had to encounter, especially in the supply of water to build the towers, which, in most cases, had to be carried to the spot from long distances, he completed all his towers by the 20th February. I next instructed him to extend a Minor Triangulation to fix the position of the Civil Station of Raipur, upon the base Achola T.S. to Mahásamand T.S., which he completed by the 12th of April, and joined my camp on its march up to Jabalpur shortly after.

(14.) Mr. Assistant Surveyor H. Healy, who joined this party on his appointment to the Survey in October, was daily instructed in the use of the small theodolite on the march from Chanár to the Central Provinces, and was subsequently sent under Mr. Clarke's orders to be instructed in ray tracing and clearing, until his services were wanted in the observatory. This young assistant I am glad to state readily became familiar with the work required to be done in the observatory and office, and promises in due time to become a useful hand.

(15.) The following computations appertaining to the Biláspur Series operations were completed during the recess of 1871.

- I. The duplicate copies of Principal and Secondary Horizontal and Vertical Angles completed—means and angles deduced and compared with their originals.
- II. Computations of 36 weights of angles, in duplicate.
- III. Polygonal computations of the Gathaora and Pathaidi hexagons, in duplicate.
- IV. Computations of 14 Principal Triangles in the above polygons, in duplicate.
- V. Computations of Latitudes, Longitudes and Azimuths of 10 Principal Stations, in duplicate.
- VI. Computations of Heights of 10 Principal stations, in duplicate.
- VII. Computations of 10 Secondary Triangles, Latitudes, Longitudes, Azimuths and Heights of the Biláspur, Ratanpur and Bisrámpur Minor Triangulation, in duplicate.
- VIII. Preliminary Chart for season 1870-71, on the scale of 1 Inch=4 Miles, with numerical data inserted thereon.

(17.) During the past field season a great deal of malarious fever prevailed amongst the men of the Establishment; and the Assistants, as well as myself were not exempt from it. The country is of a wild character; and it is more so southward.

(18.) The total expenditure during the official year 1871-72 is Rupees 40,333-10-9. The total area triangulated is 645 square miles, and the average cost per square mile is Rs. 62-8-11.

**Extract from the Narrative Report—dated 30th August 1872—of Captain  
T. T. CARTER, R. E., Deputy Superintendent 2nd Grade, in charge  
No. 3 Extra Party.**

- (1.) On the retirement of Mr. C. Lane, Deputy Superintendent 2nd Grade G. T. Survey, on the 3rd of October 1871, and pending the arrival of an officer of the Senior Department, the charge of the party was held by Mr. A. W. Donnelly, Surveyor 2nd Grade G. T. Survey, and under his orders the party left their recess quarters at \*Benares on the 8th of November, with the view to commencing operations at the G. T. Survey Bench-mark at Parsoni, embedded  $\frac{3}{5}$  of a mile from the village of Parsurman, on the road (under construction) from Muzaffarpur to Purniah, the terminal point of last season's work.
- (2.) On taking the field, Narsing Dás Native Surveyor was in charge of No. 2 Level, pending the arrival of an officer to the permanent charge of the party.
- (3.) The programme of operation as laid down by the Superintendent in his letter No. <sup>16</sup><sub>1362</sub> dated the 27th of October 1871 was as follows:  
 Superintendent's instructions. From the <sup>G. T. S.</sup><sub>H. M.</sub> embedded at Parsoni near the village of Parsurman to continue the line of levels viâ Sâhibganj (Nâthpur) to Purniah, connecting with the Great Trigonometrical Survey tower stations of Râmnagar and Dighi and such others as might be conveniently near the main line of levels. From Purniah to carry the line down to Karâgola ghât, cross the \*Ganges river and effect a junction at the G. T. Survey Bench-mark at the Pîrpanti Railway station E. I. Railway, thereby completing the circuit from Gorakhpur to Pîrpanti. After this to commence a fresh circuit from Purniah, and after connecting with the base-line stations of the Sonâkhoda base, to continue the operations down the road from Titalia to Dinâjpur, connecting with the stations of the \*Calcutta Meridional Series.
- (4.) Mr. Donnelly arrived at Parsurman on the 11th of December, and after the customary tests had been made to ascertain the stability of the Bench-mark embedded at the close of the previous season's work, and after the level staves were compared with the portable Iron standard bar and the collimation of the levels themselves examined under Mr. Donnelly's directions, work was commenced on the 13th of December from the Great Trigonometrical Survey Bench-mark at Parsoni.  
 Commencement of work.
- (5.) I arrived at \*Bombay on the 16th of December from one year's leave to England on private affairs, and there found instructions to proceed to Purniah and take over charge of the party; arriving at Purniah on the 25th of December, I placed myself in communication with Mr. Donnelly with the view to ascertaining the point up to which the operations had been carried, and what progress the work had made; on receiving his reply I was enabled to join his camp and took over charge from him on the 8th of January 1872.  
 Captain Carter takes charge.
- (6.) From the 13th of December to the 8th of January Mr. Donnelly had completed 64 miles of double leveling. Starting from Parsoni G. T. Survey Bench-mark the main line had been carried to Singesar Thán, from which point a branch line was taken to fix a permanent mark in the small civil station of Madalpur. From Singesar Thán a branch line was also carried to the Kotganwah Factory at which point it broke into two lines, one proceeding south; connecting the tower station of Dighi. Another north connecting the tower station of Râmnagar; returning to Singesar Thán the main line was continued in the direction of Nâthpur, as far as Latona village connecting with the tower station of Latona. From Latona village the leveling for the rest of the season was carried on by myself using No. 2 level (hitherto used by Narsing Dás) and Mr. Donnelly using No. 3 level; the Native Surveyor whose leveling had been very satisfactory, returning to his ordinary duties of recorder.  
 Progress of the work under Mr. Donnelly's supervision.
- (7.) From Singesar Thán the main line of levels were carried across country following a cart track, chiefly through high grass, as far as the village of Dewânganj on the road between Sapal and Pratâbganj, during this portion of work the progress was considerably delayed owing to its being impossible to take observations at long distances in consequence of the refracted state of the atmosphere due to the high grass through which the levels were taken.  
 Leveling across country.

(8.) From Dewanganj the line was (after connecting the tower station of Dewanganj) carried along the road to Prataganj and thence to Saliaganj on the left bank of the Kosi river, the river being crossed at this point, thence continuing along the road to Purniah, connecting *en-route* with the tower station of Ghiba of the N. E. Longitudinal Series.

(9.) At the request of the Collector of Purniah a number of paka points were fixed in the vicinity of the station to serve as checks on proposed leveling operations to be carried out by the municipal authorities, connected with the draining of the station; values above sea level and a chart showing their position were made over to the civil authorities.

(10.) Proceeding from Purniah the main line was continued along the road to Karágola ghát at which point the river Ganges was crossed, thence *via* the village of Píranti to the G. T. Survey Bench-mark at Píranti Railway station fixed by Lieutenant Trotter R.E. in 1864, completing the circuit from Gorakhpur to Píranti on the 20th February.

|                                                                                                                              |    |    |             |
|------------------------------------------------------------------------------------------------------------------------------|----|----|-------------|
| The height of Great Trigonometrical Survey Bench-mark at Píranti railway station as determined by Lieutenant Trotter in 1864 | .. | .. | 155.03 feet |
| Difference at Píranti.                                                                                                       | .. | .. |             |
| The value now obtained applying the correction for circuit error at Cawnpur and Dildárnagar viz. + .552 feet                 | .. | .. | 155.81      |
| Difference                                                                                                                   | .. | .. | - 0.78      |

which error to prevent disturbing the values as given in tables already published has been provisionally distributed between Parsoni and Píranti. Neglecting the circuit error at Cawnpur and at Dildárnagar the difference of level between Píranti G. T. Survey Bench-mark as determined by Lieutenant Trotter R.E. in 1864 and that now determined would be 0.23 feet.

(11.) On the line from Parsoni to Píranti 97 bench-marks were fixed, of these 5 were Bench-marks fixed. bench-marks of the G. T. Survey pattern embedded in the vicinity of trigonometrical stations as directed in Superintendent's memo No.  $\frac{19}{1577}$  of the 19th of December 1871; 4 embedded bench-marks (with pillars built to indicate their position) viz. at

Gaumanti,  $\frac{1}{2}$  way between Purniah and Náthpur.  
 Purniah civil station (Collector's Kacheri).  
 Near 14th iron mile post from Karágola ghát.  
 Karágola ghát (Post office compound).

of the remainder 59 were paka points, such as wells, temples, &c, on which the letters  $\frac{G.T.S.}{B.M.}$  were engraved at point where staff was placed; and 24 were iron mile posts on the road from Karágola ghát to Purniah, the staff resting in all cases on the top of the post.

(12.) Some difficulty was experienced in carrying the levels across the river Ganges the narrowest point at Karágola ghát being 30.83 chains, the ordinary divisions of the leveling staves could not be read at this distance, and a foot had to be measured on paper, divided into tenths and half-tenths and then attached to the staves, even these divisions could with difficulty be read with any degree of accuracy, except in the early morning and towards sun down, at which times the refraction is greatest. By multiplying the number of observations and taking morning and evening sets on two consecutive days, alternating the order of observation on the second day the difference of level between the right and left bank of the river was as follows.

|                                                         |    |             |
|---------------------------------------------------------|----|-------------|
| By Captain Carter No. 2 level (mean of 54 observations) | .. | 3.380 feet. |
| By Mr. Dounclly No. 3 level (mean of 54 observations)   | .. | 3.338 feet. |

(13.) On the completion of the circuit from Gorakhpur to Píranti, the party marched back to Purniah and commenced a new circuit from the G. T. Survey Bench-mark at the Protestant church along the main road from Purniah to Dárjiling as far as the Rámganj tower station at the N. E. end of the Sonákhoda base-line, the tower station of Sonákhoda at the S.W. end of the base-line being also connected; the work was closed for the season at the G. T. Survey Bench-mark embedded in the vicinity of the Rámganj tower station on the 22nd of March. The length of this portion of the season's work was 68 miles and on this line 4 bench-marks of the G. T. Survey pattern were embedded and pillars built to indicate their position viz. at

The encamping ground of Belgáchi  
 Ditto Assuragarh  
 Ditto Ghaisal

and at the trijunction of the village lands of Singdhai, Bagaligach and Maglama, near the 9th mile post from Karágola ghát, besides these 17 paka points were fixed and 56 iron mile posts.

The leveling was closed for this season at the Rámganj Tower station on the 22nd of March, the party arriving at Purniah on its return march on the 1st of April; after making arrangements for the safe custody of the instruments, Government stores &c. at Purniah, and furnishing the civil authorities with values of the points fixed in the vicinity of Purniah, as above mentioned, it arrived at Sáhíbganj the nearest station on the E. I. Railway, on the 10th April, *en-route* to Head Quarters Dehra Dun, the native establishment (with the exception of 7 men left in Purniah in charge of the Government property deposited there, and a few men required at Head Quarters during the recess) being permitted to proceed on leave with orders to be at Purniah on the 10th November 1872 by which time the country will have sufficiently dried up after the rains, to permit of the operations being continued.

(14.) Before leaving Purniah for recess quarters, receipts in duplicate for all paka pillars, indicating the positions of embedded Bench-marks were drawn up and delivered to the civil authorities with the view to these permanent marks being made over to the safe custody of the owners of the ground on which they are built, as in the case of Tower and Platform stations of the G. T. Survey as laid down in Departmental order No. 1 of 15th January 1866, the receipts for these pillars duly signed have been received from the Magistrate and Collector and have been made over to the Officer in charge of the Computing office, the duplicates being retained by the person in charge of the pillars.

(15.) During the season's work the following Tower Stations of the Great Trigonometrical Survey of India were connected viz:—

|                                           |                                    | Heights of remaining<br>Portion of Paka Pillar |    |
|-------------------------------------------|------------------------------------|------------------------------------------------|----|
| Dighi T. S. (N. Malúncia Series)          | .. .. .                            | 7'                                             | 8" |
| Rámnagar T.S. (N.E. Longitudinal Series.) | .. .. .                            | 13                                             | 9  |
| Latona T.S. (Ditto ditto)                 | .. .. .                            | 27                                             | 0  |
| Dewárganj T.S. (Ditto ditto)              | .. .. .                            | 14                                             | 0  |
| Ghíba T.S. (Ditto ditto)                  | .. .. .                            | 8                                              | 0  |
| Sonákhoda T.S. (Ditto ditto)              | } Sonákhoda Base-line<br>stations. | Perforated Towers<br>complete.                 |    |
| Rámganj T.S. (Ditto ditto)                |                                    |                                                |    |

a statement as to the state of these towers will not be out of place here; the 1st five are of the old pattern towers, namely solid masonry pillars in the centre of mud built towers, in all these cases the kacha part of the tower has fallen, and only so much of the paka pillar remains as given above, under these circumstances the only means of connection was by digging into the paka pillar, about the ground level and reaching the ground level markstone.

The Towers at the ends of the Sonákhoda Base-line viz: the Sonákhoda and Rámganj stations were found in good order, with the exception that the arching over the mark at the Rámganj end was broken in and the mark exposed, this was built over again. The towers were carefully closed, the walls cleared of all shrubs &c. and whitewashed.

(16.) The total out-turn of work during the season has been as follows viz:—

- 245 miles of double leveling.
- 7 Trigonometrical stations connected.
- 16 G. T. Survey Bench-marks embedded and connected.
- 8 Paka Pillars built indicating positions of embedded Bench-marks.
- 76 Paka points fixed and the letters <sup>G. T. S.</sup><sub>B. M.</sub> engraved thereon.
- 80 Iron mile posts connected on road from Karágola glát via Purniah to Dárjiling.

(17.) Drawings shewing the position of the leveling staff at 53 of the 76 Paka Bench-marks have been made and will accompany the records of the past field season's work accompanying this report.

(18.) The line of levels protracted on the scale of one mile to the inch will be completed shortly and will then be forwarded.

(19.) In conclusion I beg to bring to your notice that during the time Mr. Donnelly was in charge of the party his arrangements appear to have been very satisfactory, and subsequently he has assisted me to my entire satisfaction.

The Native Surveyors Amjad Ali and Narsing Dás, have worked hard and in every way deserved my approval.

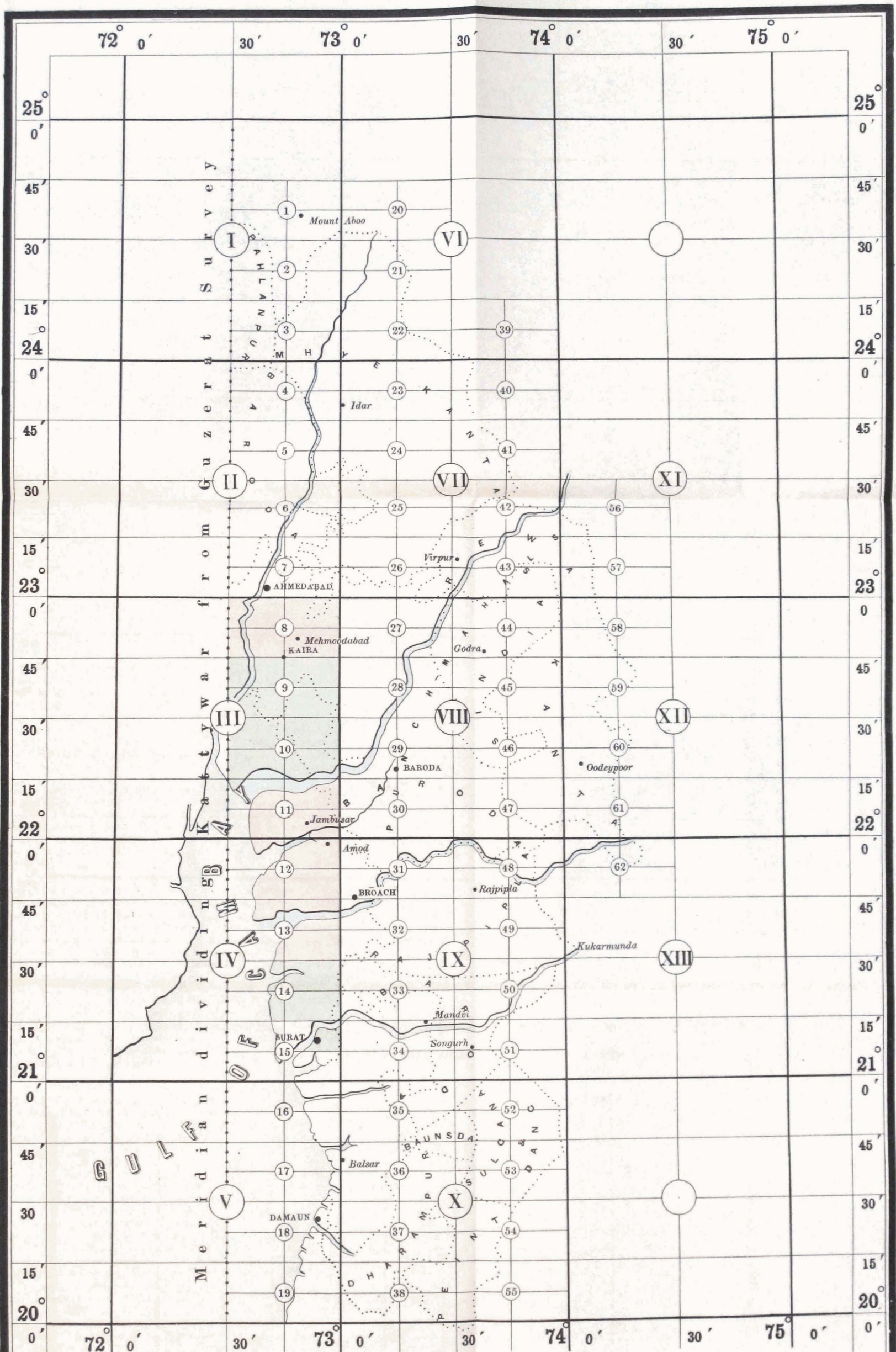
The health of the party was very good.



Extract from the Narrative Report—dated 27th August 1872—of Major C. T. HAIG,  
R. E., Officiating Deputy Superintendent 1st Grade, in charge  
Guzrat Party.

- (2.) I received charge of the Party from Lieutenant McCullagh, R.E., on the 23rd September 1871 on my return from England from two years sick leave.
- (3.) Captain Pullan and Mr. Connor joined after we had taken the field, the former on 18th December, and the latter on 5th November in place of Mr. A. Bryson who had come with us to Súrat but was then transferred to Captain Campbell's party. On taking the field I also had Mr. Goslin as an assistant, but he left me on 15th December, having sent in his resignation.
- (4.) Before reporting on the work done this year it will be as well to state briefly what had been done previous to my taking charge. The whole of the operations of the party were confined to six consecutive Sheets (30' Longitude and 15' Latitude) on the same meridian, excepting, by the way, 5 stations selected and built by Lieutenant Baird, R.E., for a Series of triangles to be run along the course of the river Mahi. Of these six sheets, numbered from 8 to 13, one only (No. 12) had been mapped; No. 8 had been three-quarters covered with net work triangulation and ready for plane tabling; Nos. 9 and 10 had been half got ready; Nos. 11 and 13 had been got ready with the exception of about the space of one plane table, *i.e.*, one eighth of a sheet in each.
- (5.) The index map therefore, on which all work done was conventionally indicated, presented rather a patchwork appearance; but this was owing to the extreme difficulty of triangulation in a dead flat country studded with trees varying in profusion from that of an English park to that of a dense forest, so that almost in no instance had a triangulator completed in a field season the portion of work expected from him.
- (6.) This was especially the case too in the laying out of the Mahi Series of triangles alluded to above, and although the length of the Series is but 64 miles and it had been worked at for two field seasons, only 7 stations had been selected covering altogether about one-third of its extent.
- (8.) Three sheets (8, 11, 13) this year have been topographically surveyed, the blank halves of sheets 9, 10 and also a fresh sheet (14) have been prepared with points ready for plane tabling, so that the index map were it not for the unfortunate loss of a plane table would now present a most orderly appearance, though I am sorry to say it does not admit of any greater out-turn of topography next season than that of this year which is however tolerably fair.
- (9.) The lost plane table was being brought to Púna from the field by Mr. McA'Fee. In \*Bombay while looking after the safe removal of some theodolites from the Railway van the tin case containing the original plane table must have been carried off by one of the coolies thinking it belonged to another passenger. Mr. McA'Fee took all the means he could think of to recover it, invoking the assistance of the Commissioner of Police and offering a reward of Rs. 50, but hitherto it is still missing.
- (10.) I now proceed to details. The Party left Púna on the 23rd October for Súrat where the tents, instruments and field equipment had been stored. At Súrat miscellaneous work, such as preparing and projecting plane tables and bringing up sundry arrears, occupied us till about the 10th November, when, having started off the Assistants to their respective duties, I left for \*Kaira visiting Bhroch (Broach) and \*Baroda to acquaint the Civil authorities of the general programme of the season's work as far as it concerned their respective districts.
- (11.) At \*Kaira I took up the question practically regarding the feasibility of utilizing the maps of the Revenue Survey which has been the subject of theoretic discussion since 1867. I have already reported at length in my No.  $\frac{8}{82}$  dated 26th January 1872 on the results of my investigations: suffice it here to say that I connected, by traversing, with our triangulation two points in the boundaries of several alternate villages (by alternate I mean separated from each other by one intervening village): I then projected these fixed points on a plane table and with a pentagraph traced out on the plane table from the Revenue Survey maps each village, making the corresponding points on the Revenue maps tally with their respective counterpoints already laid down, then I attempted to fit in between the alternate villages thus projected the boundary of the intervening villages from the Revenue Survey village maps. I found, and I was quite prepared to find, that I was attempting an impossibility, but in this way I determined exactly what amount of labour would be entailed in compiling a general map from the Revenue Survey village maps and also the degree of accuracy in the maps thus obtained, and I have as stated above fully reported thereon.

# 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 1/2 inch to the mile.  
 The one inch sheets are divided into 4 sections, known as the N.E., N.W., S.E., & S.W.,

— Denotes country Topographically Surveyed up to 1871-72.  
 — " " " " Triangulated in advance " "

Scale 1 Inch = 24 Miles 10 5 0 10 20 30 40 50  $\frac{1}{1520640}$



(12.) At \*Kaira I was joined by Captain Pullan to whom I had intended giving some triangulation in sheets 6 and 7 for which I had prepared a field chart with all the stations of the Abu Meridional Series included in those sheets projected on it, but I was obliged to abandon that plan on account of Mr. Goslin's leaving, so I entrusted Captain Pullan with the topography of Sheet 8. Being an old Kumaon and Garhwal surveyor, he soon brought his experience into play though his work was something new to him, for in place of having several pole and brush marked hill tops continually in view, as is the case in hilly country, here, after leaving a trigonometrical station it requires a keen search on the part of the surveyor to find a spot where he can even see two of his points, so that a very great proportion of the work has to be done on the back and forward ray principle. The scale too was new to him, but he soon got into full swing and then trained a Native Surveyor Bhaw Govind, who had never used a plane table before. He had also working under him Shaikh Kásim a Native Surveyor of 4 years standing, and both of these men are very favorably reported of by Captain Pullan. Shaikh Kásim turned out 172 square miles, and Bhaw Govind 109 square miles which is very fair for his first season and it is moreover extremely neatly drawn. Captain Pullan rigorously examined their work and found it throughout most exact. Captain Pullan himself turned out 242 square miles in his own good style. As he did not commence work till 26th December and Bhaw Govind independently not till 25th January, it was necessary towards the close of the season to send him a reinforcement in order to secure the completion of the Sheet so I gave him assistance which relieved him of one out of his eight plane tables. It is this plane table that has been lost.

(13.) Mr. D'Souza started on his work on 1st November and worked away assiduously, covering Sheet 14 with trigonometrical points, until 11th May when he had fixed and taken angles at 98 new stations besides observing also at 13 old stations. His triangulation extended also over above one-eighth of Sheet 15. His work lay in a country thickly studded with villages each of which is a plantation of cocoanut trees, and the villages are so close together that it was generally impossible to lay out triangulation of more than  $1\frac{1}{2}$  mile sides, a large portion indeed of his sheet is a forest of cocoanut trees. The number of stations he visited (111) being on the average 18 a month, and the average of his triangular error  $8''$  speak as to the quantity and quality of his work. Though the area covered by him cannot compare with that ordinarily covered in a season by Mr. McGill in the adjoining \*Kattywar Survey, still it is very creditable considering the extreme flatness of the country combined with the almost uniform obstruction of the cocoanut trees. In the course of his work, he extensively connected stations of the Súrat city survey with his triangulation which will enable me to prepare a very accurate map of Súrat without much labour. At the close of the season Mr. D'Souza also inspected and tested a couple of plane tables sketched by Luxumon Ghorpuray and Vital Vishnu.

(14.) Mr. Christie was placed in charge of the Mahi Series of triangulation, which he has completed after a season of almost continuous tarry up hill work beset with the obstacles of a dense forest through which most of his rays had to be cut. As before mentioned several of the stations of this Series had been selected, rays partially cut and some of the stations built before this year, so that Mr. Christie was in a measure committed to take in hand and complete a lot of half finished work which had previously been left unfinished owing to the great difficulties of clearing rays through dense jungle and to the opposition of the Gaikwár's subjects; 6 stations had previously been selected at the south end of the Series and 5 at the north, and out of the 22 rays between these stations 8 had been cleared and 1 partially cleared. But these triangles had too long sides, they varied between 7 and 10 miles and it is impossible to know whether a ray of that length merely determined by signal fires crossed a village midway or not. Mr. Christie found one of these rays that had been previously partially cleared was quite impracticable owing to its crossing a village in the forest and it was also impossible to shift the ray slightly on either side, for the latent village was one of three in *echelon*, so that a complete change in the arrangement was necessary entailing the rejection of 2 stations and 4 rays which he had nearly cleared. Mr. Christie, apprehending this danger of determining rays by signal fires, laid out the new rays after this on the ray trace system, but as soon as he got clear of the previously selected stations he contracted the width of the Series by shortening the sides so as to take as much advantage as possible of the open space of the river itself. By this means and with the assistance of Mr. McA'Fee during the months of May and June, he succeeded in completing the Series. That part of it which is entirely his own, though double the length of the portions at the extremities put together only occupied him four months in selecting and clearing whereas he was occupied  $3\frac{1}{2}$  months on that part which was supposed to have been already laid out. The final angles he observed with a  $10''$  Theodolite by Troughton and Simms working to two pairs of Zeros  $\frac{0}{180}$  and  $\frac{30}{210}$  using luminous signals throughout. There is however one slight inconsistency in the Series. The observations on one station (*i. e.* two angles) were taken by Mr. McA'Fee with a 6-inch Troughton and Simms' Theodolite. This happened through the extreme difficulty of crossing the Mahi which was much flooded, and Mr. Christie

thought it best as Mr. McA'Fee was on the other side of the river for him to take the observations and save probably a week in the completion of the series. It was then near the end of June. The side of emanation is Poída-Ghoráráo of the Guzrát Longitudinal Series—a Principal Series run by Lieutenant Nasmyth with an 18" Theodolite—and the side of verification is Sarod-Duháran of the Guzrát Coast Series—a Secondary Series run by Mr. D'Costa with a 12" Everest Theodolite.

The following Tabular Statement will shew at a glance the quantity and quality of his work.

|                                        |    |    |    |    |    |                |
|----------------------------------------|----|----|----|----|----|----------------|
| Stations Selected,                     | .. | .. | .. | .. | .. | 11             |
| Miles of ray cut,                      | .. | .. | .. | .. | .. | 149            |
| Ditto trace traverse,                  | .. | .. | .. | .. | .. | 36             |
| Stations observed at,                  | .. | .. | .. | .. | .. | 24             |
| Triangles with 3 observed angles,      | .. | .. | .. | .. | .. | 23             |
| Intersected points,                    | .. | .. | .. | .. | .. | 7              |
| Heights fixed,                         | .. | .. | .. | .. | .. | 20             |
| Mean Triangular error,                 | .. | .. | .. | .. | .. | 4".3           |
| Error of closing (side = 5.493 miles), | .. | .. | .. | .. | .. | 0".3 feet.     |
| Length of Series,                      | .. | .. | .. | .. | .. | 64 miles.      |
| Area Triangulated,                     | .. | .. | .. | .. | .. | 400 sq. miles. |

(15.) Mr. McA'Fee was appointed to cover the blank portions of sheets 8 and 9 with fixed points for the plane table Surveyors either by triangulation or traversing, extending the triangulation, wherever he could do so without much ray-cutting but substituting traversing for triangulation in close and thickly wooded country. As sheet 8 was to be topographically surveyed during the season, he of course took up that sheet first and on the completion of the field portion of this work he had to stop and reduce his observations. In sheet 8 he fixed 5 new trigonometrical stations and visited 4 old ones and ran 136 miles of traversing fixing a sufficiency of points. In the traversing he was assisted by Gopál Vishnu a traverse Surveyor transferred from the \*Kattywar party. Mr. McA'Fee was attacked with fever against which he battled, but he was at times unable to work by reason of it. He had it off and on for rather more than a month so that he was not ready to start on sheet 9 till 19th March by which time he furnished Captain Pullan, who by the by worked with him for one week computing—with all the points required in the eastern plane tables of sheet 8. During the season he also took observations at 5 stations (disconnected with his triangulation) where vertical angles were wanting, in order to compute the heights of a portion of last year's net work triangulation which by some oversight could not be computed for want of vertical observations at two or three stations connecting that season's work with the old triangulation. On the 21st April he took up the sketching in a plane table in sheet 8, the one afterwards lost, in which he sketched 40 square miles, exercising the while supervision over the traversing which was being carried on in sheet 9 by Gopál Vishnu and Ganesh Bápúji (1st) who was sent to work the available traverse party left vacant by Mr. McA'Fee taking the plane table party which arrangement was consequent on Mr. Hickie falling sick leaving a plane table party vacant. Altogether his traversing amounts to 309 miles giving an average of rather more than one point per 2 square miles. After completing the plane table he joined Mr. Christie and assisted him in clearing the rays and selecting stations on the Mahi Series so that he did not return to recess quarters till 4th July along with Mr. Christie.

(16.) Mr. Connor had to complete the net work triangulation in sheet 13 and visit a chain of stations of the previous season's triangulation for the purpose of taking vertical observations which had been altogether left undone, which he finished by 29th December having laid down 37 triangles and taken verticals at 23 stations besides. The area covered comprised 58½ square miles over which he laid down altogether 50 new fixed points. There was also a traverse of 8½ miles run in ground thickly wooded. On the completion of the field portion of this work he had to reduce his observations, compute his triangles and the latitudes and longitudes of his stations and points, because sheet 13 is one of those sheets that have been topographically surveyed this year. For these reductions I therefore directed him to join Mr. Cusson to whom the topography of the sheet was entrusted and the two worked together for a month and a half when he commenced the traversing of the blank portion of sheet 11 which has also been topographically surveyed this year but after spending a few days on that work during which he fixed one station by triangulation and ran 26 miles of traverse, I sent him on to sheet 10 to cover the blank eastern half with fixed points by traversing or by triangulation if practicable. I gave him a Native Surveyor with another traversing party to run minor traverses, Ganesh Bápúji (1st) who was afterwards succeeded by Ganesh Bápúji (2nd) and altogether that half sheet has been decorated with 15.4 miles of traversing giving on an average 1.3 fixed points per square mile. The whole of the half sheet is thickly wooded which rendered triangulation impracticable.

(17.) Mr. Hickie was entrusted with the topography of sheet 11 and under him were placed two Native Surveyors Balwant Govind and Mukund Dinkar each with a plane table and

TABULAR STATEMENT OF WORK IN GUZRAT DURING THE FIELD SEASON 1871-72.

*Triangulation.*

| OBSERVER'S NAMES.    | Instrument used.        | Area triangulated. | No. of stations visited. | 3 ANGLES OBSERVED. |                   |                 | 2 ANGLES OBSERVED. |            |                 | REMARKS. |
|----------------------|-------------------------|--------------------|--------------------------|--------------------|-------------------|-----------------|--------------------|------------|-----------------|----------|
|                      |                         |                    |                          | Triangles.         | Triangular error. | Error per mile. | No. of Heights.    | Triangles. | Error per mile. |  | No. of points. |
| Mr. A. D'Souza, ...  | 6" by Troughton & Simms | 536                | 111                      | 145                | 8                 | 0.1             | 62                 | 765        | 0.09            | 481      |
| " A. Christie, ...   | ditto                   | 400                | 25                       | 23                 | 4.3               | 0.05            | 21                 | 9          | 2.3             | 7        |
| " C. H. McA'Fee, ... | ditto                   | 38                 | 11                       | 7                  | 8.8               | 0.6             | 8                  | 19         | 5.0             | 15       |
| " E. J. Connor, ...  | 6" by Cooke & Sons      | 62                 | 51                       | 38                 | 11                | 0.52            | 51                 | 42         | 1.7             | 32       |
|                      | Total,.....             | 1036               | 198                      | 213                | ...               | ...             | 142                | 835        | ...             | 535      |

Only a very few triangles yet computed. The Mall Series.

*Plane Tabling.*

*Traversing.*

| No. | NAMES.                 | Plane Tabling. | Stations per square mile. | REMARKS. | No. | NAMES.                   | Linear miles of traverse. | REMARKS. |
|-----|------------------------|----------------|---------------------------|----------|-----|--------------------------|---------------------------|----------|
|     |                        |                |                           |          |     |                          |                           |          |
| 2   | " C. H. McA'Fee, ...   | 40.0           | 8.2                       |          | 2   | " E. J. Connor, ...      | 179.3                     |          |
| 3   | " J. Hieble, ...       | 126.0          | 13.6                      |          | 3   | " J. Hieble, ...         | 13.9                      |          |
| 4   | " D. Cusson, ...       | 190.0          | 7.4                       |          |     | <i>Native Surveyors.</i> |                           |          |
| 1   | Shaikh Káim lúys, ...  | 172.0          | 7.6                       |          | 1   | Gopal Vishnu, ...        | 148.4                     |          |
| 2   | Laximon Ghorpuray, ... | 177.0          | 9.6                       |          | 2   | Ganesh Bepuji, 1st ...   | 82.5                      |          |
| 3   | Ratwant Govind, ...    | 166.0          | 13.2                      |          | 3   | Ganesh Bepuji, 2nd ...   | 50.0                      |          |
| 4   | Bakurd Dinkar, ...     | 64.0           | 14.5                      |          |     |                          |                           |          |
| 5   | Vital Vishnu, ...      | 36.0           | 9.5                       |          |     |                          |                           |          |
| 6   | Bhaw Govind ...        | 109.0          | 12.1                      |          |     |                          |                           |          |
|     |                        | 1382           | 10.3                      |          |     |                          | 566.4                     |          |

party. The latter being a new hand, Mr. Hickie had first to train him to the work not quite *ab initio* as he had received some instruction last recess from Mr. D'Souza. Mr. Hickie was very unfortunate in losing his health which I fear will render him a delicate subject for some time to come. He had some years previously been a victim to chronic diarrhoea but had while serving on this side of India been enjoying an immunity from it until last December when it was again induced by the work on the coast which he sketched himself and where he was frequently for hours with his feet wet in the mud; that and the sun over head brought back his complaint which weakened him very much. When I visited him in January I noticed he was looking very much pulled down, but he continued to battle against the disease and worked on till 1st March when he was obliged to come into Bhroch for medical treatment which afforded him relief for the time, on which he resumed his work until the middle of April when he was obliged to give up and come again to Bhroch and then the Civil Surgeon discovered that his complaint was much more serious than he had at first supposed. He was for a short time very seriously ill but he was restored to comparative strength again and I then, during the remainder of the season, employed him on sedentary work in my office, fair copy of angle books &c. During the field season he with his own hands sketched with the plane table 126 square miles and closely inspected the work of both Balwant Govind and Mukund Dinkar who respectively turned out 166 and 64 square miles. The latter was employed from the 18th April under Captain Pullan. Mr. Hickie was also employed for about a fortnight traversing as the eastern portion of sheet 11 was too scantily provided with points.

(18.) Mr. Cusson was entrusted with the topography of sheet 13 and under him were Luxumon Ghorpuray and Vital Vishnu, the former a lad trained during the previous season, the latter a newly entertained lad. Mr. Cusson kept Vital Vishnu working with him until 15th December when he started him independently. Mr. Cusson as I have stated in para. (16) was interrupted in his topographical work by having to compute with Mr. Connor for a month and a half and again on 20th March when there were but two plane tables to be completed in sheet 13 which were made over to Luxumon Ghorpuray and Vital Vishnu, I directed him to take up a plane table in sheet 8 which he had half completed when Mr. Hickie's falling sick necessitated another change and I sent him to take Mr. Hickie's place, relieving him in sheet 8 by Mr. McA'Fee as mentioned in para. (15). Altogether Mr. Cusson with his own hands turned out 190 square miles of topography.

(19.) I have thus the pleasure of reporting favorably of the whole of my Assistants, every one of them having worked zealously and well, and the result of their combined labors must be considered highly satisfactory, comprising as it does the Topographical Survey of three sheets and the completion of the preliminary preparation of a similar area for topographical sketching next season, besides the completion of the Mahi triangulation. This considering the tender age of the party is I consider very successful.

(20.) I have also the pleasure to report the absence of any serious collisions with obstructive or litigious natives which, after the reports of Colonel Nasmyth and Lieutenant McCullagh, is I consider matter for congratulation.

(21.) Great obstruction was anticipated and indeed had been previously experienced from H. H. the Gaikwar's subjects in regard to cutting trees, but I represented through the Resident at Baroda the fact that most of the other large states in India had handsomely contributed towards defraying the cost of the Survey of their territory and suggested it would be after all but a trifling contribution on the part of the Baroda Darbár to relieve us of the *onus* of settling and awarding compensation for trees &c. This representation produced the desired effect and the Darbár sent me a Wakil (whom I attached to Mr. Christie's camp) to settle all difficulties in the way of cutting trees and to deal with all claims for compensation as claims against the Darbár and thus no further difficulties were experienced.

**Extract from the Narrative Report, dated 14th August 1872—of Captain W. M. CAMPBELL, R. E., Officiating Deputy Superintendent 2nd Grade, in charge No. 2 Extra Party.**

In the report which I submitted on 21st September last, giving a sketch of my employment on special duty in England during the preceding nine months, I mentioned that the new Zenith Sector with other instruments had just arrived in \*Bombay, and I shortly afterwards informed you that all these instruments had reached me at Púna in good order.

According to my instructions I despatched the instruments appertaining to the Electro-Longitude equipment to the care of Captain Herschel at Bangalor, and I sent an astronomical clock to your address at Dehra Dun, while I made all preparations for using the Zenith Sector for my own latitude observations during the approaching field season.

(2.) The work assigned to me was, to take observations for latitude on the Mangalur Meridional Series at points as evenly distributed as possible between Kem H. S., in latitude  $18^{\circ} 11'$  (where Lieutenant Heaviside had closed his series of observations) and Mangalur in latitude  $12^{\circ} 53'$  at which place I was instructed to choose a station, which should be also suitable for the proposed Electro-Longitude observations.

The average distance between latitude stations having always been considered as  $1^{\circ}$ , you advised me in case of the nature of the country requiring greater intervals, to endeavor to obtain two, or even three stations suitable for observation in each locality.

(3.) I had the following information to guide me in my selection of stations,—1st under instructions from Lieutenant Trotter, Mr. Wood had reconnoitred the neighborhood where it was advisable to select the first station south of Kem, and reported that out of 12 stations visited by him, Majála in latitude  $16^{\circ} 47'$  was the only one that seemed suitable.

2nd. Lieutenant Trotter who had himself executed the triangulation from latitude  $15^{\circ} 30'$  to latitude  $14^{\circ} 26'$  told me that he thought Kundgorl in latitude  $15^{\circ} 15'$  was the only point suitable for latitude observations in that portion.

These two stations being decided upon, and that at Mangalur being obligatory, it only remained to find a fourth point about latitude  $14^{\circ}$  to complete the set, dividing the total distance of  $5^{\circ} 18'$  into four intervals averaging  $1^{\circ} 20'$  each.

Accordingly this was the course I fixed upon, with the intention of using two stations in each locality if the nature of the country would admit of it.

(4.) The principal triangulation of the series from latitude  $14^{\circ} 26'$  to Mangalur, and again that of the Longitudinal Series for some distance east of Mangalur, had not been executed at the beginning of last field season, and as it was a matter of considerable importance that the latitude station at Mangalur should not only be equally suitable for the longitude observations, but should also be a station of the principal triangulation, or at least be capable of easy connection therewith, the best course appeared to be to proceed myself at once to Mangalur and select the station to answer if possible all these requirements.

This arrangement was also convenient, because it admitted of my returning from Mangalur, through the district about latitude  $14^{\circ}$  where I wished to select a latitude station, to meet the Party, (which should in the meantime have marched from Púna under charge of my assistant) at one of the points already fixed on viz. Majála and Kundgorl.

(5.) In accordance with this programme I despatched the camp from Púna under charge of Mr. Bryson (who had only just joined me from the Guzrát Party) with instruction to proceed to Kundgorl and prepare that station for observations.

The choice of Kundgorl, for the first station to be observed at, involved a return march northward to Majála, but it was the more convenient course for several reasons, chiefly because it suited my movements best with regard to time, and also gave me more opportunity of seeing the localities to be worked in, before committing myself irrevocably to any one station.

(6.) I left Bombay for Mangalur by steamer on 19th November taking my servants and camp equipage with me as far as Kamte (Coompta) where I landed them with instructions to proceed to Gursuppa by boat and there await my return from Mangalur.

(7.) On arrival at Mangalur I found a party of signallers with their heliotropes, sent to meet me by Major Branfill at my request. I lost no time in sending these men out to the 3 adjoining stations of the approximate triangulation, with which I wished if possible to



connect my proposed latitude station, substituting it for the station of the approximate series nearest to Mangalur, which being 4 or 5 miles distant from the Telegraph office, I did not consider suitable for the Electro-Longitude observations.

The Telegraph office is so very low lying and hidden from the surrounding country by higher ground and trees, that fixing trigonometrically any point in its neighborhood would have involved very considerable expenditure.

After some trouble I succeeded in finding a point to satisfy all requirements, close to the lighthouse and within a mile of the Telegraph office, and therefore capable of temporary connection therewith at slight expense.

(8.) Taking the first steamer available I reached Kamte on 28th November; and thence joined my people at Gursuppa next day.

From Gursuppa there is an excellent road over the Gháts to the north-west corner of Mysor, where I made a hurried inspection of the stations of the approximate series which seemed available for my purpose.

The season was so far advanced that I could not afford to spend so much time over this as I could have wished, but I satisfied myself that at least one station was fairly suitable, and then hurried northward as rapidly as possible joining the Party at Kundgorl on 16th December.

(9.) Some days were lost in consequence of the station not being ready to receive the observatory tent and instrument, and observations were not finished till 30th December and I started for Majála on 31st December. In the meantime I had deputed Mr. Bryson to examine the two neighboring stations Indúr and Ganúgud with a view to taking observation at one or both, but he reported them as unfit. I then sent him in advance to Majála to prepare for the work there.

(10.) On the march, I took the opportunity of inspecting the station Naolúr next adjoining Kundgorl to the north, and finding it very well adapted for my purpose, resolved to take a set of observations there on my return from Majála.

(11.) The Party reached Majála on 12th January and again I was delayed for 2 or 3 days owing to the difficulty of getting work done promptly. I sent Mr. Bryson to examine two stations Dandoba and Mawinhunda adjoining Majála, which Mr. Wood had not been able to visit the year before, and he reported that the latter was suitable for a latitude station. I had preparations made accordingly and after completing work at Majála proceeded to Mawinhunda and finished observation there on 7th February.

(12.) From Mawinhunda the Party returned south to Naolúr, where I took a set of observations and then revisited Kundgorl for a second set, which appeared to me desirable because of the adoption of some changes in the method of observation (which will be noticed later) after the first visit.

(13.) I finished work at Kundgorl on 9th March, and marched southward, whither Mr. Bryson had preceded me with instructions to examine the two stations which I thought likely to be suitable, and prepare them for observation if his examination proved satisfactory, which he did and I took a set of observation on each. These stations which I have named "Hunawali" and "Koramoraguda" are not as yet fixed by triangulation, which was closed at Chanderguti a few miles to the north by Lieutenant Trotter in 1867 and has not been continued since, but they both belong to the approximate series, and are likely to be fixed next season viz. 1872-73.

(14.) After Mr. Bryson had finished the preparatory building at these stations, as I did not expect to require his services at Mangalur, I sent him northward to re-protect and re-transfer the stations at which I had taken observations, as well as any others which he might find to require it.

(15.) I was terribly delayed at both Hunawali and Koramoraguda by clouds and fogs, the latter of which driving up from westward every night, used to put a complete stop to observations generally as early as 11 p. m., and did not clear off again till the sun got high in the heavens next morning.

These fogs may interfere with the triangulating party more seriously than they did with me, as they envelope the hills and obscure terrestrial objects generally some time before they close overhead and stop star observations.

They commence early in the hot-weather and increase in intensity as the season wears on, being also worst in the neighborhood of the Gháts.

(16.) I did not finish observations at Koramoraguda till 13th April, when I marched for Gursuppa, having decided that much the most convenient and economical route for transporting the Party to Mangalur at that season, was by the good Ghát road to Gursuppa and thence by boat down the river to Honawar and by native sailing vessel to Mangalur. The journey was made successfully and the Party reached Mangalur on 22nd April.

(17.) I put up the instrument a few feet due east of the Trigonometrical station, which being on a pillar several feet in height was not suitable.

Here again, clouds rendered my life a burden to me, for night after night I got either no work at all or only two or three observations; and in the end I considered myself very fortunate in completing my observations on 17th May; but I was forced to give up the idea of observing at two or more supplementary stations as I had proposed doing.

(18.) On 21st May I left Mangalur by steamer for Bepur (Beypore) and thence came on to Bangalur by rail, arriving on 24th May.

(19.) I shall now give a slight description of the stations which I visited.

"Majála" and "Mawinhunda," are both situated on flat-topped isolated hills standing in a plain, the general level of which is very equable.

The hill at Majala is about 560 feet above the plain, at Mawinhunda about 540 feet. At the first there is a slight preponderance of matter to the North and in the latter to the South, but in neither case is there any reason to expect appreciable disturbance of the plumbline.

(20.) "Naolúr" is on a low sharp peak, 100 or 120 feet above the level of the plain, which is, in the immediate neighborhood, rather broken by undulations.

"Kundgorl" stands on a slight swell in the middle of a very gently undulating plain. The general level of the country surrounding both of the last stations is very equable. In neither of these do I see any reason to assign a preponderance of matter on one side or the other, far less to expect any appreciable influence on the plumbline.

(21.) "Hunawali" and "Koramoraguda" are situated on hills in an undulating country of equable general level, but considerably broken up by hills, detached in groups, or in small ranges running inland from the Gháts. The country to a great extent, and the bases of both the hills in question, is covered with jungle.

The station "Hunawali" is on the highest point of a sharp ridge running North-East and South-West; its height above the plain is about 770 feet. There is probably some slight preponderance of matter on the southern side below the hill, but the hill itself has a small excess to the North.

"Koramoraguda" is on a round topped hill about 450 feet above the plain, the highest point of a little range running nearly East and West. There is a slight excess of matter in the plain below the hill to the South, and the mass of the hill itself is rather greater to North than to South of the station.

(22.) At neither of these stations do I think there is any thing sufficient in the configuration of the ground to justify a guess as to the direction of irregular attraction; but it must be remembered that they are both in the neighborhood of the Western Gháts and the great drop from the Mysor plateau into the low country of Kanara, averaging fully 2000 feet. This change of level is to the West, and several miles distant in both cases; but its line trends south-eastward and therefore the deficiency of matter caused thereby also lies to the south of the stations, but at a much greater distance from them in that direction.

(23.) The station at Mangalur is on the lighthouse hill, about 160 feet above the sea. There is nothing in the features of the ground in the vicinity sufficient to cause irregular attraction, but the mass of the high country above the Gháts lies to the East and North-East and the sea to the West.

(24.) I shall now make some remarks on the method of observation and on the instrument.

In the first set of observations at Kundgorl I made no use of the capability of the instrument for change of zero, but I introduced this at Majála.

(25.) In the middle of my observations at the latter place I had a letter from Captain Herschel in which he informed me, that he had tried the experiment of reversing his

instrument bodily, with so decided an effect on the results that he considered such reversal proved to be almost essential. I had long before contemplated making this reversal among others, but was deterred owing to the labor it involved of taking the instrument entirely to pieces, which labor however Captain Herschel avoided by the expedient of revolving it, all standing, on a metal fulcrum introduced under the centre of its base plate. The morning after receiving his letter I reversed in this manner and have done so ever since, taking half the observations at a station in each position of the instrument.

(26.) At Mawinlunda I farther introduced a reversal of the sector with regard to the microscopes. This change was a very troublesome one and its advantage problematical, but after adopting it I continued it at three stations, and then abandoned it, because I found that with uncertain weather, such as I had at the latter end of the season, every change of this sort, which divided the total observations to be obtained into groups, each to be taken in its own position, became a fertile source of delay.

(27.) At one time I adopted the plan of changing the order of position (East and West) of observation with alternate stars, at another on alternate nights. Both methods I think have arguments in their favor, but I am now of opinion that the former is the best. It is the one that Captain Herschel has adopted.

(28.) Early in the season I gave up all attempt at selecting stars in "pairs" with your sanction, and made it my first object to obtain stars depending on the greatest number of observations at Greenwich, using for this purpose both the seven-year Catalogues of 1860 and 1864. At the same time I always used an equal number of stars North and South of the Zenith, and endeavored to maintain an equality between the mean Zenith Distance, North and South.

The importance of using "pairs" seems to me to be almost entirely removed by the introduction of changes of Zero, whereby (excepting chance coincidences) a fresh set of graduations is used for every observation, whether of the same star or not.

(29.) I have discovered only one feature of the instrument which gave me uneasiness, viz., an instability of the zero of levels and microscopes, and level of transit axis, which have a tendency to change all together. I attributed this want of stability to the fact that the frame or "cradle" carrying the levels and microscopes and supporting the transit axis, stands upon four bearings, exactly equal pressure on which it is impossible to maintain. The contact is effected by a steel bolt assisting gravity and working through a thick brass plate. Consequently as the temperature varies the tension of the bolt and therefore the pressure of the cradle on its bearings also varies, and these bearings not being exactly in the same plane, or not all equally rigid (two being provided with an adjustment) strains are set up, causing the changes of zero noticed, between which and the temperature of the observatory I traced a decided connection.

(30.) When I first noticed these changes they caused me some anxiety but I have not traced any injurious effect in the zero error given by each observation, and it must be recollected that the most valuable feature of this instrument is, that any change of the sort is of no consequence whatever, provided stability may be reckoned upon for the time occupied by one double observation or for about 5 minutes only.

(31.) Throughout the season the instrument was carried on spring carts, which I constructed for that purpose at Púna, with a very great saving in pay for bearers, as these carts were dragged by the Khalásies of the Establishment, aided when requisite by ordinary coolies. They answered their purpose admirably and passed over some very bad, rough tracks, not worthy the name of road.

(32.) I regret that I am not in a position to judge of the observations by their results, which owing to the small computing power of the Party, have not yet been arrived at. The progress of the work has been greatly impeded by the necessity which I found myself under of recommending the grant of one month's privilege leave to Mr. Bryson, on very urgent private affairs.

(33.) Mr. Bryson only joined me at the commencement of last Field season; indeed he had already taken the field with the Guzrát Party, when he was transferred. He was therefore quite inexperienced in the work which he has had to perform.

I am very glad to be able to speak highly of his capacity and willingness to learn new duties and of his zeal in performing them, and I have nothing to complain of but a slight tendency to overlook details.

(34.) Nearly all the recording was done by my native writer, who is a very useful and hardworking observatory assistant.

(35.) I shall conclude this report with a short *résumé* of the season's work. The Party left Púna, on the 9th November and marched under charge of Mr. Bryson to Kundgorl H.S. close to \*Dharwar, where I rejoined it on 16th December, having in the interim visited Mangalur and selected a station there.

Between the 16th December and 17th May, observations were taken at seven stations and a second set at one of them, the distance travelled during that time being about 450 miles by land and 100 by sea. The weather during the early part of the season was favorable for observation, but in April and May very much the reverse.

(36.) The following is a statement of the cost of the operations.

The total cost of the Party during financial year 1871-72, was Rs. 17,788, which divided between 8 determinations of latitude, (including a second of one station) gives the average cost Rupees 2,223-8-0. This average however is not a fair one; as during the first five months of the year the pay of the officer in charge (Lieutenant Trotter acting) was not debited against this Party.

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**Extract from the Narrative Report—dated 6th September 1872—of Captain T. T. CARTER, R. E., Deputy Superintendent 2nd Grade, in charge  
Brahmaputra Series.**

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**PERSONNEL.**

Mr. W. G. Beverley (in charge) Asst. Supdt. 2nd Grade.

**ASSISTANTS.**

Mr. C. T. Neuville, Surveyor 2nd Grade.  
Mr. G. A. Harris, Asst. Surveyor 1st Grade.  
1 Native Doctor.  
51 Kálishies.  
15 Barkandáz Guards.

(1.) The Party as per margin left \*Calcutta on the 18th of November 1871 in charge of Mr. W. G. Beverley (who was also in charge of the Eastern Frontier Series) arriving at Káliganj on the Bráhmáputra River on the 28th of the month, where Messrs. Neuville and Harris landed to carry out the instructions as conveyed to them by Mr. Beverley.

(2.) In accordance with the programme of operations submitted for approval to the Superintendent G. T. Survey of India in Mr. Beverley's letter No. 106 of 1871, Mr. Neuville was to complete the approximate series fixing definitely the sites for the Alangjáni and Gobindpur Tower Stations, as some doubt existed whether the positions originally fixed for these Stations by Mr. Beverley in the Season of 1870-71 would last owing to the encroachment of the river. Mr. Neuville was then to fix the position of the Rangira Hill Station and visit the hill station of Gáropára to see if the rays to the plains were clear, subsequently Mr. Neuville was to examine the rays

Narsingbhanj to Kashdoho.  
Kashdoho „ Kanchipára.  
Gáropára „ Kanchipára.  
Gáropára „ Halka-Char.  
Gáropára „ Janakipur.

and if necessary make the final clearings.

(3.) At the completion of this approximate work, Mr. Neuville was to take up a minor triangulation to the Civil Station of Maimansih if time permitted, if not, he was to pay the compensation due on the above mentioned rays. Mr. Neuville carried out these instructions. The station of Alangjáni was found intact and a position chosen for a new tower to be built at Gobindpur, in place of the site originally selected up to which the river had encroached to within 40 feet. The final rays above described were cleared and compensation for trees paid.

(4.) The completion of the approximate work occupied Mr. Neuville to the 15th of February, when he proceeded to take up the minor triangulation to Maimansih, on the side Poerbari

to Rashidpur of the Bráhmáputra Series, but as time would not have permitted him to have completed the triangulation as far as Maimansinh during the season, and the 12-inch Theodolite with which he was to have done the work had not arrived, it was abandoned after taking trial rays for the 1st triangle of the series. He then proceeded to pay compensation for trees cut, in accordance with Mr. Beverley's instructions as above mentioned. This occupied Mr. Neville till the 15th of April, when he proceeded to Calcutta and thence to Head Quarters, Dehra Dun, arriving on the 9th May.

(5.) The approximate work has been completed (with the exception of building certain towers and platform stations to be afterwards enumerated) and the rays cleared up to the junction of the series with the Assám Longitudinal Series. Mr. Neville's work during the past field season is I think deserving of commendation.

(6.) Mr. G. A. Harris on landing at Káliganj on the 28th November proceeded to complete the building of the tower stations of the Series, but having completed the Tower Stations as per margin, he was directed to proceed and take up the building of the pillars on the Eastern Frontier Series, leaving Káliganj for \*Gowhatty on the 24th of February.

(7.) There remain to be built the following Tower and Platform Stations namely, at Kashidoho, Narsingbhanj, Gobindpur and Alangjáni stations, and 5 Platform stations, viz., at Gáropára, Peshkarbhita, Rangira, Singimari and Samding.

(8.) The side of continuation for the ensuing season's work, will be Parkoksa to Poelsa of the Basalia Polygon, but Mr. Neville reports that there is much fear that the station of Parkoksa will have been carried away by the river during these rains, in which case a new pillar will have to be built in the vicinity of Parkoksa and two triangles re-observed in the Basalia Polygon.

(9.) The charge of the Party was made over to me, vide Departmental Order No. 21, dated the 13th May 1872. The information given in this report is chiefly derivable from Mr. Neville the Senior Assistant with the party. The Party will take the field towards the end of October and an endeavor will be made to complete the work by the end of the field season 1873-74. There remain 3 Hexagons, 2 Pentagons and a Quadrilateral to complete the Series.

(10.) I regret to say that Mr. Neville, on the return of the Party to Head Quarters, was obliged to avail himself of two months privilege leave to recruit his health which he wishes to state has suffered severely during this, as well as the previous field season. Of the Native Establishment, about 20 per cent were generally ill with fever or dysentery.

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Extract from the Narrative Report—dated 14th September 1872—of Captain H. TROTTER, R.E., Deputy Superintendent 3rd Grade G. T. Survey, in charge \*Kattywar Survey.

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(3.) The Party left recess quarters at Púna about the 20th October, all the Assistants and Native Surveyors, proceeding as usual by rail to Súrat, thence across the Gulf of \*Cambay by bandar-boat to \*Gogo, our starting point for the interior of Kattywar. A few days march took them to the ground they had to survey and nearly all had commenced work by the 20th November.

(4.) I returned myself to Púna from privilege leave on the 9th November, the arrangements for taking the field having been ably conducted during my absence by the Assistant Superintendent Mr. McGill. Mr. Fielding had remained behind in Púna under my instructions to complete some of the mapping and records: and by the 14th November, I was able to despatch to Head Quarters, for publication, the whole of the fair copies of the maps completed during the previous season viz. sheets XXVI, XXVII and XXVIII of the Kattywar Survey scale 2"=1 mile.





(5.) On the 15th of the same month Mr. Fielding and I started for the districts and on arrival at \*Bombay, were somewhat alarmed at reading a paragraph in the newspapers to the effect that a tremendous storm had swept over the Gulf of Cambay on the 12th, and that many vessels had been wrecked, especially between Súrat and Gogo; that the sea wall at the latter place had been washed away and a great amount of damage done; that a number of tents had been swept away, amongst them those of an assistant in the Trigonometrical Survey. This was so far satisfactory, in that it was probable that the assistants had safely arrived; but knowing that the usual camping ground at Gogo was situated immediately behind this very sea wall, and fearing that very probably the whole of our tents, instruments, stores, records, &c. (which had been despatched by country craft direct from Bombay along with the Subordinate Native Establishment and the Assistants, and my own horses) might have been deposited there as usual, I was naturally very anxious until, on my arrival at Gogo on the 20th, I learned, that by a great piece of good fortune, owing to the unhealthy state of the camp followers, Mr. McGill had directed the whole of the Head Quarters camp to await my arrival at Wartej, about 12 miles inland, instead of at Gogo, where I had expected to find them. Thus no harm or damage was done to Government or to my own property; but Mr. Fielding's tent had unfortunately been pitched in the usual place and he found, on his arrival, everything that he had more or less injured by the salt water. His tents and boxes had been carried away by the force of the waves and had been deposited at a considerable distance off, close by the missionary's bungalow. Altogether, however, it is a source of congratulation that so little damage was done. Had the storm occurred a few days earlier the consequences might have been most disastrous.

(6.) Mr. Wyatt left Púna at the same time as the other Assistants, proceeding from Bombay by pattimar (country-boat) direct to Jafarabad, a port on the sea coast of Kattywar situated in sheet XXIX, a portion of the survey of which sheet had been left unfinished the previous season and which I had deputed Mr. Wyatt to complete.

(7.) The whole of the Assistants worked steadily and well throughout the season which may certainly be considered to have been a successful one, the actual amount of work completed being as follows:—

(8.) 2036 square miles have been topographically surveyed on the scale of 2" to the mile, 1940 square miles have been covered with a net-work of triangles preparatory to topographical survey, 779 linear miles of Täalluka boundary have been traversed with theodolite and chain, every boundary stone having been fixed, besides which 156 linear miles of traverse have been run along the margin of the season's work to test the accuracy of the detail survey.

Amount of work done.

(9.) The majority of the plane tablers commenced work in sheet XXV and worked steadily northwards, completing before the end of the season the whole of the topography of sheets XXIII, XXIV, and XXV, a very satisfactory out-turn of work considering the number of hands employed (viz: five European Assistants, two of whom were quite new to the work, and five Natives of whom one was a raw-hand). The ground in sheet XXV was mostly flat with the exception of one plane table, but in the sheets to the north there was an enormous amount of detail, requiring a large expenditure of time and labour to survey. Had it not been for this I might probably have a still little larger out-turn of work to record; for the past season has happily been an unusually healthy one and there was comparatively little sickness in the field though I regret to say there has been a great deal since our return to quarters.

(10.) Whilst the majority of the Assistants were employed in those three sheets, Mr. Wyatt was hard at work in sheet XXIX where he had first of all to complete a piece of triangulation, then run some traverses, and finally complete the topography of that portion of the sheets XXIX and XXX which was left unfinished last year. This was all completed satisfactorily before the end of May.

(11.) I had thus the satisfaction by the end of the season of having the completed portion of the Kattywar Survey in a more compact form than it has ever yet presented. It will be seen by reference to the Index Map that the topography now completed includes sheets V to IX, XII to XIX, and XXIII to XXX. This will enable degree sheets VI and VII to be prepared on a scale of 4 miles to the inch.

(12.) I am happy to say that in the ground we have been surveying during the past season nearly the whole of the Täalluka boundaries have been properly demarcated by the local committees appointed for the purpose, and that in the maps we shall send in this year there will be comparatively few "undemarcated" boundaries to disfigure them.

(13.) Whilst the filling in, of the topographical detail in sheets XXIII to XXV and in XXIX and XXX was progressing, Mr. McGill was carrying on the triangulation in the



north, over the ground to be surveyed topographically during the approaching field season. Sheet XXII had been triangulated in season 1870-71, and I had instructed Mr. McGill to endeavour to complete the triangulation of sheets X, XI, XX and XXI: this was finished by the end of the season.

(15.) During the approaching season nearly all hands will be employed on the topography of sheet XXII and of those sheets that have just been triangulated over by Mr. McGill, who will himself be employed in triangulating in the vicinity of Rájkot.

(16.) I have been in frequent consultation with Colonel W. W. Anderson, the Political Agent of Kattywar, as to the ground he would now wish taken up for survey, and he is anxious that I should commence operations in the vicinity of Rájkot, (the Head Quarters of the Political Agency) good maps of the country about which are very much wanted, that portion of the existing map of Kattywar being exceedingly unreliable. To show the urgent necessity that exists for a more reliable map of the country, than that which at present exists, I may mention 2 or 3 comparisons I have made between our work of the past season and the existing map, which was compiled in the Chief Engineer's Office, Bombay.

| Distance in miles between |                      | Correct          | According to existing map |
|---------------------------|----------------------|------------------|---------------------------|
| Anandpur and Chohila      |                      | 20 $\frac{1}{4}$ | 26                        |
| Ditto ditto               | Adkot and Panchaorda | 3                | 7 $\frac{1}{4}$           |
| Ditto ditto               | Babra and Jasdan     | 14               | 17                        |
| Ditto ditto               | Karasia and Jasdan   | 7                | 2 $\frac{1}{2}$           |

(17.) Besides these linear inaccuracies the lines of watershed and drainage are in many instances entirely incorrect; so much so that for any engineering purposes, the old map may be considered as worse than useless. I recently had a visit in my office in Púna from the Agent of the Bombay \*Baroda and Central India Railway, with reference to a proposed extension of their line from Wadwán (sheet XII), the present terminus of the Railway in Kattywar. An examination of the original maps of the past season induced him to lay out for detail survey altogether a different line to what he had originally intended.

(18.) I now proceed to report separately on the work of each Assistant. Lieutenant A. W. Baird, Assistant Superintendent joined the party in June, on return from sick leave in England, and has recently been appointed to the independent charge of a Party now being formed for the purpose of carrying on tidal and spirit leveling operations in Western India. During the few months that he has been attached to this office, Lieutenant Baird has been very regular in his attendance at office and has been of very great assistance, both in the ordinary computations and also in the reduction and arrangement of the traverse computations. We have now in the office a large mass of records connected with the Tíalluka traverses and Lieutenant Baird has been indexing and arranging these in a methodical manner, a work which will save much time and trouble hereafter.

(19.) Mr. McGill left Gogo on the 9th November, but the great storm of the 12th which was felt nearly all over eastern Kattywar) was followed by a succession of storms more or less severe, during which a great quantity of rain fell, delaying very considerably all the Assistants on their march and making the journey to the interior a most unpleasant one, as the roads in Kattywar after heavy rain are all but impassable. These heavy showers continued up to the 20th and did a great deal of damage to the grain crops, then in course of collection, as also to the cut grass, a great quantity of which was ruined, and nearly all the remainder more or less damaged: cotton however was benefited by it, and perhaps on the whole it did as much good as harm, as the previous fall of rain had been very scant and the young crops of all kinds were much in want of moisture. Notwithstanding the rain Mr. McGill was able to commence his observations in sheet XII on the 20th November, and by dint of that hard and steady work on which I have more than once had the pleasure of reporting, completed the work allotted to him by the middle of April. Many of his stations of observation were old Tower Stations of the Kattywar and Guzrát Longitudinal Series and considerable difficulty was experienced, as in most cases the platform surrounding the paka central pillar had crumbled away; and as the greater number of these towers were from 20 to 40 feet in height it was a matter of no small trouble to erect wooden platforms to support the observatory tent, especially in a country where timber is very scarce and difficult to procure. Mr. McGill adopted a plan of sending to the headmen of all the surrounding villages receipts for ropes, bamboos, timber, &c. These receipts contained a promise to return all the stores when done with. By this means he used to collect in an hour or two material sufficient to construct his platform, which was erected in a few hours more at a cost of a few rupees, whilst had he not adopted this

expedient, he might have been delayed days at each station and spent a small fortune in the purchase of stores from the neighbouring towns of Dholera an Wadwán. It is rather a peculiarity of the district that men will often *lend* material when no amount of persuasion will induce them to sell.

(20.) This district triangulated over by Mr. McGill is almost a dead flat with very little detail and will prove easy ground for our Surveyors. It is, like the rest of Kattywar, divided into numerous petty states, the north-western portion is mostly the property of Dhrángdra one of the four first-class states of the country. I paid a visit to the "Ráj" as the chief of the State is called, during the cold weather and the Darbár Officials have always been very obliging and ready to help us as far as practicable, affording a marked contrast to the neighbouring state of Wadwán, which has obtained rather an unenviable reputation of an opposite kind.

(21.) The Dhrángdra Ráj is an enterprising and energetic man, and is pushing on of his own accord various works of improvement, such as the construction of roads, building of dharmśálas, planting out of trees, and in even helping forward the construction of a railway, which amongst other benefits will carry away to distant markets the excellent building stones of various kinds that are found in his territory, more especially to the north of the town of Dhrángdra where beautiful sandstone is procurable.

(22.) The other principal states in the District are Talsana, Rájpara, Lakhtar, Bajana and Patri. Portions also of the states of Limri and Wadwán enter into these sheets, which nearly all belong to the district of Kattywar called "Jhalawar" or country of the "Jhalas" a tribe of Rájputés said to have settled down in these parts in about the 8th century. The original name of this tribe was "Mukwahana" a name said to be still existing in Central India. Several of the smaller states once formed a portion of Dhrángdra and although now actually entirely independent, their chiefs do not consider their investiture on succession to the crown complete until presented with a dress by the Dhrángdra Ráj.

(23.) With the exception of occasional low stony ridges bare of cultivation the country is entirely flat, and is on the whole fertile. The sandy soils produce bájri and jawári crops and the blacker soil which was once very famous for the quality and quantity of its wheat is now chiefly covered with cotton. The water of the district is not good, towards the Runn it is brackish and is mostly collected in tanks, a great many of which get dry in the hot weather following a bad monsoon, in which case wells are generally dug at the bottom of the tank. A more elaborate description of the country will be given after it has been topographically surveyed.

(24.) Mr. McGill in the course of the season's operations covered a space of 1760 square miles with 165 triangles, besides measuring 947 triangles (only 2 angles observed) for purposes of fixing points for our detail Surveyors. He observed from and fixed the heights of 103 stations, besides fixing the heights of 98 stations which he did not visit, altogether a first-rate season's work; other details connected with which will be found in the tabular statement attached to this report.

(25.) Mr. F. Ryall, who joined the Party during my absence on privilege leave in October, left for the field with the other Assistants at the end of that month. He had never had any previous experience in plane tabling, so I sent him to learn under Mr. Gwynne, one of my best trained hands. He was somewhat slow in picking up the work and remained with Mr. Gwynne until the end of December, when he commenced independent work. His progress was for some time very slow, but as the season advanced, he got on faster and at the close had completed 85 square miles of survey on the 2' scale. I am glad to say that his mapping was very carefully and accurately done. Mr. G. Anding rejoined the party from sick leave on the 1st of June, since which date he has been employed in miscellaneous computations under Mr. McGill.

(26.) Mr. J. Wood was transferred from the Astronomical to the Kattywar Party shortly before we took the field. He had no prior experience in the work of a topographical party, but he practised with a plane table in the neighbourhood of Púna before leaving for the districts. He also, during the latter half of November, worked with Mr. Gwynne preparatory to commencing independent work. During the season he completed 114 miles of detail survey. His out-turn would have been greater, but there was a good deal of detail in the ground he had to survey; besides which I made him constantly change boards with a young Native Surveyor (Nílkant) who was out in the field for the first time and whom it was necessary to train in habits of accuracy, which I thought would best be done by constantly checking his work by an accurate and careful Surveyor, such as Mr. Wood has proved himself to be. This assistant has been very regular in his attendance in office and has been of much use both in the computations and mapping.

(27.) Mr. Gwynne surveyed during the season 161 square miles. This is not so large as his usual out-turn, but most of the ground he worked over was hilly and full of detail; besides which he was in the early part of the season considerably delayed by having to instruct Mr. Ryall and one of the Native Surveyors in the theory and practice of plane tabling. The ground surveyed by Mr. Gwynne is as usual well and truthfully delineated. In recess Mr. Gwynne has been most useful: his skill and experience in preparing the maps coupled with his steady application to work makes him a valuable assistant in the office.

(28.) Mr. T. Rendell worked well in the field, completing the survey of 216 Square miles, part of which was intricate and with a good deal of detail. His work is accurate and neatly executed. In office, since return to Head Quarters Mr. Rendell has done good service in looking after the reduction of the traverses, although I regret to say that illness has somewhat interfered with his regular attendance in office.

(29.) There is a great deal of labour now incurred in the reduction of our Täalluka traverses, the calculations and plotting of which occupy the time of about four assistants during the whole recess, and as unfortunately some of the men who execute the traverses are not sufficiently educated to be entrusted with the computations, a great deal of extra labour is thrown on to the hands of those who would otherwise be employed in the ordinary routine work of the office. This would indicate the necessity of refusing to entertain in future as Native Surveyors candidates who have not sufficient knowledge of English and of elementary mathematics to enable them to compute out their own traverses.

(30.) Although the system now adopted of computing out by rectangular co-ordinates all our traverses, causes great additional labour yet it is no doubt more than compensated for in the increased value of the results, as our traverses can now be plotted at any time on any desired scale and will be of great use in future surveys for revenue purposes.

(31.) Mr. E. N. Wyatt has, as usual, done a first-rate season's work, viz., triangulated over 140 square miles of country, computed out his triangles in the field and surveyed topographically on the 2" scale 245 square miles (in sheets XXIX and XXX) of country, parts of which were very hilly and intricate. Besides this he has run 41 miles of traverse along Täalluka boundaries.

(32.) As before explained there was a quantity of unfinished work, both triangulation, detail Survey and traversing to be finished in sheets XXIX and XXX before those sheets could be got ready for publication. It was a very hard season's work to get through, and I selected Mr. Wyatt for the purpose knowing that he, if anybody, would accomplish it. I am glad to say it was completed to my entire satisfaction, although I much regret that Mr. Wyatt has since suffered severely in health from his exertions in the field. Details regarding Mr. Wyatt's triangulation will be found in the "Tabular Statement." Considering that it was his first attempt at triangulation, the results may be pronounced good. His traverses however have a rather larger error than most of those executed by other Surveyors during the past season. This is probably owing to his not having the same opportunities of testing the length of his measuring chains as those Surveyors who were working near my own camp. His errors were nearly always in deficiency.

(33.) Mr. Wyatt only returned to Head Quarters late in May and on the 1st July left Púna on three months privilege leave.

(34.) Mr. W. Fielding has turned out 219 square miles of detail survey in a very creditable manner and would have done more but that I kept constantly changing boards with some of the junior Surveyors a process which, though decreasing materially the out-turn of work, adds very much to its value.

(35.) Mr. Fielding worked steadily and zealously throughout the season and continues to give every satisfaction. He also has been granted three months privilege leave which he availed himself of on the 1st of August.

(36.) Of the Native Surveyors Vissaji Ragonáth has been very useful in the field in preparing and projecting plane tables, in occasional computations, in giving out traverses and other miscellaneous work. In Púna he has been mostly employed in the traverse computations.

(37.) Govindji Mahálay surveyed 260 square miles of country in very creditable style and has worked hard and steadily in office in plotting traverses, &c.

(38.) Vishnu Moreshwar surveyed 222 square miles in good style and though frequently sick has been usefully employed in office in tracing, drawing, &c.

(39.) Ráoji Naráyan and Shrídhár Saccarám surveyed 174 and 258 square miles respectively. Both these Surveyors, especially the latter, have much improved both as regards quality and quantity of their work; although in their anxiety for a creditable out-turn they are occasionally apt to hurry too much over their ground.

(40.) Nílkant Vittal, brother of Shrídhár Saccarám and a new hand this season, completed 82 square miles of country and bids fair to become a good Surveyor.

(41.) Of the Traverse Surveyors, Nursu Dinkar, Krishna Govind and Bolúji Bhosaker completed respectively 299, 170 and 270 miles of boundary traverse and the two latter in addition traversed 75 and 81 miles respectively of check lines. The traverses this season will stand very favorable comparison with those of former years. They have all been computed out and corrections applied from the true geodetical distances.

(44.) Owing to the large out-turn of field work during the past two seasons and the amount of work involved in the traverse computations as well as the absence from sickness of many of the Assistants, our computations and mapping are somewhat in arrears, but I hope, before the close of the recess, to be able to send to Head Quarters for publication fair copies of all our last season's maps.

(45.) The country under detail survey by Mr. Wyatt in sheets XXX and XXXI has been described in former reports. The Northern part of his work forms the Southern portion of the Gir Range of mountains, one of the few places in India still forming the haunt of the Lion.

(46.) I have on many occasions during the past few years, while passing through the Gir, tried hard to shoot one of these animals, but I have never been rewarded by success until the present year, when accompanied by Mr. Wyatt, who was surveying in the neighbourhood, we had the good fortune to bag two full grown ones and two cubs. As I do not know of any naturalist or sportsman (Dr. Jerdon not excepted) who has written any account of the habits of the Lion, a few details may not be uninteresting. It is erroneous to suppose that the Kattywar (Guzrát) Lion is maneless, although in the specimens I have seen, the mane has been considerably shorter and of lighter colour than that of the African species. One that I shot, supposed to have been eight years old from its containing that number of lobes in its liver, had the hair covering the back of the head and neck not more than a few inches long. The dimensions of this animal taken as it lay dead on the ground were as follows:—

|                                         |        |
|-----------------------------------------|--------|
| Length from nose to tip of tail .. .. . | 8' 10" |
| „ of head and body alone .. .. .        | 5' 11" |
| „ of tail .. .. .                       | 2' 11" |
| Height at shoulder .. .. .              | 3' 4"  |
| Girth of Neck .. .. .                   | 2' 6"  |
| „ Chest .. .. .                         | 4' 1"  |
| „ Fore-arm .. .. .                      | 1' 9"  |
| Length of hair on mane .. .. .          | 5"     |

(47.) In appearance its colour is very much like that of a camel or a female nílgáe, and I have on one occasion when at a distance actually mistaken a lion for the latter animal. From its colour it derived the name, by which it is known in most parts of Guzrát, “Untia-Bág” or “Camel coloured Tiger.” In the Gir however it is always called “Sáwaj,” a name that I do not think is known out of Kattywar. The male is rather darker than the female and is a little heavier about the head and shoulders; the female being very much the same shape as the common tiger. Their habits are somewhat similar to those of the tiger. They always travel at night leaving their daily resting place about sunset. Their first visit is generally to the water, after which they wander about in search of food, often going many miles over hill and dale in their nightly peregrinations. In passing from one favorite resting place to another they generally make use of the best roads the country affords, and I have often met their foot-marks going for miles along the road I have been myself traversing; and if one did happen to travel in that country on a fine moonlight night, I can imagine nothing more likely to occur than a chance rencontre with one of these forest kings. They feed chiefly on nílgáe, sámbar and wild hog, a single blow of their paw generally sufficing to break the back of the largest animal. They sometimes commit considerable depredations on the herds of buffaloes that are taken into the Gir for grazing. Owing to the great heat, the cattle are generally allowed to wallow in the mud and lie under trees during the hottest part of the day; and at night they are driven out to graze. As a rule they keep together, in which case they are never disturbed by the Lion; but if by chance a sick one should lag behind or should any wander away to a distance from the rest of the herd, the Lion, if there be one near, is sure to bag it, however big and powerful it may be. As long as the herd keeps together, however, there is no fear, as the Lion dare not attack. If the kill be made early in the evening and the lion be hungry, he will at once

TABULAR STATEMENT OF OUT-TURN OF WORK IN KATTYWAR DURING THE FIELD SEASON 1871-72.

Triangulation.

| No. | OBSERVERS' NAMES. | Instrument used.              | Area triangulated. | 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.            | Discrepancy per mile. | Average Discrepancy per mile. |
| 1   | Mr. J. McGill,    | Cooke and Sons' 7" No. 1,566. | Sq: miles<br>1760  | 201                          | 657                           | 103                      | "                            | feet<br>0.5            | 947                   | feet<br>1.3                  |                       |                               |
| 2   | " E. N. Wyatt,    | Tr. & Summs' 6" " 700.        | 140                | 20                           | 82                            | 19                       | 18.4                         | 0.8                    | 100                   | 1.6                          |                       |                               |
|     | Total             | ...                           | 1900               | 221                          | 739                           | 122                      | Mean 15.15                   | Mean 0.65              | 1047                  | Mean 1.55                    |                       |                               |

Topography.

Traverses.

| No. | PLANE TABLING.           | Area surveyed Scale 2 inches = 1 mile. | Average No. of plane table stations per mile. | REMARKS. | NAMES.           | NO. OF LINEAR MILES TRAVERSED. |              | REMARKS.                                      |
|-----|--------------------------|----------------------------------------|-----------------------------------------------|----------|------------------|--------------------------------|--------------|-----------------------------------------------|
|     |                          |                                        |                                               |          |                  | Taalka Boundary.               | Check Lines. |                                               |
| 1   | Mr. F. Ryall,            | Sq: miles<br>85                        | 11.3                                          |          | Mr. E. N. Wyatt, | 41.2                           | .....        | Average error in traverse work per 1000 links |
| 2   | " J. Wood,               | 114                                    | 18.9                                          |          | Nursu Dinkar,    | 239.4                          | .....        | Mr. Wyatt, 1.77 links                         |
| 3   | " N. Gwynne,             | 161                                    | 9.1                                           |          | Krishna Govind,  | 169.8                          | .....        | Nursu Dinkar, 0.84 "                          |
| 4   | " T. Rendell,            | 216                                    | 7.4                                           |          | Bolaji Bhesaker, | 269.0                          | 81.1         | Krishna Govind, 0.48 "                        |
| 5   | " E. N. Wyatt,           | 245                                    | 6.4                                           |          |                  |                                |              | Bolaji Bhesaker, 0.75 "                       |
| 6   | " W. Fielding,           | 219                                    | 8.9                                           |          |                  |                                |              |                                               |
|     | <i>Native Surveyors.</i> |                                        |                                               |          |                  |                                |              |                                               |
| 1   | Govindji Mahalay,        | 260                                    | 8.0                                           |          |                  |                                |              |                                               |
| 2   | Vishnu Moreshwar,        | 222                                    | 10.4                                          |          |                  |                                |              |                                               |
| 3   | Baoji Narayan,           | 174                                    | 8.5                                           |          |                  |                                |              |                                               |
| 4   | Shridhar Saccarim,       | 258                                    | 10.6                                          |          |                  |                                |              |                                               |
| 5   | Nikant Vitthal,          | 82                                     | 13.5                                          |          |                  |                                |              |                                               |
|     | Total                    | 2036                                   | 10.3                                          |          |                  | 779.4                          | 155.9        |                                               |

commence eating it, but will always leave it about daylight and go and rest for the day at some secluded spot in the neighbourhood, either down near the water in the shade of Caranda and other trees, or, what is perhaps more common, they will go on the top of some neighbouring hill where they may get a cool breeze and where they lie out in the open under the shade of a big stone or, when procurable, of a large banyan tree. When disturbed they do not slink away like a tiger or panther, but walk or run upright without any attempt at concealment. Being very nearly the same colour as the ground and of the scorched leafless trees with which these hills are covered in the hot weather, it is very difficult to see them before being seen oneself; and this generally happens, owing to the frequent absence of undergrowth in these jungles before the sportsman gets within range.

(48.) I have never heard an authentic instance of an unwounded lion attacking a man, but when wounded, I should say that their ferocity would fully equal that of the tiger. It is a curious fact that not a tiger or a bear exists in a wild state in the whole of Kattywar. Panthers however are very numerous in the Gir as well as in other parts of the country.

(49.) As far as I know from my own experience and from enquiries I have made, I am of opinion that there are not more than fifty lions in the whole country. The female generally has two cubs, but probably, as is the case with other animals of the kind, there are three born—it being supposed that the first born is always devoured by the mother.

(50.) The country surveyed topographically in sheets XXIII, XXIV and XXV has also been described in last year's report. A fuller description will be given when the general report on the degree sheet is prepared.

(51.) Late in the season, after inspecting Mr. Wyatt's work, I went down to the south and examined very carefully the whole coast line between Diu and Verawal with the object of selecting stations for tidal observations. There is a place near Diu, to the N. E. of the island, which I think would be very well adapted for the purpose. It is the spot where observations were taken by Mr. D'Costa under Colonel Nasmyth's superintendence in 1855. There is a low deep channel to the W. of the island of Diu, just opposite the town of Brancavara, which for some reasons would be more suitable, but which would not be so well protected during the S. W. monsoons. From this place up to and beyond Verawal there is no suitable spot. There are many creeks which might at first sight look promising, but a little investigation always brings to light the existence of a bar with a little or no water over it at low springs. I have communicated the result of my investigations to Lieutenant Baird who has now been entrusted with the carrying out of the proposed tidal observations. I applied to the Bombay Government for the loan of a steamer or other vessel, to enable me to make a more extensive examination of the coast line, but competent authorities decided that it would be too dangerous a trip to undertake so late in the season; and I was obliged to content myself with the examination of a comparatively small strip of coast. I hope however that arrangements will be made to enable Lieutenant Baird to carry out a very complete survey of the coast during the approaching cold weather; so that, on the arrival of the new instruments now being constructed in England under Colonel Walker's superintendence, it is to be hoped the tidal observations on this side of India may fairly be started.

(52.) The total expenditure on the Party during the past financial year has been Rupees 68,830, against 66,859 of the previous year, whilst the out-turn of work finally completed is 2,036 square miles, against 2,064 of the former year. Deducting Rs. 3,600, the cost of the Boundary Survey Establishment, we have an average expenditure per square mile of mapping completed of Rs. 32-0-7, against Rs. 30-10-4 of 1870-71 and Rs. 58-9 of 1869-70.

(53.) It is again a pleasure for me to be able to acknowledge the cordial assistance we always receive from Colonel W. W. Anderson the Political Agent and the Assistants under his orders. The country is in a somewhat disturbed state, the police arrangements being very inefficient, owing to the enormous number of petty states into which the country is sub-divided; but although there have been bands of mounted and well armed robbers traversing the country, against whom I have been more than once warned by the Political Assistants, I am happy to say that in no instance have they interfered with or annoyed either myself or any of our Survey Parties, although villages have been attacked and looted within a few miles of where my assistants have been working. The large tracts of wild hilly ground existing in the Gir and other places in Kattywar, afford admirable places of refuge for these bands, when the plains become too hot to hold them.

**Extract from the Narrative Report—dated 29th August 1872—of Lieutenant J. HILL,  
R.E., Assistant Superintendent 1st Grade G. T. Survey, in charge \* Kumaon  
and \* Gurhwal Party.**

(1.) When the skeleton sheets of the large scale survey of Masúri and Landaur were completed, a reduction by photography was made from them at the Head Quarters' Office to serve as a guide map for Masúri and Landaur. Three of those sheets, which include the most important part of the sanatorium, were published in the summer of 1867, and the guide map was published in April 1871. During that interval of four years several houses had been built, and other changes made, and the above-mentioned reduction was only published so as to be a convenience to the public until a more perfect guide map could be prepared.

(2.) On the return of the party to Masúri in the last week of April 1871, the preparation of a second edition of the guide map was commenced, on the basis of the reduction mentioned in the preceding paragraph. This second edition contains all the changes that have taken place in the sanatorium since the preparation of the original

The Recess of 1871.

Guide Map for Masúri and Landaur. Second Edition.

maps. It is furnished with a table of distances, and an index, and a number of new barometric heights are also entered in it. The measurements for the table of distances were made by Mr. J. Low with a perambulator of Sir A. S. Waugh's pattern, and in addition to them some distances were extracted from a table prepared by Mr. J. B. N. Hennessey several years ago, and kindly placed at my disposal by him. The new houses which had been built, and the other changes which had taken place in Masúri and Landaur were laid down by Messrs. J. Peyton and T. Kinney on the original large scale maps, and afterwards entered in the guide map by the latter officer, who assisted greatly in the general preparation of the map. Mr. H. Todd took the barometric height observations with an aneroid barometer of 4½ inches diameter. A similar stationary instrument was read in my office at intervals of half an hour during the time he was engaged on this duty, and the curve of atmospheric pressure indicated by it was used to correct the readings of the transported barometer: the results thus obtained have proved very satisfactory. On the completion of the map in September 1871 it was sent to the Head Quarters office at Dehra Dun, and there published.

(3.) The main work of the recess was the preparation of the fair maps of the Kosi

Kosi Valley Survey Maps.

Valley Survey, which comprise 8 large shaded sheets, and the same number of skeleton charts. The preparation of those maps was a work of time, for they were intended to enable an Engineer to measure the slope of the ground at any particular spot in the survey, and to attain that object it was necessary to adopt a rather laborious method of shading, as explained in my last year's Narrative Report, and the shading was effected by the interpolation of horizontal lines according to a scale of shade which gave a vertical interval of about 15 feet between the *hachures*. In the skeleton charts the hill shading was omitted, but the dotted contour lines were retained.

(5.) The field work began with the extension of the triangulation in the higher mountain

Survey of the higher ranges of the Himalayas.

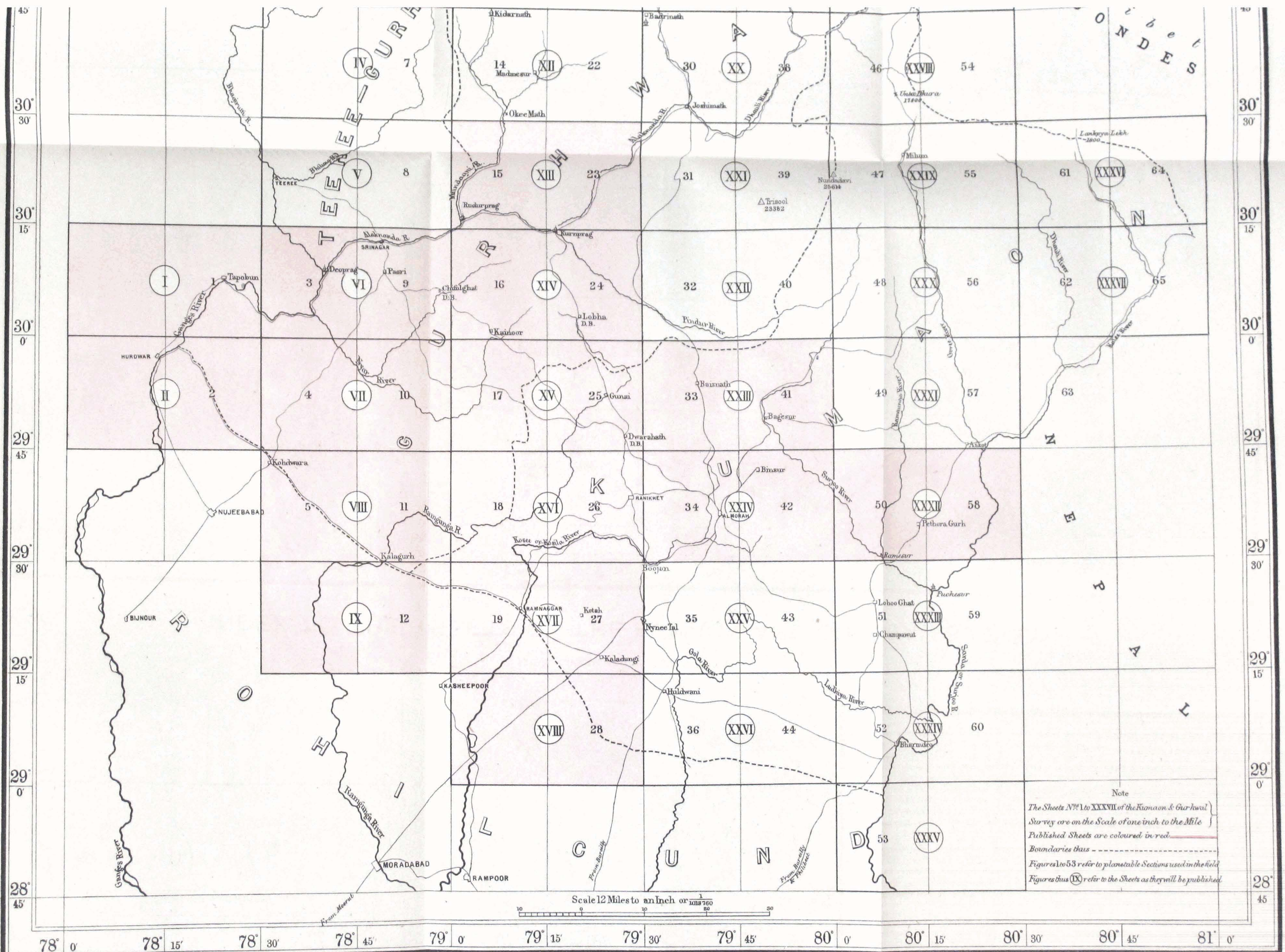
ranges of Gurhwal, Messrs. J. Low and L. Pocock were selected to perform it. Their work consisted in extending, as far as the limited time available would permit, the two minor series of triangles on which they had been engaged in 1869. Mr. Low extended his series up the Mána valley from the temple of Badrináth to the village of Ghastoli, and fixed a sufficient number of points to enable the topographers to finish the survey of the valley; and Mr. Pocock was able to complete thoroughly the triangulation of the Níti valley from the village of Kargúti to the Níti Pass. The details of their work are included in the tabular statement on page 45-a.

(6.) On reaching the Níti Pass, Mr. Pocock chose three stations on the watershed

Trans-Sutlej Peaks.

(all of them just over 17,000 feet above the level of the sea) from which he was able to fix the positions of 8 remarkable peaks beyond the \*Sutlej. One is the famous Kailás Parbat, the most commanding peak visible from the Níti Pass; another is a peak about 7 miles to the north of the Choka La, laid down as Sápu by Mr. Pocock.

(7.) The difficulties to be overcome in carrying a triangulation over such valleys as those of the Mána and Níti are by no means insignificant. Both those valleys are enclosed by mountain ranges the average height of whose peaks is considerably over 21,000 feet above the level of the sea, and the spurs are as lofty as the ranges from which they spring, until they come within a few miles of the main watercourses of the valleys. The valleys present the appearance of narrow gorges overhung by stupendous and inaccessible precipices, and it is obvious that in such ground a triangulator has little or no choice as to the shape of his figures, but has in many cases to content himself with observing from any commanding point on which he may be able to set up his in-



Note  
 The Sheets Nos 1 to XXXVII of the Kumaon & Garhwal Survey are on the Scale of one inch to the Mile  
 Published Sheets are coloured in red  
 Boundaries thus -----  
 Figures 1 to 53 refer to plane-table Sections used in the field  
 Figures thus (IX) refer to the Sheets as they will be published

Scale 12 Miles to an Inch or  $\frac{1}{1018760}$





DETAILS OF TRIANGULATION, KUMAON AND GURHWAL PARTY. SEASON 1871-72.

| NAME.                            | Area in square miles. | 1st Class Second-ary Triangles. | 2nd Class Second-ary Triangles. | Stations visited. | Intersected points. | Trigonometrical heights. | Barometrical heights observations. | Points whose Elevations have been computed. | Average Area in square miles to each Point. | Average Area in square miles to each height. | Number of Boundary Pillars fixed. | REMARKS.                                  |
|----------------------------------|-----------------------|---------------------------------|---------------------------------|-------------------|---------------------|--------------------------|------------------------------------|---------------------------------------------|---------------------------------------------|----------------------------------------------|-----------------------------------|-------------------------------------------|
| Lieut. H. M. Chambers, R.E., ... | 240                   | 18                              | 101                             | 19                | 59                  | 70                       | ...                                | ...                                         | 8.1                                         | 3.4                                          | ...                               | Lower mountain districts near Nai-ni-Tal. |
| Mr. E. C. Rysall, ...            | 660                   | 33                              | 290                             | 27                | 151                 | 93                       | ...                                | ...                                         | 3.7                                         | 7.1                                          | ...                               | Forest-clad Bhabbar hills.                |
| " J. Low, ...                    | 150                   | 10                              | 58                              | 11                | 31                  | 42                       | 11                                 | ...                                         | 3.6                                         | 3.6                                          | ...                               | Higher mountain ranges of Gurb-wal.       |
| " L. Pocock, ...                 | 340                   | 14                              | 49                              | 15                | 26                  | 41                       | 25                                 | ...                                         | 6.3                                         | 5.3                                          | ...                               | Higher mountain ranges of Gurb-wal.       |
| " T. Kinney, ...                 | 130                   | 0                               | 12                              | 14                | 0                   | 12                       | ...                                | ...                                         | 10.9                                        | 10.9                                         | 15                                | Bhabbar district.                         |
| " T. Kinney, ...                 | 302                   | 14                              | ...                             | ...               | 8                   | 8                        | ...                                | ...                                         | 1.1                                         | ...                                          | ...                               | Trans-Sutlej peaks.                       |
| " T. Kinney, ...                 | 40                    | 5                               | 32                              | 10                | 27                  | 21                       | ...                                | ...                                         | 4.0                                         | 2.0                                          | ...                               | Forest-clad Bhabbar hills.                |
| Total, ...                       | 1862                  | 80                              | 546                             | 96                | 302                 | 287                      | 36                                 | 533                                         | 4.0                                         | 5.6                                          | 15                                |                                           |

Topographical Details.

| NAME.                 | Area surveyed in square miles. | Plane Table stations. | Average No. of Plane stations per square mile. | Number of square miles under cultivation. | REMARKS.                                                                                 |
|-----------------------|--------------------------------|-----------------------|------------------------------------------------|-------------------------------------------|------------------------------------------------------------------------------------------|
| Mr. E. C. Rysall, ... | 38                             | 243                   | 6.4                                            | 0                                         | Chandrinair wooded hills of a height varying from 1,000 to 2,000 feet above sea-level.   |
| " J. Peyton, ...      | *263                           | 473                   | 1.8                                            | 83                                        | Chiefly forest ground of a height varying from 2,500 to 8,100 feet above sea-level.      |
| " J. Low, ...         | *338                           | 763                   | 2.3                                            | 41                                        | Chiefly forest ground of a height varying from 3,000 to 9,000 feet above sea-level.      |
| " L. Pocock, ...      | 210                            | 383                   | 1.8                                            | 13                                        | Chiefly forest ground of a height varying from 770 to 7,100 feet above sea-level.        |
| " H. Todd, ...        | 218                            | 416                   | 1.8                                            | 21                                        | Chiefly forest ground of a height varying from 3,500 to 9,000 feet above sea-level.      |
| " E. Litchfield, ...  | 173                            | 503                   | 2.9                                            | 16                                        | Chiefly forest ground of a height varying from 2,500 to 7,700 feet above sea-level.      |
| Total, ...            | 1279                           | 2615                  | 2.2                                            | 127                                       | * These areas are exclusive of 93 square miles of the Nepal border sketched from Kumaon. |

trument. To the physical difficulties he has to encounter must be added the difficulties of obtaining carriage, supplies, and fuel. In these ranges the forest line ceases at an altitude of about 11,000 feet above sea level. Up to an elevation of 14,000 feet firewood is carried up from the forests and stacked for use; but above that elevation the Surveyors are dependent for fuel on the root of a small wild plant which is found at elevations of 13,000 feet and upwards, and the task of collecting a sufficient quantity of this root is one of great labour. There being very little cultivation in these regions, the inhabitants descend during the month of October to the lower districts of Kumaon and Gurhwal and barter their salt for grain which they carry back to their homes in the mountains. In order that Messrs. Low & Pocock might carry on their work successfully, they had to look to the civil authorities for assistance. This was given them most effectually by Captain Garstin the Senior Assistant Commissioner of Gurhwal. He arranged for their supplies, their carriage, and their fuel, and, as in former years, did every thing in his power to help on the progress of the survey.

(8.) The chief work of the field season consisted in completing the triangulation of both

The Field Season of 1871-72. the country to the east of Naini-Tal and the Bhábar tracts between Haldwáni and Bharmdeo, and in surveying topographically the districts round Baiznáth, Bageswar, Lohághát, Pitorágarh, and a part of the Bhábar to the south of Káli Dungi, all of which are within the district of Kumaon. It was also thought necessary to triangulate and sketch some ground opposite Hardwar where the low sandstone hills on the left bank of the \*Ganges extend for a short distance beyond the boundary of Gurhwal, and terminate in the plains to the north of Aságarh.

(9.) The triangulation was apportioned to Lieutenant H. M. Chambers R. E., and Messrs. E. C. Ryall, L. Pocock, and T. Kinney, and the topography to Messrs. E. C. Ryall, J. Peyton, J. Low, L. Pocock, H. Todd and E. Litchfield.

(10.) I shall confine myself to the general character of the work done. Its details are to be found in the tabular statement on the preceding page.

(11.) Lieutenant Chambers was employed in my camp familiarising himself with the

Lieutenant H.M. Chambers, R.E. use of a 12-inch theodolite, till the beginning of the new year. During that time the ground allotted to him for triangulation was being staved. It lies to the east of Naini-Tal, and is of a height varying from about 1,500 to 7,500 feet above sea-level. It is chiefly remarkable for a cluster of small lakes grouped together in the neighbourhood of Bhím-Tal. In other respects it is like ground of a similar altitude in other parts of Kumaon, such as has been described in former reports.

(12.) During the winter months the people of this district leave it to cultivate their fields in the Bhábar. Carriage could not, therefore, be obtained on the spot, and it became necessary to hire permanent coolies from other districts to enable Lieutenant Chambers to carry on his work.

(13.) There was then a considerable quantity of snow on the higher ground, and it chanced most unfortunately that while Lieutenant Chambers was crossing a snow-drift on the 11th January he fell and sustained a fracture of the collar bone. This accident obliged him to take sick leave, and he was not permitted by the Surgeon who attended him to resume work until the 25th February. He succeeded, however, by making great exertions, in finishing his triangulation by the end of the field season; and the results of his work, as since tested by computation, have proved very satisfactory.

(14.) Mr. Ryall was employed on the triangulation (including its computation,) and

Mr. E. C. Ryall. Survey of Chándipahár. the sketching of the hill tract of Chándipahár opposite Hardwar mentioned in para: (8.) In intricacy this piece of ground is unequalled by any part of Kumaon or Gurhwal. Its survey, which was a matter of no little labour, I found, on inspection, to be thoroughly well done.

(15.) Mr. Ryall has furnished the following notes descriptive of the Chándipahár hills.

"The Chándipahár portion of the Sewálíks, in the Bijnaur District, is bounded on the West by the river Gauges and on the South-East by the Páli Rau up to its junction with the Khara Sot: from thence the boundary runs up the Khara Sot about  $2\frac{1}{2}$  miles, turns up into a small tributary in a North-westerly direction, crosses a low ridge and goes into the Glasirau ka Sot, continuing along this Sot till its junction with the Ganges.

"The whole of this tract of country is densely covered with forest. The Northern slopes of the hills are principally clad with Sál trees. The Southern sides of the hills are generally rugged, and are consequently almost entirely deserted by Sál trees. The bottom of the hills is densely covered with bamboos, which contribute a good deal to the revenue, giving employment to scores of bamboo cutters.

"It appears that owing to the great demand for charcoal in the Rúrki Workshops, the Chándípahár hills have been made over entirely to the Superintendent of the Rúrki Workshops, who leases out certain tracts of forests to charcoal burners.

"The formation of the hills is chiefly of sandstone, identical with that of the Sewáliks of Dehra Dun. The whole formation is so very much broken up that it presents a sea of confusion, and renders the tracing out of the different little spurs, knolls and streams (which are almost alike one another) a matter of great difficulty."

(16.) The Principal Hill Station of Chándípahár (which belongs to the Great Arc Series)

Repair of Chándípahár H. S. having fallen out of repair, instructions were received to undertake its restoration. As Mr. Ryall was on the spot I entrusted this work to him, and he commenced upon it as soon as he had finished his survey of the contiguous hills. The slipping away of the whole of the Southern half of the original platform caused a great deal of damage to the side of the hill below the station, and it was only after cutting down for about 22 feet that Mr. Ryall found ground firm enough for a foundation. He completed the repair of the station in 10 days, and then started to take up the work assigned to him in Kumaon.

(17.) Mr. Ryall's work in Kumaon consisted in completing the triangulation of the

Bhábar Triangulation. Bhábar hills which extend from Haldwáni eastward to Bharmdeo. These hills are even more densely covered with forest than those to the West of Haldwáni, and the ground in general is somewhat intricate in character: carriage, also, is not to be procured without considerable difficulty. In spite of these drawbacks Mr. Ryall was able to finish his triangulation, and at the same time a most excellent season's work, by the second week in April.

(18.) Mr. Peyton was employed in the Pitorágarh district. From its eastern margin

Mr. J. Peyton. above the river Káli he was able to sketch 48 square miles of the Nepál border. The part of Nepál so sketched seems to be of a bolder and more rugged character than the country opposite to it in Kumaon. Mr. Peyton closed work in the last week in April. Before he did so, I inspected his ground and found it, as usual, faithfully and artistically delineated.

(19.) Mr. Peyton gives the following particulars regarding the district he surveyed.

"The Pitorágarh district is highly cultivated; but a great many of the villages, especially those near the Káli river, are surrounded by dense belts of jungle, the Chír pine being the predominating tree. The Dhaj mountain on the north throws out very thickly wooded spurs in the direction of the Káli, with a very gradual descent for about 6 miles, and then an abrupt fall, with steep precipitous ground, on the edge of the river. This appears to be a remarkable feature of nearly all the ridges, which rise precipitously from the river, and then slope up very gradually to the main range which forms the watershed of the Káli and Rámnganga. The Askot district north of Dhaj is traversed by a large tributary of the Káli, called Charma Gadh, and has a good deal of undulating ground, all under cultivation, the villagers being chiefly Dótíáls from Nepál, who have been compelled by the high rate of land assessment to leave the Mahárájá's territory and settle in Kumaon; and all the productive land on the banks of the Káli is now in their possession, the Chír forest being extensively cleared, and villages rising on all sides, with broad green belts of cultivation, forming a most pleasing relief to the sombre monotony of the forest. So rapidly is the work of reclaiming forest going on, that probably in a few years very little jungle will be left; in fact only in such places as are rendered inaccessible by huge precipices.

"The rock and general formation is limestone, but here and there a crumbling kind of sandstone is predominant, especially in the lower spurs overhanging the Káli.

"The roads, both Government and village, are generally steep in this part of Kumaon. Besides the great main road to Almora, which has a very steep gradient on both banks of the Rámnganga and Sarju, there is a tolerably good road to the higher districts on the north, much used by traders from Thibet, who bring large flocks of sheep laden with borax, which they sell in large quantities at Rámnagar, Bharmdeo, and other places at the foot of the hills. There is a very fair road from Pitorágarh to Julaghát, easily passable for mounted travellers and laden cattle, about 12 miles in all, or easy two marches by halting half way at the village of Mumakot. Leaving Kumaon by the suspension bridge at Julaghát, that road rises by a sharp zig-zag for about a mile, and then running along the crest of a high range with a gentle ascent, leads to the Fort of Baitharri in Nepál. There are also some good village paths leading about the higher ranges in Askot. The custom of the villagers being to establish cattle sheds on all the open plateaux and easy ground, it follows that fair paths will be found running along most of the great ranges. Besides the main road to Almora, there is a circuitous road *viâ* Thal, and Bageswar, which is much used during the time when fairs are held at both places, in February at Bageswar, and in May at Thal.

"In the Pitorágarh district, wheat and rice are the great staples of production.

(20.) Mr. Low closed work in the Mána Valley on the 5th November, and started for

Mr. J. Low.—Topography of ground round Bageswar, and in Káli Kumaon.

Kumaon to take up the sketching of the ground in the neighbourhood of Bageswar. He reached Bageswar and commenced his work there on the 19th of the same month. The country to the north of Bageswar on the right bank of the river Sarju he found to be the most difficult to sketch. The hills are there precipitous, lofty, and covered with dense forest. The rest of his ground presented few difficulties. It contains here and there a considerable amount of forest, but in general it is open, well cultivated, and dotted with numerous villages. He finished his work in this district by the beginning of April, and then marched into Káli Kumaon to sketch the part of the frontier which lies immediately to the north and south of the junction of the Sarju and Káli rivers. In addition to surveying this piece of country he was able to sketch 45 square miles of the Nepál frontier which were visible from his ground. On inspecting his work, I found it to be well and carefully done, and to exhibit a marked improvement on the last work he turned out on the same scale in 1869. He closed work for the season at the end of the first week in May.

(21.) The following are Mr. Low's notes on the part of the country he surveyed.

"The most remarkable place in the portion of country sketched by me is the town of Bageswar, celebrated for its Bazar, Temple, and two large fairs, the first and larger held in the latter end of January, and the second and smaller in February or March. The fairs are partly sacred festivals held in honour of the deity Bagnáth, to which flock devotees, pleasure seekers, and traders from the surrounding *patties*, and from Thibetan Tartary. Trade transactions also take place to a large extent, it being the emporium for all the surrounding country. The articles offered consist of the household property in common use, besides cloth, wearing apparel, skins, salt, borax, Thibetan ponies, and cattle from Gurhwal and the Chamba states. The Thibetan ponies being in greater request at the civil stations of Almora, Kánikhet, and Naini-Tal, fetch very large prices. Regarding the other articles of merchandise; salt, borax, and skins from the interior of Thibet form the principal staples of trade; the transport of the two former being effected by means of sheep and goats, which, on account of the rugged nature of the hills, afford the simplest and easiest method of carriage. In consequence of the utility of these animals to the traders large prices are offered, and it is not an unusual thing for Rs. 6-8 or Rs. 7 to be given for a good Chamba goat, which goats are always in consequence of their size and strength taken in preference to the sheep and goats of other districts. Salt is only procurable here at Bageswar, unless it be in the plains at Rámnagar many marches away. Regarding the borax; as Thibet is the only place in the east from which it is to be had, it can be readily understood that the trade in it is very great. Several thousand maunds of this article pass through Bageswar every year.

"The principal river is the Sarju, which is joined at Bageswar by the Guunti. Its banks during the rainy season are very malarious, but in the winter they are the resort of cattle dealers as they afford luxurious pasturage.

"Of the roads, the chief one running by the right bank of the Sarju may be considered the high way, being the one by which the traffic of Thibet is transported. After reaching Bageswar it is joined by those coming from Sameswar, Katur, and Sanodar, the Katur road being used by travellers from Gurhwal, the Sameswar by those travelling from Ránikhet and Háwal bāgh. These roads are in excellent preservation.

"In the Karáhi *patti*, in this district, are a few iron mines worked only to an extent to suit the requirements of the neighbouring *pattis*. They are worked by Domes, or the lowest class of people in Kumaon and Gurhwal, who prefer using only the bark of the Chir pine for smelting purposes as it burns with great intensity and emits no smoke.

"The ground I surveyed topographically in Káli Kumaon is well cultivated. The spurs of the hills run down into the large streams in a very precipitous manner, and the cultivated parts are therefore to be found in the more elevated portions of the spurs and ridges.

"From Tamli (a group of villages in Talla Des) there is a newly cut road about 3 feet wide leading to Lohághát. The road from Lohághát *viz* Pacheswar, to Pitorágarh, which was formerly a regular made road, is now only a footpath, and this footpath is now scarcely traceable when it passes through cultivation.

"There are ferries over the Sarju at Khet Patoli and Dálibána, near Pacheswar. To cross the Káli into Nepál rafts floated on dried pumpkin shells are made use of; another method is to cross by swimming, the swimmer being aided by a couple of these shells tied together, on which he rests his chest."

(22.) On completing the triangulation of the Niti valley, Mr. Pocock marched south to take up his work in the Blúbar. The portion of

Mr. L. Pocock.—Topography in the Dhábar and Káli Kumaon.

ground allotted to him there lies near Káli Dungi, to its south, and is thickly covered with forest except

in those spots where clearances have been made for cultivation. It is also quite flat, and it had therefore to be surveyed principally by the method of traversing. Before commencing the topography of this tract, it was necessary for Mr. Pocock to fix a few trigonometrical

points to serve as checks on his traverses. This he did by observing both from the points themselves and from trigonometrical stations on the low hills near Káli Dungi which command his ground; and he also computed out in the field the points (12 in number) he thus determined. He finished his Bhábar work by the end of February and started to take up the sketching of the country south of Lohághát in Káli Kumaon. He closed his work for the season on the 15th April, and I found it, on inspection, very carefully and accurately done.

(23.) Mr. Pocock has furnished the following notes on the ground he surveyed.

"The first portion of the ground surveyed by me lies between longs.  $79^{\circ} 15'$  and  $79^{\circ} 30'$ . It is bounded on the South by the fiscal boundary of the Tarái, and on the North by latitude  $29^{\circ} 15'$  which is about three miles from the foot of the hills. Except such parts as are cultivated, the ground is densely covered over with large forest trees. The Sissu, growing over the sides of the large open ravines, is the only large tree of any value. The Khair (catechu) grows every where in close neighbourhood with the Sissu: this tree is much used by catechu dealers. The Sissu in former days, owing to its great value, was used most recklessly by the people of the neighbouring districts, and owing to the slow growth of this tree, the last 16 or 17 years of conserving the forest have not been sufficient to produce any large Sissu trees. Besides the many trees to be met with, there are large undergrowths of plants and creepers; more especially down in the Tarái portions where the cane grows in great abundance. The Tarái is a most difficult tract to traverse over, owing to the many swamps that intersect it. Without guides it is almost impossible to go through it.

"The part of the road from Murábad to Káli Dungi which passes through this work is in fine order. No hackeries are permitted to travel on the metalled portion. The other roads are in good order during the winter and spring months. During the rains they are very little used, and not kept in repair, and the grass grows on them to the height of ten and twelve feet. The grass is always cut away on the setting in of winter.

"The second portion of my work lies in the Champáwat pargana in Káli Kumaon, between latitudes  $29^{\circ} 15'$  and  $29^{\circ} 20'$  and longitudes  $80^{\circ} 0'$  and  $80^{\circ} 15'$ .

"The Champáwat Valley, nearly 5,000 feet above sea level, is very picturesque, covered as it is with villages and cultivation, and surrounded by hills covered with oak and chír. I came across several clumps of deodár (cedar) which are all considered sacred.

"When commencing work on this ground I found it very difficult to procure coolies and provisions as nearly all the inhabitants were down in the Bhábar.

"Most of the ground in this work is covered with forest, and is in some parts very precipitous.

"The road from Bhamdeo *viâ* the large village of Bilkhet to Champáwat is in a very bad state, as it is now never repaired. The new road from Bhamdeo to Lohághát *viâ* Champáwat is a fine, gently sloping one, and is kept in splendid order".

(24.) Mr. Todd marched into Kumaon to take up his work in the neighbourhood of

Mr. H. Todd.  
Topography of the ground round Baijnáth.

Baijnáth. Towards its northern boundary and to the west in the direction of Bhadkot peak, it is lofty, steep, and densely covered with forest. In other parts, although there is a large proportion of forest, the country is comparatively open, and contains, in addition to a large amount of general cultivation, numerous tea plantations. Some of these plantations seem to have been abandoned, and others are only partially cultivated, which is perhaps owing to the planters having found out that a large poorly cultivated area is not so remunerative as a small one highly cultivated and richly manured. Mr. Todd has delineated his ground with minute accuracy, and has shown its varied character with excellent effect. He finished his work on the 11th April.

(25.) The following are Mr. Todd's notes on the portion of country he surveyed.

"The ground sketched by me is chiefly composed of high ridges varying from 6,000 to 9,000 feet above sea level and mostly covered with dense forest of oak and pine, the oak confining itself to the western and northern ridges where the ground becomes more rugged and precipitous and rises to a higher elevation. The pine is to be found on comparatively more gentle and rounded slopes. Deodárs are only to be found in clumps, and chiefly about temples. The largest clump is to the extreme south of my work, the wood of which is utilised by Government for bridges &c. in the vicinity. The valleys are mostly all open and the greater portion of them is under heavy cultivation. The Baijnáth valley is the only one where a good portion of the ground lies waste, owing to a description of grass difficult to uproot, and destructive to all cultivation. The roots of this grass have been known to penetrate through those of the tea plant.

"From the number of tea plantations scattered through my work planters seem to have been under the impression that the ground was well adapted for such cultivation, but judging from the number deserted and the condition of others I presume this is not the case. The largest and most productive of the plantations are Kosáni and Dunagiri, but a good portion of the latter has been allowed to run waste.

"The roads intersecting my work run for the most part along the valleys, through cultivation, and are of easy slope and in fair order. The principal one keeps along the Kosi till within half a mile of Kosáni tea plantation when it ascends the ridge that forms the watershed of the Gumti and Kosi rivers; then, with a stiff descent of two miles on the north face of the ridge, runs through very

open ground, passing through Baijnáth and crossing a high range on the north, descends into the Pindar Valley, keeping along the south bank till its junction with the Alaknanda, where one road branches off north to Karnprág, and another to Srinagar. At right angles to this road and starting from Sameswar is a very fair road to Bageswar which, with a gradual slope, ascends the Mansári gadh and, crossing a wooded ridge which closes the valley on the east, dips down into the Sarju Valley. At the point where this road branches off from the main one another leaves in an opposite direction, along the Sali gadh, towards Dváráháth. Higher up another road starts from Baijnáth keeping along the left bank of the Gumti with a tolerably easy slope the whole way to Bageswar. All the above high roads are practicable for laden cattle and mounted travellers."

(26.) Mr. Kinney accompanied my office and was employed on general current work.

Mr. T. Kinney.

He has proved himself a very efficient assistant.

In March I sent him for a few days, for training and practice in minor triangulation, to Mr. Ryall who was then working to the east of Haldwáni. On sending him back to my camp, Mr. Ryall reported that "Mr. Kinney showed great willingness and aptitude, and the little time that was devoted to his instruction was fully made up to me by him." The work he did while with Mr. Ryall is shown in the tabular statement on page 45—<sub>a</sub>

(27.) Mr. Litchfield marched into Kumaon with Mr. Peyton to take up the plane-

Mr. E. F. Litchfield.

tabling of the country immediately to the west of

Mr. Peyton's ground. Mr. Litchfield, although he had had some training in plane-tableing on large scales, had never done any independent work on the 1-inch scale. Mr. Peyton was accordingly directed to see him start work, and give him any assistance that might seem necessary. Mr. Peyton considered that his supervision was only necessary for the first day: on the second he left, and Mr. Litchfield continued his work alone. At first Mr. Litchfield worked slowly, but he took great pains, and what he turned out, if its area is not very large, I found on inspection to be accurate and satisfactory. At the end of the season he was working at a fair rate, and his sketching had then improved considerably in style. He closed work on the 13th April.

(28.) The following are Mr. Litchfield's notes on the part of the country he surveyed.

"The Lamkeswar range runs through my work nearly east and west, and is steeper on the south side than the north. The top and higher portions of the ridge are densely wooded, but the valleys and lower spurs are mostly cultivated. The ground near Gangolíháth is undulating and nearly all cultivated; and that to the east of Rameswar is like a basin, and also nearly all under cultivation.

"The Pitorágarh road is very steep and bad on either side of Gangolíháth where it descends to the bridges over the Sarju and Rámganga. A much better road is the one from Lohághát to Pitorágarh which crosses the Sarju about two miles and a half below Rameswar. A fair is annually held at Rameswar at a spot on the right bank of the river just below the junction of the Sarju and the Rámganga. The river is fordable at the junction, but is very rapid lower down. At Rameswar there are several resting houses and a temple. There is very good fishing near Rameswar.

"Near the village of Bhaneswar there is a remarkable cave which is regarded as very sacred by the people. They believe that there are there four subterranean passages leading to the four sacred places Rameswar, Bageswar, Pachewar and Sameswar, and my guide pointed them out to me as he led me along the cave. This cave is so constantly visited by the natives that the stones are as smooth as glass, and the rock perfectly black from the smoke of the torches.

"In the part of the country I surveyed, the villagers were very much harassed by packs of wild dogs which killed nearly every animal they came across. I never succeeded in shooting one, but some villagers brought me a pup that they had caught while the pack were devouring a deer. It was of a dirty buff colour, with upright ears and a bushy tail, resembling a wolf. It refused all food, and died in a couple of days."

(29.) The time available for field operations was necessarily short, and that time was

General Review of the field operations.

further curtailed about a month by bad weather. Bear-

ing this in mind, the general out-turn of work is large; and its execution is, without exception, creditable to the assistants.

(30.) In the lower parganas immediately above the Bhábar it is impossible, during the winter months, to obtain carriage and supplies on the spot; for these districts are then deserted by their inhabitants who go to carry on their cultivation and graze their cattle in the Bhábar. It was, therefore, necessary in these deserted districts to go to the expense of hiring permanent coolies from elsewhere.

(31.) The Bhábar districts in the neighbourhoods of Káli Dungi and Haldwáni are densely populated during the winter months by cultivators from the higher districts, and also by a large number of idlers and cattle grazers who come down to enjoy the mild climate of the Bhábar, but who do not assist in its cultivation.

(32.) During the field season there were no deaths from disease, and only one by an accident. A khalási working with Mr Ryall fell over a precipice and was killed on the spot.

There were several cases of fever and dysentery, due probably to the large amount of bad weather experienced during the season; and two men in my camp were attacked by small-pox, but by taking the usual precautions it did not spread. On the whole the health of the party was good during the field season, and the men worked willingly and well.

(33.) Before leaving the subject of the field operations, I beg to acknowledge the assistance which has in general been rendered to me by the civil authorities. My thanks are also due to Captain Campbell of the Forest Department for the great assistance he afforded the Survey while it was being carried over the forest districts in his charge.

(34.) On returning to quarters, the computations connected with the triangulation carried on during the field season, and the preparation of the fair maps of the country sketched at the same time were taken up. The fair maps (four in number) will be ready for publication before the end of the recess.

(35.) On the 30th May of the present recess was announced, to the deep regret both of myself and all the other numbers of this party, the sudden death of Lieutenant H. M. Chambers, R.E. He joined us on the 1st July 1871, and since then, up to a few days before his death, he had been working among us faithfully and well, winning respect and regard both on account of his attainments, and his amiable and manly character. The Department has lost in him a most promising officer, and I feel sure that his untimely death has been felt as a personal sorrow by all who knew him.

(37.) Since the commencement of the recess the Assistants have been employed on computations and mapping. They are doing good work, and are giving every satisfaction. The native draftsmen also are working diligently and well.

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**Extract from the Narrative Report—dated 6th September 1872—of Captain J. HERSCHEL, R.E., Offg. Deputy Superintendent 1st Grade G. T. Survey, in charge No. 1 Extra Party.**

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The present Report has been delayed in the hope that some results of the last field season's operations, similar to those contained in postscripts to my former reports, might be included in it. Unfortunately I am not able to append them, the reductions being still incomplete. It must therefore be confined to narrating the movements of the party, the distribution of the stations of observation, and such details of method as may seem of interest.

(2.) This was the 3rd season during which the Zenith Sector had been in use. It was, on arrival, to be employed in determining latitudes along the southern half of the Great Arc, *viz.* from Cape Comorin to Elichpur; at such intervals, of a degree or more, as the nature of the country would permit or indicate as advantageous. During the two previous seasons it had been used in this way at Bangalor, at Cape Comorin, at two intermediate localities, and lastly near Ballávi (Belary). It remained to fill up the gap between the last named station and Elichpur. This has now been done; somewhat less thoroughly perhaps than might have been originally hoped for—two of the intervals being rather large but as uniformly and completely as various difficulties and other considerations would permit.

(3.) About this time last year it had been decided that the Solar eclipse which was to occur towards the middle of December should be taken advantage of. Previous experience of work of the special kind contemplated led to my being directed to arrange to be present. It thus came about that it was not till the 20th of December that I was free to join my camp in person. The delay however was not so great on this account as would seem to be the case, as the first station to be visited was not far short of a month's march from Bangalor, and preparations (not requiring my presence) were necessary, which would occupy another week or ten days.

(4.) In effect the party left Bangalor in the beginning of November, about 15 or 20 days later than I should otherwise have directed. This had to be made up by extreme economy of time during the following months, as under any circumstances there was plenty to do; and eventually by staying out in intense heat, longer than any body liked. However the work was accomplished. The gap mentioned above was filled up by 4 groups of stations which I will now proceed to indicate more precisely.



(5.) They are named the DARUR, † KODANGAL, SONTANA, BADGAON, groups, after the principal stations round which they are respectively situated. The last three of these were, in a measure, obligatory; being stations at which our late lamented comrade and fellow-labourer, Captain Basevi had taken pendulum observations for the determination of the local force of gravity. The first is in the tract known as the *Ráichur Doáb*, between the *Tongábudra* and *Kistna* rivers about 25 miles east of the well known Railway Station of the above name. The last is about 20 miles S.W. of Amráoti, in east Berár. The others are at intermediate points in the Haidarabad Territory. I may here conveniently give the geographical positions of the 9 groups which form the subject of this and the previous two reports, as well as of some other points along the same meridian at which latitudes have been observed in former days; with a view to showing the distribution.

TABLE of Southern Arc Latitude Stations.

| Name of Group (G) or Station (S) | No. of Stations | Approx. Lat. | Approx. Long. | Initial of observer and year of observation<br>Lambton (L) Everest (E) Waugh (W)<br>Campbell (C) Herschel (H) |                                           |
|----------------------------------|-----------------|--------------|---------------|---------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| Cape Comorin                     | G.              | 6            | 8° 13'        | 77° 44'                                                                                                       | L. 1809 (at Punnæ); H. 1871.              |
| Mallapatti                       | G.              | 4            | 9 29          | 78 3                                                                                                          | H. 1870-71.                               |
| Pachapáliam                      | G.              | 3            | 11 0          | 77 45                                                                                                         | L. 1806; H. 1870.                         |
| Bangalor                         | G.              | 3            | 13 3          | 77 40                                                                                                         | L. 1805 and 1806 (Dodágunta); H. 1870.    |
| Paugarh                          | G.              | 2            | 14 3          | 77 25                                                                                                         | L. 1805-06 Paugarh and Bomásundrum.       |
| Honúr                            | G.              | 5            | 14 54         | 77 8                                                                                                          | H. 1871.                                  |
| Namthabad                        | S.              | 1            | 15 6          | 77 40                                                                                                         | L. 1811.                                  |
| Dánúr                            | G.              | 5            | 16 12         | 77 44                                                                                                         | H. 1871-72.                               |
| Kodangal                         | G.              | 5            | 17 8          | 77 42                                                                                                         | H. 1872.                                  |
| Damergida                        | S.              | 1            | 18 3          | 77 43                                                                                                         | L. 1815, E. 1825, W. 1840-41.             |
| Somtána                          | G.              | 4            | 19 5          | 77 42                                                                                                         | H. 1872.                                  |
| Badgáon                          | G.              | 4            | 20 44         | 77 39                                                                                                         | H. 1872.                                  |
| Ashti                            | S.              | 1            | 21 3          | 77 40                                                                                                         | Unknown.                                  |
| Ládi                             | S.              | 1            | 23 9          | 77 45                                                                                                         | C. 1864-65. [65, and 1865-66.             |
| Kaliánpur                        | S.              | 1            | 24 7          | 77 42                                                                                                         | E. 1825, W. 1830-40, E. 1840-41, C. 1864- |

(6.) In the above table I have indicated the year, and name of previous observer, where there was occasion. It will be understood that the concurrence of Colonel Lambton's name with mine implies that he had observed at one of the stations composing my group.

(7.) Had circumstances admitted of it a group, or station, would have been desirable between *Ashti* and *Ládi*; but an interval of 2° though greater than what has been aimed at, is not exceptional, and is of no real consequence.

(8.) I may remark that I have reason to believe that, apart from constant errors (which a precise knowledge of the instrument which he used and of his method of observing can alone enable us to surmise—and these are not forthcoming) Colonel Lambton's observations are sufficiently good to be included in the list; and that I have been engaged at intervals in reducing them. The main difficulty is the labour of computation, owing to the want of the requisite astronomical tables, for reducing for the apparent motion of the stars, for those early years. I hope however to be able to deal with this satisfactorily as soon as the current work is further advanced.

(9.) The 4 groups which I have named as representing the last season's out-turn contain 18 stations of observation viz. 5, 5, 4, and 4 respectively. Of these the precise geodetic positions of the first two groups, viz. those about DARUR and KODANGAL can alone be considered available for immediate comparison with the astronomic values—the principal triangulation which was being conducted by Lieutenant M. W. Rogers R.E., along the line of the Great Arc northwards from Bangalor, having been overtaken at the last named station. The next group in order—that of SONTANA—surrounds (but does not include) the principal station so named. It was considered on examination to be both unsuitable and difficult of ascent—in fact impracticable. I could not but admire, though feeling it undesirable to imitate, the zeal which must have animated Captain Basevi in accepting such a station for his operations. He had camels however, and I had carts. Whether he was able to take any of them to the top, I do not know;

† Lieutenant Rogers' Darur.

but I should have had to depend wholly on *coolies*, and the delay would have been serious. The determination of the astronomic latitude at 4 neighbouring points round about the hill will, I believe, answer the purpose nearly if not quite as well. Of the BANGALOR group it is sufficient to say that a direct comparison with the geodetic position will be possible at once, at the central station; but at the outlying three which complete it, only whenever these shall be trigonometrically connected.

(10.) I have next to mention a few changes in the routine of observation, which were introduced with the object of eliminating constant errors. (See paras : 16 and 17 of last report). To obviate the liability supposing it to exist, of the microscope run changing its value from time to time, the following rule was framed. *Whenever the index minute to be recorded is 2 or 7, 12 or 17 &c., the microscope reading is to be taken from the upper and lower graduations, both readings being entered in the record.\** The record is thus made to supply directly a current check on the run, and data for a corresponding correction; and possibly, if continued, for an examination of the graduation. Runs were obtained in this way in the course of work, at about 200 different readings; and, as far as they go, they prove that at no single one of these is the graduation notably false: the evidence is insufficient to establish more as yet. They do however establish that the "run," though on the whole constant, is liable to slight alteration at different stations, thus justifying the practice.

(11.) In my last report I mentioned that a peculiar source of error seemed to exist in the levels of this instrument. Being unable to account for it, but feeling that it directly vitiated the results, I resolved on the first opportunity to put in practice a design I had for reversing the instrument on its pier, and then to take a set of observations in the reversed position. The opportunity was supplied by the Ballári Treasury. [Being just about to cross the Kistna and move far into the Haidarabad Territory a supply of coin was essential, but this I could not get for a long time.] The reversal of which I speak was effected by introducing a small metal button under the centre of the instrument, after prizing the latter up on one side with a lever. On lowering it upon the button a condition of unstable equilibrium obtained in which the instrument could be turned round, so to speak with a finger, with perfect safety, the feet just grazing the stone slab on which the instrument stands. On trial the method proved so satisfactory that I was perhaps too easily convinced, when I came to reduce the observations provisionally, that it was imperative to put it in practice at every station. I am far from saying that the conclusion was wrong; only that later experience raises a doubt whether the constant error which I *did* detect in *that* instance will be traceable in all. One thing is certain that, as in all cases of reversal, one or more of the class of constant errors will be eliminated. It will be eminently satisfactory if the practice of reversal, as carried out during the remaining 14 stations, should prove that the eliminated errors are insignificant in amount. Still more if it should appear that, but for it, the whole season's work would have contained errors which could not have otherwise been proved to exist. For the sake of past work however, I am in hopes that some definite conclusion may be arrived at which may rescue it from that suspicion.

(12.) As a rule from 30 to 35 stars were observed each night; and two full nights, or even two nearly full ones, were considered sufficient for each station—the instrument being in the reversed position on the second. In general the stations of a group are within a short march of each other; so that it was possible in good weather, to begin a new station every 3rd night. Thus the Kodangal group of 5 stations occupied only 15 nights (February 4th to February 18th) from first to last. The next would have been done at the same rate, but for an accident † in putting up the instrument at the last station. The damage sustained was repaired during the day, but the anxiety and labour of effecting it (thermometer 95°—100°) prevented my getting a good night's work, and then the weather changed. By still further reducing the number of stars, this speed might be kept up; but as it was, nothing but the necessity of getting through the work could have reconciled me to the wearisome round of putting up or taking down the instrument at *least every other day*. At every station too—and indeed every night almost—the meridional direction has to be sought out by transits, and adjustments repeated, before the regular work can be commenced, all of which though harassing does not shew in the record. Latterly this had generally to be done with the thermometer at or about 105°. The external temperature recorded at the last station, on the last night, on commencing work at 7-40 P.M., is 98°; falling however to 80° by 3 A.M. at which hour the Sector and observatory were taken down (for the last time) by moon-light, and a march of 8 miles effected.

(13.) This station was within half a mile of a Railway station (Nágpur branch): but on the last day—when all the arrangements were complete for breaking up the camp and returning by rail to Bangalor at once—we learnt to our disappointment that we could not use it, but must march down the line to the next principal station, some 16 miles distant.

\* I give this rule in full, because it seems to be suitable for adoption generally—in azimuthal as well as vertical observations. It increases the number of microscope readings by 1 in 5 (or less if relaxed)—but removes all possibility of overlooking an erroneous run.

† A full report was communicated at the time. The injured part has been since re-examined and nearly all trace removed.

(14.) Thus ended the most exhausting field season, which I (individually) have experienced. To those of the party who entered upon it six weeks earlier than I did, with a march of 240 miles, the latter portion with its intense heat must have been still more trying. The table which I have given shows that the latitude of  $20^{\circ} 44'$  was reached, that of Bangalore being  $13^{\circ} 0'$ . This difference represents a direct distance of nearly 550 miles which was of course largely exceeded by the wanderings in the Haidarabad wildernesses, where no road ever was. Much of the country traversed was unutterably stony, and unsuited for wheeled carriage, which is almost unknown there. The long distances which had to be gone over to get from one group of stations to another supplied leisure it is true, for the partial reduction of the observations, thus in some measure redeeming the time otherwise so fruitlessly expended; but I may conclude this narrative with the earnest hope, that no party engaged in work of this kind may ever again have to go over so much ground in search of suitable sites.

(15.) I very much regret that I cannot produce any final numerical results. So far as an estimate may go, however, I may hazard the conclusion that a remarkable disturbance of attraction will be found by comparison of the astronomic and geodetic amplitudes between HONUR and DARUR. These groups are only  $1^{\circ} 18'$  apart, yet there seems to be an abnormal attraction producing a discrepancy of nearly  $9'$  of arc—the presumption being that the plumb line is drawn north-wards at the northern station by nearly the whole amount.

(16.) The same presumed effect is somewhat modified at the next group,  $0^{\circ} 56'$  to the north, where it amounts to only  $6'$  or  $7'$ . It is about the same at BADGAON. This presumption rests mainly on the general agreement (except at Bangalore) of the astronomic and geodetic values at all the southern points and, *with a reservation as to the correctness of the adopted ellipticity with which the latter are computed*, on the absence of any bias towards one sign or the other in the *apparent* local deflection in other parts of India. I believe this is the largest deflection yet found in this country, which may not be directly attributed to mountain masses.

(17.) There does not appear to be—so far as I can yet judge—any strong additional evidence of the *sensitiveness* of local attraction to *small* change of place. It is traceable indeed, but not with sufficient distinctness to require me at present to add to what I have already said on this subject in a former report.

(18.) The health of the party has, on the whole, been exceedingly good. Two cases of small pox occurred, but both happily recovered. Of these the Native Doctor—Hospital Assistant I. Soveriappen whose name I mention specially as having caught the disease in the performance of his duty—supplied one. Vaccination was resorted to to check the liability to infection, at the small military station of Hingoli which we happened to reach at the time. I may mention that this was the only Station which we approached during the season.

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#### POSTSCRIPT, dated 30th September 1872.

(19.) The reduction of the observations described in the body of the report having now been brought to an end—though much remains to be done towards tracing errors to their source—I am enabled to summarize the principal results. It will be convenient to exhibit them in the same tabular form as before. In explanation of the Table which follows it is only necessary to say that the Geodetic latitudes of the first two groups are those furnished by Lieutenant Rogers and are based on the astronomic latitude of a point near \* Calcutta; while that of Badgaon S. though in the same terms, *i.e.* derived from the same origin, has been obtained by applying the geodetic amplitude (according to Everest) between BADGAON and DUDALA—the northernmost point to which Lieutenant Rogers' operations extend—to the latitude of the latter station furnished to me by that officer. At the time of writing the body of this report—in which it will be seen that I have estimated the difference at Badgaon at  $6'$  or  $7'$  instead of  $11'$ —I had overlooked the fact which has now been forced upon me by the discrepancy between the latitude so obtained and that given in Everest's "Meridional Arc" (and which I find mentioned in the 26th paragraph of Colonel Walker's Report for 1868-69)—a discrepancy of  $4'$  in latitude generated in the triangulation between Kaliánpur and Calcutta.

(20.) The whole of the triangulation of Southern India derives its latitude element from the *astronomic latitude of Calcutta, which was supposed to be nearly identical with that which would be assigned by good triangulation emanating from the origin Kaliánpur*. This supposition was based on the assumption that the existing triangulation, though admittedly inferior, would not prove so misleading as it is now known to have been. The result is important. All latitudes derived from the *Calcutta* origin must be diminished by  $4'$  to make them comparable, geodetically, with those derived from *Kaliánpur*: or, *vice versa*, the latter must be increased by  $4'$ . This is equally applicable where the question is one of differences between astronomic and geodetic latitudes.

(21.) There is no virtue in the astronomic latitude of Kaliánpur any more than in that of Calcutta, or of any other point where direct observation might have supplied an origin for computed latitudes; and if we assume that the Calcutta latitude was unaffected by local attraction, then that of Kaliánpur is too small by 4" and a correction of -4" must be applied to all values of  $\lambda_o - \lambda_c$  in Northern and Western India while those shown in the present Table need no such correction. On the other hand if we assume that the Kaliánpur normal is true, and not locally deflected, all the said values of  $\lambda_o - \lambda_c$  stand unimpached, while the present ones must receive a correction of + 4". In any case however there is only a change in local disturbance between *Kaliánpur* and *BANGAON* of 7" instead of the 11" which, for the sake of uniformity, I am obliged to show in the Table.

(22.) The difference of latitude between *Badgáon* and *Kaliánpur* is 3° 20' and the change in disturbance is 7", or about 2" per degree. This is not much when we remark that a change of 1".7 may occur (as between XXV and XXVI or between XXVII and XXVIII) in about 8 or 10 miles. But a little further South we find—from *HONUA* to *DARUA*, distant from each other only 1° 15' in latitude and 35' in longitude *i.e.* 98 miles,—a change of 8". It is absolutely impossible to admit that any errors of measurement can account for more than a small fraction of this amount and therefore the conclusion cannot be avoided that the attraction is disturbed in a grossly irregular way, which makes it a matter of indifference, so far as any question of Figure alone is concerned, whether the results are rigorously correct or not.

(23.) And now as to the degree of accuracy to which these may lay claim: I am not in a position to say what the "probable error" is theoretically; but judging from the accordance *inter se* of results depending on the observations of successive nights taken severally, it is pretty safe to say that no one of the co-latitudes given above is in error so much as one-tenth of a second.

(24.) The effect of reversal has been investigated closely, without any more decisive results than these—1st The observations are very slightly biassed by position: but the effect is barely traceable because 2nd They are all subject to errors of greater magnitude, which take effect in an intermittent way and seem to be due to the positions of the bubbles in the levels. Errors of this class affect the observations in groups, and if a night's work consists of only one or two such groups, the mean result for that night has often a large error from this source, which masks that which might otherwise be more confidently attributed to the orbiculation of the instrument.

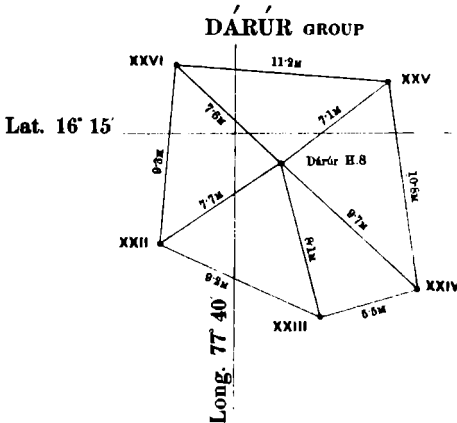
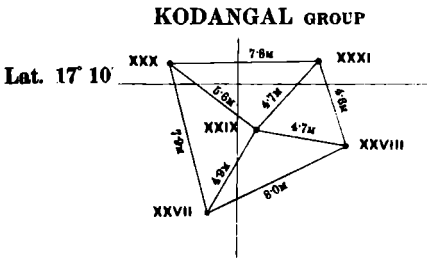
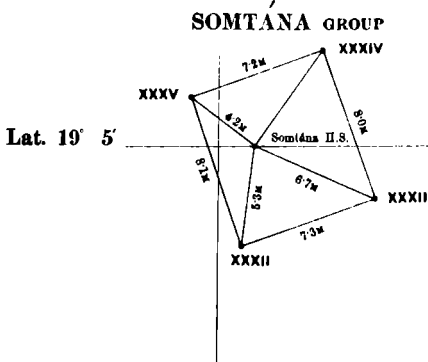
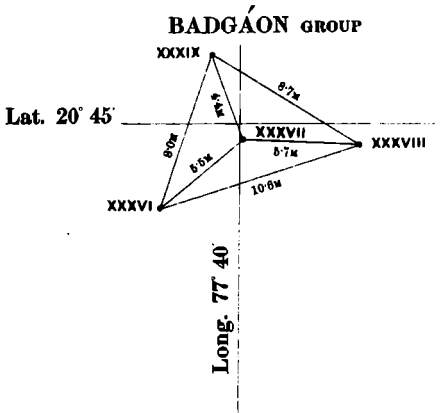
(25.) On the whole, there is insufficient justification for any alteration of previous results on this account, but the system of reversal has obviously so much in its favour that in my opinion it ought never to be neglected in future operations. And, with regard to what I have said above about an irregularity in the levels affecting groups of observations, I suggest the propriety of *purposely* and *frequently* altering their readings during the course of work, and of making a re-adjustment of level, say every hour, a part of the routine. The level corrections are the weak point: it is fitting that they should receive the most attention.

## Comparison of Astronomic and Geodetic Latitudes. 1871-72.

| Number of Station<br>and<br>Name of Group | Geodetic   |           |             | Co-latitude |                 | Difference<br>$\lambda_o - \lambda_c$ | Difference<br>from Mean |
|-------------------------------------------|------------|-----------|-------------|-------------|-----------------|---------------------------------------|-------------------------|
|                                           | Latitude   | Longitude |             | Geodetic    | Astro-<br>nomic |                                       |                         |
|                                           | ° ' "      | ° ' "     | ° ' "       | "           | "               | "                                     | "                       |
| <i>Cape Comorin Group</i> ...             | 8 13 ...   | 77 44 ... | 81 47 ...   | ...         | ...             | - 0.13                                |                         |
| <i>Mallapatti</i> " ...                   | 9 29 ...   | 78 3 ...  | 80 31 ...   | ...         | ...             | 0.42                                  |                         |
| <i>Pachapátian</i> " ...                  | 11 0 ...   | 77 45 ... | 79 0 ...    | ...         | ...             | 1.49                                  |                         |
| <i>Bangalor</i> " ...                     | 13 3 ...   | 77 40 ... | 76 57 ...   | ...         | ...             | 6.62                                  |                         |
| <i>Hovúr</i> " ...                        | 14 54 ...  | 77 8 ...  | 75 6 ...    | ...         | ...             | 0.10                                  |                         |
| <b>XXII</b> ...                           | 16 9 54.33 | 77 36 39  | 73 50 5.67  | 13.36       | - 7.69          | + 0.51                                |                         |
| <b>XXIII</b> ...                          | 6 39.96    | 43 54     | 53 20.04    | 28.14       | 8.10            | + .10                                 |                         |
| <b>XXIV</b> ...                           | 7 57.50    | 48 19     | 52 2.50     | 11.21       | 8.71            | - .51                                 |                         |
| <b>XXV</b> ...                            | 17 23.07   | 46 58     | 42 36.93    | 46.02       | 9.09            | - .89                                 |                         |
| <b>XXVI</b> ...                           | 18 9.60    | 37 17     | 41 50.40    | 57.80       | 7.40            | + .80                                 |                         |
| <i>Dárúr Group</i> ...                    | 16 12 ...  | 77 43 ... | 73 48 ...   | ...         | - 8.20          | ...                                   |                         |
| <b>XXVII</b> ...                          | 17 4 8.71  | 77 38 50  | 72 55 51.29 | 59.01       | - 7.72          | - 1.18                                |                         |
| <b>XXVIII</b> ...                         | 7 19.33    | 44 56     | 52 40.67    | 46.68       | 6.01            | + 0.53                                |                         |
| <b>XXIX</b> ...                           | 8 0.01     | 40 53     | 51 59.99    | 66.40       | 6.41            | + .13                                 |                         |
| <b>XXX</b> ...                            | 10 56.61   | 36 57     | 49 3.39     | 9.67        | 6.28            | + .26                                 |                         |
| <b>XXXI</b> ...                           | 11 3.10    | 43 35     | 48 56.90    | 63.17       | 6.27            | + .27                                 |                         |
| <i>Kodangal Group</i> ...                 | 17 8 ...   | 77 41 ... | 72 52 ...   | ...         | - 6.54          | ...                                   |                         |
| <b>XXXII</b> ...                          | 19 1 ...   | 77 40 ... | 70 58 ...   | 38.39       | ...             | ...                                   |                         |
| <b>XXXIII</b> ...                         | 2 ...      | 46 ...    | 57 ...      | 17.23       | ...             | ...                                   |                         |
| <b>XXXIV</b> ...                          | 9 ...      | 44 ...    | 50 ...      | 35.65       | ...             | ...                                   |                         |
| <b>XXXV</b> ...                           | 7 ...      | 38 ...    | 52 ...      | 45.35       | ...             | ...                                   |                         |
| <i>Somtána Group</i> ...                  | 19 5 ...   | 77 42 ... | 70 55 ..    | ...         | ...             | ...                                   |                         |
| <b>XXXVI</b> ...                          | 20 41 ...  | 77 35 ... | 69 18 ...   | 37.76       | ...             | ...                                   |                         |
| <b>XXXVII</b> ...                         | 44 26      | 39 ...    | 15 33       | 44.45       | -11             | ...                                   |                         |
| <b>XXXVIII</b> ...                        | 44 ...     | 44 ...    | 15 ...      | 56.67       | ...             | ...                                   |                         |
| <b>XXXIX</b> ...                          | 48 ...     | 37 ...    | 11 ...      | 52.86       | ...             | ...                                   |                         |
| <i>Badgáon Group</i> ...                  | 20 45 ...  | 77 39 ... | 69 15 ...   | ...         | -11             | ...                                   |                         |

NOTE.— $\lambda_o$   $\lambda_c$  stand for observed and computed latitude, or distance of zenith from the equator. When  $\lambda_o - \lambda_c$  is +,  $\lambda_o$  or the observed distance, is greater than  $\lambda_c$  or the computed distance; *i. e.* the astronomic is N of the geodetic zenith, and therefore the plumb-line is deflected towards the South. *Vice versa* when  $\lambda_o - \lambda_c$  is - (as above) the plumb-line is deflected towards the North.

**ROUGH CHART TO ILLUSTRATE POSITIONS  
OF ZENITH DISTANCE STATIONS  
1871-72.**





**Extract from the Narrative Report—dated 1st May 1872—of J. B. N. HENNESSEY, Esq., Deputy Superintendent 1st Grade, G. T. Survey, In charge Computing Office.**

On 1st May 1871.

**PERSONNEL.**

J. B. N. Hennessey, Esq.,     ∴ Deputy Superintendent 1st Grade.  
 W. H. Cole, Esq., M.A.,     ∴ Assistent. Superintendent 1st Grade.  
 Lieutenant H. M. Chambers, R.E.     Do.     2nd Grade.

*Computing Branch.*

Mr. C. Wood.  
 Bábu Gunga Pershad.  
 „ Cally Mohun Ghose.  
 „ Kally Coomar.  
 „ Gopal Chunder.

and 8 other native computers including map and record keeper and librarian.

*Printing Branch.*

Mr. M. J. O'Connor.

(1.) The following changes have occurred in the establishment of the Computing Office, during the last 12 months. Lieutenant H. M. Chambers, R.E., having completed his course of instruction, was transferred to the \*Kumaon and \*Gurlwal Party on 1st July, and Mr. Peychers, Assistant Surveyor 1st Grade, was transferred to this office on 1st September: a vacancy created by dismissal was duly filled, and nominations made to four other computerships of suitable candidates. Also, the retirement of Mr. W. H. Scott on pension, led to the appointment in his place, as head of the Drawing Office, of Mr. G. W. E. Atkinson, Surveyor 4th Grade, on 1st April 1872; Mr. Atkinson having joined this Office on 1st January 1872.

*Calculating Branch.*

(2.) The circuits of the triangulation included in the Sironj-Chach quadrilateral having been made consistent, as described in my last report, there remained a large amount of calculation, chiefly in connection with the auxiliary principal stations, to complete the triangulation in question. Accordingly, 268 triangles, entering in groups of 2 and upwards into 110 figures, were subjected to the usual conditions and made consistent by the method of least squares; so that the whole mass of this work now stands reduced by the most accurate of modern processes, which is certainly not more elaborate than is due to the very superior quality of the field operations. The computations of the principal stations involved 818 triangles, 115 new deductions (double) of latitude, longitude and azimuth, and verification and correction of several hundred deductions approximately calculated, all in duplicate.

Continued.

(3.) The ordinary computations performed are given in the following statement.

| Subject                                                                    | Quantity                           |
|----------------------------------------------------------------------------|------------------------------------|
| Numbered pages of, and indexed .. .. .                                     | 41 vols: of angle books.           |
| Mean readings examined or computed, .. .. .                                | 47 openings ditto.                 |
| Abstracted observed angles, .. .. .                                        | 704 angles.                        |
| Computed zero means and general means, .. .. .                             | 370 do.                            |
| Compared abstract of observed angles, .. .. .                              | 733 do.                            |
| Computed latitudes, longitudes and azimuths of Secondary Stations, .. .. . | 88 single deductions.              |
| Do. weights of observed angles .. .. .                                     | 450 angles.                        |
| Do. differences of heights of Principal Stations, .. .. .                  | 1500                               |
| Do. circumpolar Star observations for azimuth .. .. .                      | 14 stations.                       |
| Do. "indeterminate factors" in terms of errors, .. .. .                    | 4 compound figures                 |
| Do. observations for time, .. .. .                                         | 25 sets.                           |
| Do. reduction of Meteorological observations .. .. .                       | { Twice a day throughout the year. |

} In duplicate

(4.) The principal triangulation having been computed, as already described, it became necessary to take the secondary work into consideration: points of this class are frequently valuable for purposes of after survey and their value is rapidly on the increase with the demand for Railways, Roads, Canals &c., and the surveys these projects entail. Considerable care and discrimination are, however, essential in dealing with the Secondary triangulation, so as to secure its full utility on the one hand, and on the other to avoid redundant calculations, which if attempted would probably lead to more work than could be accomplished. In view of these

*Secondary Triangulation.*



*Calculating Branch.—(Continued.)*

desiderata a general scheme is being elaborated in connection with the subject under notice, and a suitable process has been devised for producing the consistency required in these operations: the method of calculation has been applied in 3 instances, and it appears to meet the required want satisfactorily.

(5.) The results compiled for the press are as follows:—1 simple and 3 compound figures, and 11 quadrilaterals; pages 192 of Synopsis of Principal Stations Latitudes, Longitudes, Azimuths, Differences of Height, Heights and Descriptions of Spirit-levelled Bench-Marks; pages 200 of Observed Azimuths; and 17 pages of Spirit-levelled Stations of season 1870-71.

(6.) Besides the compilation of computed or observed results, to be set up in book form, a somewhat similar procedure is required for numerical charts and their accompaniments to meet the urgent wants of surveys now in progress. In the absence of such charts, a manuscript copy of numerical tables has to be prepared for each applicant; and this work must needs be repeated for adjacent operations at least, at a loss of time and liability to mistakes which all repetitions must involve: add to this, tables without diagrams lose a sensible portion of their value. As an effectual remedy for all these drawbacks, Colonel J. T. Walker, R.E., Superintendent G. T. Survey, devised an extension of the details formerly given on charts; so that his modern numerical chart supplies all essential numerical and descriptive facts, chiefly on the diagram or chart of triangulation itself. The numerical chart thus composed is photozincographed, so that facsimiles are available at a moment's notice. It will however be readily seen, that the value of these charts falls to zero, unless scrupulous care is exercised to secure accuracy in the preparation of the single manuscript required for copying or reducing with the camera; in fact, each such chart, of so much value to every Survey Executive, is a diagram illustrated with the epitomised results of a small volume. It therefore follows, that the required compilation of data for Charts and examination of proofs, involves no little labor at the outset, though the result is highly satisfactory and economical in the end. During the twelve-month under notice, 4 numerical charts were compared against the original computations, and data compiled for the following:—

|                                                   | CHARTS.   |
|---------------------------------------------------|-----------|
| Northern portions of *Bombay triangulation, .. .. | 3 sheets. |
| South Konkan Series, .. ..                        | 1 "       |
| Great Indus do. .. ..                             | 7 "       |
| Gurhāgarh, do. .. ..                              | 1 "       |
| Rāvi and Chināb Minor Triangulation, .. ..        | 2 "       |
| Bider Longitudinal Series, .. ..                  | 1 "       |
| Assam Valley do. (1870-71), .. ..                 | 1 "       |
| Gora do. .. ..                                    | 2 "       |
| Rahūn do. .. ..                                   | 1 "       |
| Great Arc do. (1869-70), .. ..                    | 2 "       |
| Bilāspur do. .. ..                                | 1 "       |
| Great Arc do. (N. Section), .. ..                 | 6 "       |
| N. W. Himalaya do. .. ..                          | 2 "       |

Also, a synopsis of sides for the whole of the Sironj-Chach quadrilateral was prepared, for plotting diagrams to illustrate the "reduction of figures" given in the printed volumes passing through the press.

(7.) Consequent on orders by the Government, a careful comparison was made between two spirit levels, one by Messrs. Cooke & Sons, the other by Messrs. Troughton & Simms, and a suitable line was levelled over by Mr. C. Wood and the undersigned with the view of affording data for reporting on the relative merits of these two instruments. The use of a 1st-class Theodolite and the departmental method of observing azimuths were taught to Lieutenant J. Hill, R. E., Mr. W. H. Cole, M. A., and Mr. W. G. Beverley. Twenty-five sets of observations were taken for time. And meteorological observations, twice on every day of the year, were made as usual at Dehra Dun Observatory, and the reduced results supplied to the reporter on meteorology, N. W. Provinces†; also similar observations were taken at Masūri for about 6 months.

(8.) The correspondence, lists and descriptions involved in the protection of the G. T. Survey stations have been persevered in as heretofore, and I need scarcely add that such protection is hardly of less importance than the primary surveying operations. The station marks are essential for all after surveys, and will serve the required purposes for an indefinite number

† *Cost of maintenance of Meteorological Stations.*—This seems the proper place to state that the observatory at Dehra costs the Meteorological Department nothing; both the establishment and the instruments belong to the Great Trigonometrical Survey. (*Report for 1871 on Meteorological observations N. W. Provinces, by Murray Thomson Esq., M.D., F.R.S., &c.*)



## Photo-zincographic Branch—(Continued.)

## Maps

| Subject                                                                  | When published | No. of parts | No. of copies printed |
|--------------------------------------------------------------------------|----------------|--------------|-----------------------|
| Index to Guzrát Survey, .. .. .                                          | Sept. 1871.    | 1            | 474                   |
| „ Kattywar „ .. .. .                                                     | Oct. „         | 1            | 465                   |
| Spirit Levelling operations No. 14 .. .. .                               | „ „            | 1            | 105                   |
| „ „ „ 15 .. .. .                                                         | „ „            | 1            | 105                   |
| Eastern British Frontier skeleton, .. .. .                               | „ „            | 1            | 26                    |
| „ „ contoured, .. .. .                                                   | „ „            | 1            | 26                    |
| Delhi Map, .. .. .                                                       | Novr. „        | 1            | 309                   |
| Index to Kosi valley Survey, .. .. .                                     | „ „            | 1            | 410                   |
| Guide Map to Masúri and Landaur (2nd edition) .. .. .                    | „ „            | 1            | 222                   |
| Spirit Levelling operations No. 9 .. .. .                                | Decr. „        | 1            | 105                   |
| Kosi Valley Survey sheet „ 3 skeleton, .. .. .                           | „ „            | 1            | 111                   |
| „ „ 3 contoured, .. .. .                                                 | Jany. 1872.    | 1            | 105                   |
| Kattywar sheet No. 27 .. .. .                                            | Feb. „         | 1            | 105                   |
| „ „ 28 .. .. .                                                           | „ „            | 1            | 105                   |
| Route map from the Panjáb to Badukshán, .. .. .                          | „ „            | 1            | 441                   |
| Index to Level Charts, .. .. .                                           | „ „            | 1            | 480                   |
| Kosi Valley Survey sheet No. 1 skeleton, .. .. .                         | „ „            | 1            | 105                   |
| „ „ 1 contoured, .. .. .                                                 | „ „            | 1            | 105                   |
| „ „ 2 „ .. .. .                                                          | „ „            | 1            | 105                   |
| „ „ 2 skeleton, .. .. .                                                  | „ „            | 1            | 105                   |
| „ „ 5 „ .. .. .                                                          | „ „            | 1            | 105                   |
| „ „ 5 contoured, .. .. .                                                 | „ „            | 1            | 105                   |
| „ „ 6 „ .. .. .                                                          | „ „            | 1            | 105                   |
| „ „ 6 skeleton, .. .. .                                                  | „ „            | 1            | 105                   |
| Chamba map, upper left half ( <i>for Supdt. Chamba States</i> ) .. .. .  | „ „            | 1            | 100                   |
| Kosi Valley Survey sheet No. 4 skeleton, .. .. .                         | March, „       | 1            | 105                   |
| „ „ 4 contoured, .. .. .                                                 | „ „            | 1            | 105                   |
| „ „ 7 „ .. .. .                                                          | „ „            | 1            | 105                   |
| „ „ 7 skeleton, .. .. .                                                  | „ „            | 1            | 105                   |
| „ „ 8 „ .. .. .                                                          | „ „            | 1            | 105                   |
| „ „ 8 contoured, .. .. .                                                 | „ „            | 1            | 105                   |
| Kattywar sheet No. 26, .. .. .                                           | April „        | 1            | 105                   |
| Chamba map, upper right half ( <i>for Supdt. Chamba States</i> ) .. .. . | „ „            | 1            | 100                   |
| „ lower „ „ Do. do, .. .. .                                              | „ „            | 1            | 100                   |
| „ „ left half. Do. do, .. .. .                                           | „ „            | 1            | 100                   |
| Mirza's route to Badukshán, .. .. .                                      | „ „            | 1            | 52                    |
|                                                                          | Total          | 118          | 10131                 |
| <i>Numerical Charts.</i>                                                 |                |              |                       |
| Great Arc Revision, season 1869-70, N. Section, .. .. .                  | June, 1871.    | 1            | 66                    |
| Northern portions of Bombay No. 3, .. .. .                               | „ „            | 1            | 65                    |
| „ „ „ 10, .. .. .                                                        | „ „            | 1            | 67                    |
| Great Arc Revision, season 1869-70, S. Section, .. .. .                  | „ „            | 1            | 65                    |
| Great Indus Series No. 3, .. .. .                                        | August, „      | 1            | 65                    |
| Northern portions of Bombay No. 6, .. .. .                               | „ „            | 1            | 65                    |
| „ „ „ 5, .. .. .                                                         | Sept. „        | 1            | 65                    |
| Great Indus Series No. 11, .. .. .                                       | „ „            | 1            | 68                    |
| „ „ „ 12, .. .. .                                                        | „ „            | 1            | 66                    |
| Biláspur Meridional Series, season 1870-71, .. .. .                      | „ „            | 1            | 66                    |
| Assam Valley Triangulation, season 1870-71, .. .. .                      | Oct. „         | 1            | 65                    |
| Great Indus Series No. 1, .. .. .                                        | „ „            | 1            | 65                    |
| South Konkan Series, .. .. .                                             | Novr. „        | 3            | 65                    |
| Great Indus Series No. 2, .. .. .                                        | Decr. „        | 1            | 65                    |
| „ „ 4, .. .. .                                                           | „ „            | 1            | 65                    |
| „ „ 10, .. .. .                                                          | „ „            | 1            | 65                    |
| Bider Longitudinal Series, season 1869-70, .. .. .                       | „ „            | 1            | 65                    |
| Northern portions of Bombay No. 8, .. .. .                               | Jany. 1872.    | 1            | 60                    |
| Gurhagarh Meridional Series, seasons 1858-60, .. .. .                    | „ „            | 1            | 65                    |

*Photo-zincographic Branch—(Continued.)*

*Numerical Charts.*

| Subject.                                                | When published. | No. of parts. | No. of copies printed. |
|---------------------------------------------------------|-----------------|---------------|------------------------|
| Khágán and Pesháwar triangulation, .. .. .              | April 1872.     | 1             | 8                      |
| Rávi and Chináb River triangulation, .. .. .            | „ „             | 3             | 64                     |
| Great Arc Revision, season 1870-71, N. Section, .. .. . | „ „             | 1             | 65                     |
| Total ..                                                |                 | 26            | 1375                   |

*Plates and Diagrams.*

| Subject                      | When published. | No. of copies printed. |
|------------------------------|-----------------|------------------------|
| Bench-marks &c., &c. .. .. . | June 1871,      | 520                    |
|                              | August „        | 483                    |
|                              | Sept. „         | 305                    |
|                              | Oct. „          | 498                    |
|                              | Novr. „         | 1087                   |
|                              | Decr. „         | 793                    |
|                              | Jany. 1872,     | 216                    |
|                              | Febry. „        | 1035                   |
| Total, ..                    |                 | 4937                   |

Professional and Office forms .. .. . 13,655

7248 Maps and 547 Numerical Charts were issued during the year. The forms were expended as fast as they could be printed; indeed the demand was greater than the supply, so that I look forward to the arrival of the two additional presses despatched from England under orders from the Secretary of State for India. Contrasting the work performed in 1870-71 with that done in 1871-72, we have the following:—

| Year.   | Maps.  | Charts. | Plates and Diagrams. | Forms. |
|---------|--------|---------|----------------------|--------|
| 1870-71 | 6,465  | 839     | 13,205               | 10,482 |
| 1871-72 | 10,131 | 1,375   | 4,937                | 13,655 |

Though the total number of prints of all sorts is about the same in the two years contrasted, a far larger amount of the elaborate kinds of work, maps and charts, has been performed: both these sorts of prints are photo-zincographed. Hitherto the forms were zincographed from pen transfers, to admit of introducing in new transfers such improvements as were suggested from time to time. It is, however, an advantage, in the cases of certain well-established forms, to take negatives of them, and this has accordingly been done in those instances where it appeared desirable.

(11.) An abstract of the work executed since 1866-67 is given below.

| Subject                            | 1866-67<br>No. of<br>prints. | 1867-68<br>No. of<br>prints. | 1868-69<br>No. of<br>prints. | 1869-70<br>No. of<br>prints. | 1870-71<br>No. of<br>prints. | 1871-72<br>No. of<br>prints. |
|------------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| Maps, Charts and Diagrams, .. .. . | 7,118                        | 7,376                        | 5,538                        | 12,315                       | 20,509                       | 16,443                       |
| Forms, .. .. .                     | 5,152                        | 10,531                       | 10,800                       | 13,571                       | 10,482                       | 13,655                       |

*Typographic Branch.*

(12.) The work performed by the printing office during the past year and since 1865-66 is concisely stated in this table,

|                    | 1865-66 | 1866-67 | 1867-68 | 1868-69 | 1869-70 | 1870-71 | 1871-72 |
|--------------------|---------|---------|---------|---------|---------|---------|---------|
| Pages composed, .. | 377     | 756     | 641     | 697     | 693     | 819     | 1,143   |
| Do. printed, ..    | 53,339  | 93,411  | 126,696 | 155,025 | 106,231 | 234,828 | 241,348 |

the total pages composed during the past year may be subdivided under the following heads.

|                                                                                           |    |      |        |
|-------------------------------------------------------------------------------------------|----|------|--------|
| Observations and Calculations for the volumes of the Great Trigonometrical Survey in hand | .. | 547  | pages. |
| Pamphlet of Levelling operations, season 1870-71                                          | .. | 21   | „      |
| Report to the Government, season 1870-71                                                  | .. | 103  | „      |
| Data for Charts, Descriptions of Bench-marks, Routes, Professional Orders and Memoranda   | .. | 472  | „      |
| Total                                                                                     | .. | 1143 | „      |

*Drawing Office.*

(13.) The introduction of Photo-zincography for the purpose of copying Maps, Numerical Charts &c., has necessarily produced an influence on the Drawing Office where the originals to be copied are chiefly prepared: the draftsman now must needs draw under the conditions most favorable for the Photo-zincographic process; so that these two branches, the drawing and copying, are completely dependent on each other. This relation has induced an amount of general supervision of the Drawing Office at my hands, and recently when a small expansion of this office, to meet urgent demands, was sanctioned by the Government, the selection of candidates and the organization of this establishment devolved on me, in accordance with the orders of the Officiating Superintendent. I am glad to report, that the head of the Drawing Office, Mr. G. W. E. Atkinson, is now provided with a promising class of workmen, and I expect they will prove efficient assistants in time, under his care and training.

*No. 4 Extra Party.*

(14.) Captain W. J. Heaviside, R.E., received charge of this party from me on 20th April 1872, and as he has been good enough, at my request, to mention the duties discharged by me between 19th September 1871 (the date the party returned to Dehra Dun from camp), and transfer of the party to him, it is unnecessary for me to make any repetitions here. I may add that the duty of completing the late Captain Basevi's valuable observations has been entrusted to Captain Heaviside, and that in compliance with the Superintendent's wishes, I shall have much pleasure in assisting Captain Heaviside to become acquainted with the processes followed by Captain Basevi in taking Pendulum observations.

(15.) In concluding this report, I trust I may be permitted to express my acknowledgments of the services rendered by my assistants. Mr. W. H. Cole, M.A., continues to co-operate with me both cordially and with excellent results, and the general efficiency to which he has now attained enables him to originate projects of no little value. Mr. C. Wood is as valuable an assistant as ever; he is always ready to take a share in any duty whatever that may be in hand and he invariably works both quickly and well. Mr. Peychers has proved a useful and most willing hand and I fully expect that in course of time he will become as competent as he is willing. Bābu Gunga Pershad continues to render excellent service, and his experience combined with his steadiness and intelligence have enabled him to acquire a familiarity with the duties of this Office which he is always ready to make good use of. The services of Bābū Cally Mohun Ghose, Kally Coomar, Gopal Chunder and Tarapodo are deserving of commendation, nor have I reasons to be dissatisfied with the remaining computers; some of these are young hands who have been admitted on such excellent recommendations, that I expect to be able to report very favorably on their progress in due course. Messrs. Ollenbach and Dyson in the Photo-zincographic office continue to work willingly and effectively. Mr. O'Connor, the printer, is as efficient as zealous in the discharge of his duties.

*Total Eclipse of the Sun. December 11-12, 1871.*

(16.) This eclipse was observed at Utakamand, Nālgiri hills, Lat. N. 11° 24', Long. E., 76° 49', Height above sea level 8,642 feet, under the directions of Colonel J. F. Tennant, R.E., F.R.S., &c., who was assisted by Captain J. Waterhouse from the Surveyor General's Calcutta Office and by Captain J. Herschel, R.E., and myself from the Great Trigonometrical

*Total Eclipse of the Sun. December 11-12, 1871.*

Survey. Colonel Tennant has already written a report to Government on the expedition which he conducted, besides his communication to Dr. Huggins which appeared in the monthly notices of the Royal Astronomical Society, vol: XXXII No. 3, January 1872; in addition, I have my own report to Colonel Tennant on the part of the operations assigned to me: it may therefore be sufficient to make a few extracts from these papers, confining myself generally to those portions which touch on my own duties.

*Extracts from Colonel Tennant's report to Government.*

"The photographic operations were under the general charge of Mr. J. B. N. Hennessey of the G. T. Survey, with whom was associated Captain Waterhouse, for the special purpose of attending to the technical manipulations."

\* \* \* \* \*

"The lens employed was one of Dallmeyer's largest "Rapid Rectilinears" of 4 inches (10 c. m.) aperture, and about 33 inches (83.7 c. m.) equivalent focus. This was attached to a cylindrical metal camera, which was mounted on an equatorial stand, and a clock was provided to keep the camera automatically up to the object to be photographed"

"The camera was furnished with 6 dark slides, each to hold a plate 5" square." \* \* \*

*Extracts from Mr. Hennessey's report to Colonel Tennant.*

(5.) "After due discussion and consideration Colonel Tennant decided that we should try to secure 6 negatives during totality, and that the successive periods of exposure should be 5', 10', 15', 15', 10', and 5'; this conclusion of course assumed that the sky would be free from cloud or mist. As will be seen, these periods afford intervals of 10 seconds between consecutive negatives to change the slides, besides a period to spare at the commencement and end of 5 seconds.

(6.) "Subject to these conditions we proceeded to rehearse our parts, Captain Waterhouse changed the slides and opened and shut them. Mr. Willis counted seconds 1 to 130 audibly, following the hand of a chronometer placed before him, while I made the required exposure by uncovering the lens, and also noted the limiting seconds. After a moderate amount of practice we found ourselves able to carry out the prescribed programme leisurely and with certainty.

(7.) "I may here add a few words with respect to the counting. My agreement with Mr. Willis was this: some 10 or 15 seconds before totality I was to call out 'mark 0': on this he should keep repeating the word "nought" as the hand marked a complete second; meanwhile I was to watch the sun and to give the signal "count," directly totality occurred; when in place of saying "nought," Mr. Willis was to commence counting the seconds audibly, beginning with 1 and going on to 130, or until I stopped him. I had a small paper board strapped to the back of my left hand on which I recorded the limiting seconds of each exposure. These arrangements were found simple and effectual, and under favorable circumstances they would furnish the means of noting with some accuracy the times when totality began and ended. They however involve a very moderate amount of mental arithmetic from the individual in my place, but the tax is so limited that most persons could do the needful after a little practice.

(8.) "The morning of the 12th December dawned with but little promise of affording us a clear view during the coming totality. The sky was free from cloud and the stars shone brightly at 2 A.M.; a couple of hours later we were enveloped in a mist, which at times was so dense that objects only 50 yards distant were hardly visible in the gray light of dawn: and as the light increased and we could see through little gaps in the fog, there appeared floating below an endless mass of clouds, which the brisk southerly breeze kept driving against us. Notwithstanding we went through the last rehearsal of our parts, and at 20 minutes to totality as agreed on I gave Captain Waterhouse the signal to commence immersing the plates.

(9.) "Some 10 minutes before totality I focussed the camera on the solar cusps, and about 5 minutes later we were all at our posts: the first slide was in its place, the instrument was set and being driven satisfactorily, and we were ready to perform our parts if permitted to do so: meanwhile the mist kept streaming persistently against us; it came up clinging to the surface of the hill and in depth it probably did not extend beyond 50 feet above us, but it was sufficiently dense to make the distant hills appear quite dim and in addition it varied in density from one moment to another, thus making the task of timing the exposures hazardous if not hopeless.

(10.) "In expectation of a clear sky, I had purposed availing myself of the ample leisure I should have enjoyed, to watch the shadow of the eclipse, to study the corona with the view of making sketches subsequently and in fact to examine and note all that appeared; but the presence of the mist made it essential that I should devote my attention entirely to the duty of exposing. It was also plain, that under existing circumstances, the programme detailed in para. (5) should not be adhered to, and I resolved to act to the best of my judgement in the matter.

(11.) "As totality approached I was surprised while looking at the sun to find an apparent absence of all mist; this however was by no means real, for the fog appeared plainly, driving over us as

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† Mr. Willis volunteered his services for the occasion and performed his part with every desirable skill and accuracy.

*Total Eclipse of the Sun. December 11-12, 1871.*

" before, when I directed my view some  $10^\circ$  below the sun. I accordingly kept a steady watch in this direction during the periods of exposure, and I am thus able to state with certainty, that throughout totality the mist was driving over us in one continued and generally diminishing stream, which varied in density but which was always plainly visible. Watching the mist in this manner and guided by its density in regulating the exposures, I opened and closed the lens for negatives Nos. 1 to 4, so that the durations of these exposures are by no means comparable. Subsequently I resolved to make the longest exposure that could then be afforded, preceding this by one of 5 seconds. This led to Nos. 5 and 6, the latter of which was barely within the limit of totality. The times and periods of exposure, the former reckoned from commencement of counting are as follows:—

| Negative No.                                                                            | Duration. |
|-----------------------------------------------------------------------------------------|-----------|
| 1. was exposed 4' to 19' from commencement of reckoning ( <i>i.e.</i> totality nearly.) | 15'       |
| Ditto 2. do. 34 to 44 ditto ditto                                                       | 10        |
| Ditto 3. do. 55 to 63 ditto ditto                                                       | 8         |
| Ditto 4. do. 74 to 80 ditto ditto                                                       | 6         |
| Ditto 5. do. 88 to 93 ditto ditto                                                       | 5         |
| Ditto 6. do. 103 to 123 ditto ditto                                                     | 20        |

" I estimate that when Mr. Willis counted 1, the totality had lasted  $\frac{3}{4}$  second, hence approximately the duration of totality was about 122 seconds.

(12.) " It is hardly necessary to add that I accompanied Captain Waterhouse into the dark room, or that I anxiously looked on while he developed the negatives with his usual skill and care. The addition however enables me to offer my testimony of the fact that the negatives were all fully developed, and this may be desirable in presence of the circumstance that the *longest* exposed negative No. 6 exhibits the *least* details of the corona; a deficiency which is most nearly approached in No. 5 which had the shortest exposure: moreover during the exposures of Nos. 5 and 6 the mist was least dense. I may here add for what it is worth, that so far as I can conjecture 8 seconds exposure would have been ample at our station had a clear sky prevailed.

(13.) " Though as already stated I was deterred from looking steadfastly at the appearance of the eclipsed sun, I yet took every opportunity of glancing at it and did so for perhaps 2 or 3 seconds at a time. Thus viewed, the general outline of the corona looked like a snuff glass or figure 8, in which comparisons the 2 re-entering angles must be understood as exaggerated much beyond the reality. There were no conspicuous prominences; but of those visible, the ones about the vertex were the strongest. I saw no rays or streamers stretching greatly beyond the moon, and so far as I could estimate, the entire phenomena of the corona were included within an annulus of half the moon's diameter around her edge. In brief, what I remembered to have seen during totality is exhibited in the negatives Nos. 1 to 4. They contain details of which I was unconscious, but I am not aware that they are deficient in any respect.

(14.) " Before parting with the set of six negatives I examined them as closely as the dull light of a cloudy afternoon would permit, and I was naturally struck by the close resemblance they bore to one another, for I had been led to expect that the corona shifted from side to side, or at least that certain of its features altered considerably in some way with the moon's progress. This progress certainly does not produce any readily apparent change in the corona; nor yet are the rays most abundant in the radial prolongation of the prominences; in fact a prominence is visible almost exactly under each angle of the two main rifts, which rifts are nearly North and South. As to the rifts they exist only in the absence of rays. Thus the two main rifts are outlined by the termination of rays, which just at the re-entering angles where they are shortest, jut out some 5 or 6 minutes from the moon's edge. The longest rays appear beyond the lower limb, and here they are full 18 minutes or more in length. In general the rays are radial from some point in the eclipsed body, unless a possible bundle in, I think, the lower and right hand corner is an exception. The tips of these rays present the curious appearance of a sheaf of corn when its ears are blown over by the wind.

(15.) " Apart from the local examination which no doubt each set of negatives will undergo, it appears highly desirable that all the sets taken at Baikul, Avanasly, Ceylon, Australia, Dodabetta, &c., should be collected together and compared by competent examiners; it need hardly be added that such comparison should be made between the negatives and not between prints, for the latter cannot be relied on as sufficiently exact representations of their originals. The Baikul and Dodabetta negatives were taken with similar instruments and will therefore readily admit of comparison; it will be interesting to enquire whether the latter negatives, taken at a considerable height differ in any respects from all the other sets. Colonel Tennant's method of mounting will secure the negatives from ordinary risks."

*Extracts from Colonel Tennant's letter to Dr. Huggins.\**

" Now to the photographs. We have had some glorious mornings. Yesterday Herschel and I were up at 7 *Argis*, but had no great amount of examination, as our intention was to focus slit, &c. on stars. Though the evenings have been misty, at times the mornings have been very clear, and we hoped they would remain so. Last night was very clear, and continued so till about 2<sup>h</sup> 30<sup>m</sup> a. m., when it became cloudy, and afterwards rained slightly. By the time for getting up it was less

*Total Eclipse of the Sun. December 11-12, 1871.*

“thick, and rain had ceased, but a wind had sprung up from the S.E. (I believe), which, of course, kept a driving mist on the hill. The Sun seemed to lose as much power by obscuration as it gained by rising, and was powerless to disperse this as it would otherwise have done, and our instruments were dripping. This I had thought possible in such a case, but I had hoped that the fine weather had set in, as such mist seems abnormal so late in the season. Very few minutes after totality the mist vanished from the returning heat.

“Under these circumstances one might have thought photographs hopeless, and I went despondingly to ask for results. I found, to my great astonishment, that they had six apparently good ones, which is due to Hennessey, who exposed, having thrown over our programme, and increased his exposures, while Captain Waterhouse, who did the photographer's part ably, backed him by rapidly changing the slides.”

*Extracts from Colonel Tennant's report to Government.*

“From the original photographs Captain Waterhouse has made some positive transparencies on glass which give a good general idea of them. I take, however, the following descriptions from the original negatives, some of which give a great deal of detail which is lost in copying.

“No. 1 is perhaps the most perfect. It had an exposure of 15 seconds near the commencement of the eclipse. I have found that the middle of the eclipse was at 14h. 27m. 4s. Greenwich mean time according to the tables. Mr. Hennessey, who had most facilities for marking the duration of totality, gives it as a little more than 122 seconds. From these data, and the reckoning formerly given, I reckon that this plate was exposed from 14h. 24m. 7s. to 14h. 26m. 22s. of Greenwich mean time. The disk of the moon is surrounded by a narrow, very luminous border almost indistinguishable from the prominences, but whose inner edge is sharply defined by the moon, except in one or two places, and whose outer one varies very much in distance from this, and is much less sharply defined. There is much encroachment of light on the dark surface of the moon, and this is greatest at the places of prominences, and especially at the lower part of the disc where the solar edge is nearest. Here the encroachment nearly obliterates the disc in some places, and presents a very marked outline; here, too, the brilliant band is brightest and widest, and its outer edge most defined. Outside this is the corona, at the bottom are seen several rays with ill-defined edges. One of these to the right (S) of lowest point is markedly curved; the outer end pointing S. W. The great rift to the south, and a less marked one to the north, each have a prominence at the base;—close to the vertex is seen the small rift which was spectroscopically examined. There is structure clearly seen in the whole of the corona, and, except in the case of the curved ray of which I have spoken, it seems to me that there is a tendency to radiate from prominences. Some of the longest rays may be faintly traced to a distance of  $\frac{3}{4}$ ths of the moon's diameter.

“No. 2.—It is evident, on looking at this, that the chemical action has been much less: the encroachment of the general light on the lunar disc is much reduced, while that of the prominences is more conspicuous. The broad band of light at the bottom of No. 1 giving an appearance of a well defined portion of corona has disappeared, and the light now decreases gradually from the moon's edge. The outline of the lower edge of the south rift is shown as more curved; but comparison shows that this is not so much a real change of form, as the result of the fainter portions being less depicted. The radial structure of the corona is as marked here as in the last photograph, and the same tendency to stream from prominences may be recognized with perhaps more facility. The exposure may be considered to have lasted from 14h. 26m. 37s. to 14h. 26m. 47s. of Greenwich mean time. There is a good deal of fog about the plate.

“No. 3.—Here the active effects are evidently between those in Nos. 1 and 2; the outline of the south rift is restored very much to its appearance in No. 1; and the photograph otherwise requires little remark. It may be considered to have been exposed from 14h. 26m. 58s. to 14h. 26m. 6s. of Greenwich mean time.

“No. 4 is a good deal like No. 2, save that the lower prominences, being more covered, the glare there is much less. Placed on a dark ground, and viewed as positives, these two photographs are very similar; viewed as transparencies, No. 2 has decidedly more detail and extent. It may be considered as having been exposed from 14h. 27m. 17s. to 14h. 27m. 23s. of Greenwich mean time.

“No. 5.—This has less detail than any of the preceding photographs, and there is a want of sharp definition, showing that there was some motion of the camera relative to the object. This may be due to the action of the clock ceasing, as I have mentioned it did during the exposure of plate 6, and I am disposed to think it is so, but the short exposure makes the effect small, and leaves this photograph available as evidence of the general permanence of the corona during totality. It may be considered as exposed between 14h. 27m. 31s. and 14h. 27m. 36s. Greenwich mean time.

“No. 6.—As I have mentioned before, the clock manifestly ceased acting during this exposure. Looking at the upper edge one sees the succession in which the peaks of the chromosphere appeared, and it is evident that a momentary exposure would have sufficed for depicting these” \* \* \* \* \*

*Extracts from Colonel Tennant's Report to Government. Conclusions.*

“Spectroscope and polariscope have so far agreed in assigning a solar origin to the main phenomenon of the corona; and, if we examine the photographs, we shall have the same result. It is quite



*Total Eclipse of the Sun. December 11-12, 1872.*

“impossible not to connect the south prominence with the corresponding rift, at whose base it lies, and whose sides clearly in a general way radiate from it. A comparison of No. 1, and the later photographs, shows that the connection lasted, and that in fact, the moon passed over the corona. Nos. 1 and 3 do not show any changes in the forms and positions of the portions of the corona, and an examination of the later photographs, Nos. 4 and 5, though the definition is not so perfect, quite supports this. That on the true solar corona is superposed an atmospheric phenomenon is probable enough; but, as I said in 1868, the corona is solar. It is the atmosphere of the sun in its colder parts. It is, indeed, to some extent self-luminous, but mainly it shines, as I reported in 1868, by reflected light.”

\* \* \* \* \*

“The following, then, seems to be the constitution of our sun. There is a nucleus which gives out continuous white light like solid or liquid bodies, and even dense gases: surrounding this is a layer of heavy vapors intensely heated, but far less so than the nucleus; in which, if a state of equilibrium could exist, the heavier vapors would be lowest. Above this is a layer of glowing hydrogen of very slight density accompanied by that gas which gives the line  $D_3$ . Still further up these gases in a cooler state become mixed with what gives out the green line K 1474, and lastly, that alone seems to remain.

“Of the solar nucleus we know little certainly, possibly we never shall know much, as it is almost hidden from our view, but we do know that its temperature is so high that we have reason to believe that unless subjected to enormous pressure every terrestrial element would be vaporized. It has been estimated in millions of degrees, but such statements can convey no intelligible idea. We do not know anything of the substance producing the chromospheric line  $D_3$ . Professor Respighi's observations at Podocotta would go to show that it is inseparable from the hydrogen of the chromosphere. The substance, however, producing the green line K 1474, is one of the most interesting. We not only meet the evidence of its existence in the sun, but when the higher layers of our own atmosphere are reached we meet, at the great height at which Auroras take place, a substance which gives out a light apparently identical, and again Angström and Kirchhoff have assigned the power of giving this line to the vapor of iron. It seems nearly impossible that at the low temperature which we know must exist in the upper strata of our atmosphere there can possibly be iron vapor. Is it possible that iron possesses the property of occluding the gas, whose distinctive line is K 1474? If it be so, this gas must be under ordinary circumstances of temperature and pressure almost immeasurably rare.”



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

| YEAR & MONTH. | BAROMETER.          |          |         | HYGROMETER.   |               |               |               | THERMOMETER.   |              |              |              |           |           | WIND.              |                                 | CLOUD.              |                     | RAIN.                |                 |
|---------------|---------------------|----------|---------|---------------|---------------|---------------|---------------|----------------|--------------|--------------|--------------|-----------|-----------|--------------------|---------------------------------|---------------------|---------------------|----------------------|-----------------|
|               | h. m. At 9 30 A. M. | Highest. | Lowest. | At 9 30 A. M. |               | At 3 30 P. M. |               | Dry Bulb.      |              |              | Wet Bulb.    |           |           | Average direction. | Mean force in lbs per sq. foot. | h. m. At 9 30 A. M. | h. m. At 3 30 P. M. | No. of days it fell. | Fall in inches. |
|               |                     |          |         | Monthly Mean. | Monthly Mean. | Monthly Mean. | Monthly Mean. | Max: in Grass. | Min: in Air. | Max: in Air. | Min: in Air. | Max: Wet. | Min: Wet. |                    |                                 |                     |                     |                      |                 |
| 1871          | 27.652              | 27.774   | 27.669  | 27.680        | 44.5          | 45.2          | 85.5          | 30.0           | 75.2         | 35.6         | 55.7         | 61.8      | 48.9      | W.                 | .00                             | 2                   | 3                   | 3                    | .46             |
| January       | 849                 | 719      | 505     | 630           | 49.6          | 49.3          | 90.1          | 39.6           | 79.7         | 43.4         | 62.0         | 60.7      | 39.5      | S.E.               | .00                             | 4                   | 5                   | 7                    | 2.54            |
| February      | 751                 | 657      | 437     | 577           | 47.7          | 45.6          | 87.3          | 40.2           | 90.0         | 44.5         | 67.3         | 66.1      | 52.7      | W.                 | .00                             | 4                   | 9                   | 0                    | .00             |
| March         | 705                 | 609      | 397     | 515           | 47.7          | 44.2          | 86.2          | 40.2           | 90.0         | 44.5         | 67.3         | 66.1      | 52.7      | S.W.               | .01                             | 3                   | 4                   | 4                    | .43             |
| April         | 657                 | 528      | 374     | 432           | 43.2          | 38.6          | 80.5          | 36.9           | 84.0         | 40.2         | 60.5         | 58.9      | 45.8      | S.W.               | .01                             | 4                   | 6                   | 14                   | 3.44            |
| May           | 641                 | 388      | 183     | 306           | 41.5          | 36.3          | 77.9          | 33.0           | 81.0         | 38.6         | 56.8         | 56.8      | 45.8      | N.E. & S.          | .00                             | 9                   | 7                   | 24                   | 9.131           |
| June          | 520                 | 370      | 189     | 311           | 37.7          | 32.9          | 80.9          | 30.8           | 84.0         | 35.6         | 56.8         | 56.8      | 45.8      | N.                 | .00                             | 8                   | 9                   | 29                   | 8.632           |
| July          | 589                 | 439      | 309     | 373           | 42.5          | 38.6          | 86.5          | 33.0           | 89.2         | 40.2         | 65.1         | 63.2      | 50.6      | N. & W.            | .00                             | 8                   | 8                   | 28                   | 8.339           |
| August        | 632                 | 537      | 296     | 435           | 42.5          | 38.6          | 86.5          | 33.0           | 89.2         | 40.2         | 65.1         | 63.2      | 50.6      | N. & W.            | .00                             | 5                   | 5                   | 16                   | 11.03           |
| September     | 601                 | 673      | 476     | 584           | 48.4          | 48.3          | 91.9          | 36.0           | 81.4         | 40.8         | 63.8         | 63.4      | 33.7      | W.                 | .00                             | 0                   | 0                   | 0                    | .00             |
| October       | 864                 | 787      | 552     | 691           | 48.4          | 48.3          | 91.9          | 36.0           | 81.4         | 40.8         | 63.8         | 63.4      | 33.7      | W.                 | .00                             | 1                   | 1                   | 0                    | .00             |
| November      | 864                 | 787      | 552     | 691           | 48.4          | 48.3          | 91.9          | 36.0           | 81.4         | 40.8         | 63.8         | 63.4      | 33.7      | W.                 | .00                             | 0                   | 0                   | 0                    | .00             |
| December      | 28.016              | 842      | 618     | 719           | 41.0          | 36.3          | 80.3          | 28.3           | 77.2         | 41.1         | 58.0         | 60.3      | 47.8      | W.                 | .00                             | 3                   | 4                   | 3                    | 1.32            |

ABSTRACT OF RAIN-FALL AT DEHRA DUN G. T. SURVEY OFFICE FROM 1861 TO 1871.

| MONTH.     | 1861.  | 1862. | 1863. | 1864. | 1865. | 1866. | 1867. | 1868. | 1869. | 1870. | 1871.  |
|------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| January.   | —      | —     | 3.31  | .36   | 1.03  | —     | 1.25  | 2.69  | 1.67  | .04   | .46    |
| February.  | —      | —     | .00   | 2.18  | 6.48  | —     | 1.46  | 7.28  | 1.43  | 1.39  | 2.54   |
| March.     | —      | —     | 1.69  | .52   | 4.67  | —     | 1.43  | 1.74  | 7.25  | 4.13  | .00    |
| April.     | —      | —     | .33   | .21   | 1.35  | 2.50  | .84   | .11   | .11   | 1.84  | .43    |
| May.       | —      | —     | .31   | 2.53  | 6.45  | —     | 3.21  | .82   | .00   | .31   | 3.44   |
| June.      | 12.19  | —     | 12.19 | .20   | 2.10  | 8.21  | 9.94  | 6.83  | 2.96  | 7.04  | 24.34  |
| July.      | 24.53  | 28.66 | 36.96 | 37.60 | 19.12 | 34.75 | 28.69 | 21.25 | 20.66 | 33.05 | 86.32  |
| August.    | 45.22  | 54.75 | 24.78 | 22.50 | 29.40 | 23.70 | 23.63 | 12.85 | 10.79 | 26.45 | 85.39  |
| September. | 9.31   | 20.20 | 2.19  | 7.21  | 10.06 | 5.60  | 3.02  | 23.56 | 13.78 | 11.03 | 11.03  |
| October.   | .02    | 5.52  | .60   | 1.63  | .00   | .20   | .93   | .05   | 2.30  | 1.89  | .00    |
| November.  | .01    | .40   | .00   | .17   | .00   | .00   | .00   | .00   | .00   | .00   | .00    |
| December.  | .00    | .00   | .60   | .03   | 4.02  | —     | .00   | .18   | 1.22  | .01   | 1.32   |
| Total.     | 100.91 | 99.60 | 89.91 | 75.37 | 85.58 | 74.96 | 75.09 | 57.56 | 77.04 | 91.43 | 118.27 |

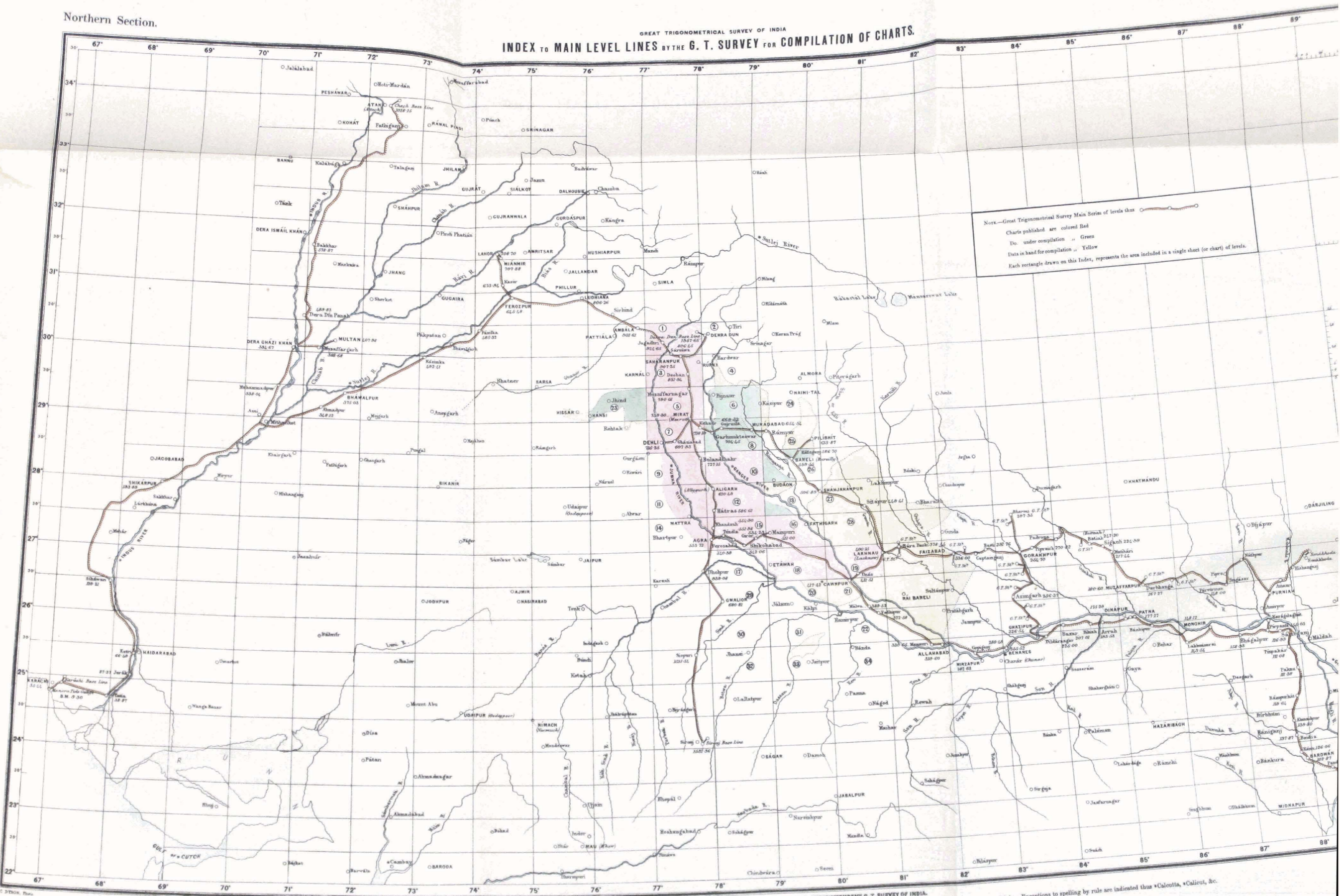
NOTE.—Where blanks occur no record is forthcoming. Height of Barometer Cistern above Mean Sea Level, 2332.41 feet.


**Annual Return of amount of Work executed in the Drawing Branch of the Office of Superintendent G. T. Survey, from 1st May 1871 to 30th April 1872.**

| DESCRIPTION OF WORK.                                                                                                                       |                                                                                                                                              |                                                                                                                   |                        |                              | REMARKS.                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|------------------------|------------------------------|---------------------------------------------|
| Sheet No. 9 of Levels in the N.W. Provinces (Compilation). <i>Vide Annual Return for 1870-71,</i> }                                        |                                                                                                                                              |                                                                                                                   |                        |                              | For Photo-zincography.                      |
| Do. No. 11                                                                                                                                 | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ditto, ...                   | ditto.                                      |
| Do. No. 14                                                                                                                                 | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ditto, ...                   | ditto.                                      |
| Do. No. 15                                                                                                                                 | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ditto, ...                   | ditto.                                      |
| Do. No. 1                                                                                                                                  | Preliminary Chart of the Great Indus Series, ...                                                                                             |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do. No. 2                                                                                                                                  | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ...                          | ditto.                                      |
| Do. No. 3                                                                                                                                  | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ...                          | ditto.                                      |
| Do. No. 11                                                                                                                                 | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ...                          | ditto.                                      |
| Do. No. 12                                                                                                                                 | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ...                          | ditto.                                      |
| Do. No. 1                                                                                                                                  | ditto                                                                                                                                        | ditto                                                                                                             | of the Kashmír Series. | ...                          | ditto.                                      |
| Do. No. 4                                                                                                                                  | ditto                                                                                                                                        | ditto                                                                                                             | ditto,                 | ...                          | ditto.                                      |
| Do. No. 5                                                                                                                                  | ditto                                                                                                                                        | ditto                                                                                                             | ditto,                 | ...                          | ditto.                                      |
| Do. No. 5                                                                                                                                  | ditto of Triangulation in the Northern Portions of the *Bombay }<br>Presidency examined and passed. <i>Vide Annual Return for 1870-71,</i> } |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do. No. 6                                                                                                                                  | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ditto, ...                   | ditto.                                      |
| Do. No. 8                                                                                                                                  | ditto                                                                                                                                        | ditto                                                                                                             | ditto                  | ...                          | ditto.                                      |
| Do. No. 1                                                                                                                                  | ditto of the *Sutlej Series, ...                                                                                                             |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do. No. 2                                                                                                                                  | ditto                                                                                                                                        | ditto,                                                                                                            | ...                    | ...                          | ditto.                                      |
| Do. No. 3                                                                                                                                  | ditto                                                                                                                                        | ditto,                                                                                                            | ...                    | ...                          | ditto.                                      |
| Do. No. 4                                                                                                                                  | ditto                                                                                                                                        | ditto,                                                                                                            | ...                    | ...                          | ditto.                                      |
| Preliminary Chart of the Jogi-Tila Series,—Minor Triangulation along Rávi and }<br>Chináb Rivers, ...                                      |                                                                                                                                              |                                                                                                                   |                        |                              | ditto.                                      |
| Do.                                                                                                                                        | of the North-West Himalaya Series, Season 1850-51, ...                                                                                       |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | of the Bider Longitudinal Series, Season 1869-70, ...                                                                                        |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | ditto                                                                                                                                        | ditto                                                                                                             | Season 1870-71, ...    | ...                          | ditto.                                      |
| Do.                                                                                                                                        | of the Gurhágárh Meridional Series, Seasons 1858-60, ...                                                                                     |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | of the Rahún Meridional Series, Season 1856-57, ...                                                                                          |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | of the Pesháwar and Khágán Triangulation, ...                                                                                                |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | of the Assám Valley Triangulation, Season 1870-71, ...                                                                                       |                                                                                                                   |                        | ...                          | ditto.                                      |
| Prepared a Chart of the Násik Triangulation between Lat. 19° 30' and 20° 30', and }<br>Long. 73° 30' and 74° 30', ...                      |                                                                                                                                              |                                                                                                                   |                        |                              | For Computing Office use.                   |
| Do.                                                                                                                                        | an Extract from the Preliminary Chart of the Great Arc Series Northern Section,                                                              |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | an Extract from Khanpísúra Series between the parallels of 20° and 22°,                                                                      |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | Sheet No. 1                                                                                                                                  | Map of Routes in Northern India (Compilation), Scale }<br>1 inch = 16 miles, Lat. 33° to 38°, Long. 68° to 76°, } |                        | ...                          | For Photo-zincography.                      |
| Do.                                                                                                                                        | do. No. 2                                                                                                                                    | ditto                                                                                                             | ditto                  | 33° to 38° „ 76° to 81°, ... | ditto.                                      |
| Do.                                                                                                                                        | do. No. 3                                                                                                                                    | ditto                                                                                                             | ditto                  | 28° to 33° „ 68° to 76°, ... | ditto.                                      |
| Do.                                                                                                                                        | Rough Skeleton plan of the town of Mangalur, ...                                                                                             |                                                                                                                   |                        | ...                          | For Major Branfill.                         |
| Do.                                                                                                                                        | Route Map from Panjáb to Badukshán, Scale 1 inch = 16 miles, ...                                                                             |                                                                                                                   |                        | ...                          | For reduction by Photography.               |
| Do.                                                                                                                                        | a trace of the Chaumba Territory (on linen) with hills, Scale 1 inch = 2 miles,                                                              |                                                                                                                   |                        | ...                          | For Photo-zincography.                      |
| Do.                                                                                                                                        | a trace of the Biláspur Meridional Series, ...                                                                                               |                                                                                                                   |                        | ...                          | For use of Bider Longitudinal Series party. |
| Do.                                                                                                                                        | a trace of Minor Triangulation extending over the Nílgiiri and Kundar }<br>Mountains (on linen), ...                                         |                                                                                                                   |                        | ...                          | For Computing Office use.                   |
| Do.                                                                                                                                        | a trace of triangles extending over portion of province of *Coimbatore, ...                                                                  |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | small Chart illustrating Spirit Levelling operations section VIII, season }<br>1870-71, scale 1 inch = 20 miles, ...                         |                                                                                                                   |                        | ...                          | For Photo-zincography.                      |
| Do.                                                                                                                                        | Index to the Level Sheets, scale 1 inch = 32 miles, ...                                                                                      |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | General Skeleton Map of Delhi, scale 1 inch = 16 miles, ...                                                                                  |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | Map of the Country round Delhi, scale 1 inch = 2 miles, ...                                                                                  |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | Plan of the battle of Delhi in 1803, ...                                                                                                     |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | Plan of the City of Delhi, ...                                                                                                               |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | Plan showing the position of British army before Delhi from June 8th to }<br>September 14th 1857, ...                                        |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | Trans-Frontier Map No. 2 (compilation), scale 1 inch = 16 miles, between }<br>Lat. 34° and 39° 30' and Longitude 73° and 82°, ...            |                                                                                                                   |                        | ...                          | ditto.                                      |
| Do.                                                                                                                                        | a copy of the ground plan and plan in elevation of the G. T. Survey Office }<br>Delkra Dun, ...                                              |                                                                                                                   |                        | ...                          | For Office use.                             |
| Reduced and incorporated additional triangulation in 3 copies of the G. T. Survey }<br>Index Chart for its completion to 1st May 1871, ... |                                                                                                                                              |                                                                                                                   |                        |                              | To be engraved.                             |
| Examined proofs of Preliminary Charts, Maps &c., and other miscellaneous duties, ...                                                       |                                                                                                                                              |                                                                                                                   |                        |                              |                                             |
| Colored 4,703 copies of Maps of various kinds, ...                                                                                         |                                                                                                                                              |                                                                                                                   |                        |                              |                                             |

Northern Section.

GREAT TRIGONOMETRICAL SURVEY OF INDIA  
INDEX TO MAIN LEVEL LINES BY THE G. T. SURVEY FOR COMPILATION OF CHARTS.



Note.—Great Trigonometrical Survey Main Series of levels thus   
Charts published are colored Red  
Do. under compilation " Green  
Data in hand for compilation " Yellow  
Each rectangle drawn on this Index, represents the area included in a single sheet (or chart) of levels.

Rules for pronouncing Indian proper names: a has a variable sound as in woman, rural, paltry; d as in tartan; f as in clique; g as in ravine; w as in bull; s as in rural; o as in note; e as o in say; ou as ou in cloud; ai as i in ride; g as in gong; shad as shād; basar as básar. Exceptions to spelling by rule are indicated thus \*Calcutta, \*Calicut, &c.

COMPILED UNDER THE INSTRUCTIONS OF MAJOR T. C. MONTGOMERY, R. E., F. R. S., &c., 1877. SUPERINTENDENT G. T. SURVEY OF INDIA.


Scale 1 inch = 80 Miles or 128000 Feet

Photographed at the G. T. Survey Office, Dehra Dun, September 1872.

Northern Section.

GREAT TRIGONOMETRICAL SURVEY OF INDIA  
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References

- Route Survey ..... denoted by
- Peaks fixed by the G. T. Survey ..... do.
- Do. .... by Route Survey ..... do.
- British Boundary ..... colored Red
- Nepal do. .... do. Green
- Sikhim do. .... do. Neutral tint
- Chino-Tibetan do. .... do. Yellow
- Glaciers ..... do. Emerald-Green
- Jong signifies Fort
- Gonpa " Buddhist Monastery
- Chu " River.
- La " Pass.

Note. The Country from Sarka Tarjam to Gaidara Jong from Pundick Map

PHOTOZINCOGRAPHED UNDER THE ORDERS OF COLONEL J. T. WALKER, R.E., F.R.S., &C., SUPDT. GREAT TRIGONOMETRICAL SURVEY OF INDIA AT THE G. T. SURVEY OFFICE

Rules for pronouncing Indian proper names; a has a variable sound as in women, rural, petty; d as in tartan; f as in fat; g as in gem; h as in hall; k as in king; l as in lid; m as in mad; n as in nose; o as in odd; p as in pot; r as in run; s as in son; sh as in shawl; t as in top; v as in vein; y as in yet; z as in zone.

GREAT TRIGONOMETRICAL SURVEY OF INDIA.



THE  
**DINGRI-MAIDAN**  
 AND  
**UPPER ARUN RIVER**  
 WITH THE  
**EASTERN AND WESTERN SOURCES**  
 OF THE  
**KOSI OR KOSIKI RIVER**  
 THE GREAT EASTERN TRIBUTARY OF THE  
**GANGES**  
 ALSO  
**PART OF GREAT TIBET**  
 FROM A  
 ROUTE SURVEY MADE BY AN ASIATIC EXPLORER  
 CORRECTED FROM THE ORIGINAL MATERIALS  
 BY  
**MAJOR T. G. MONTOMERIE, R.E., F.R.S., F.R.G.S.**  
 Hon. Assoc. of the Indian Geographical Society, &c.  
 DEPUTY SUPERINTENDENT  
 G. T. SURVEY OF INDIA.

ONEL J. T. WALKER, R.E., F.R.S. & C., SUPDT. GREAT TRIGONOMETRICAL SURVEY OF INDIA AT THE G. T. SURVEY OFFICE, DEHRA DUN, FEBRUARY 1873.—HILL SHADING BY H. SINDON.  
 Correcting Indian proper names: a has a variable sound as in women, rural, poetry; d as in tartan; s as in ball; f as in reverse; w as in rural; c as in road; e as in red; g as in group; sh as an shid; h as in hair. Exceptions to spelling by rule are indicated thus: Calcutta, Calicut, &c.  
 G. O. COLLETT, 2000

**Memorandum on the Trans-Himalayan Explorations for 1871, by Major T. G. MONTGOMERIE, R.E., Deputy Superintendent G. T. Survey, in charge of the Trans-Himalayan Exploring Parties.**

The explorations which I have selected for this year's report have been made by explorer No: 9, during more than one expedition: it is not expedient to refer to him in any way that would lead to his identification, as any such indications are apt to be conveyed to frontier places, and in some cases have caused great inconvenience to the explorers by obliging them to start by out of the way routes &c., and occasionally have hindered them when far beyond the frontier by means of letters sent from our frontiers.

The explorer, for one portion of his work, made his way from Dárjiling, passing through Sikkim into Great Tibet; it is not however necessary to refer to his journey in detail until he got beyond what Sir William Hooker called the Wallangchoon pass, as up to that point Sir William has already given us an admirable description of the country.

The explorer, on trying to pass into Tibet, was as usual stopped and told that he would not be allowed to proceed farther, as he was not known to any one, nor able to give any satisfactory evidence as to his being what he stated. He was consequently rather in despair, but was fortunate enough to ingratiate himself with the chief official of a large Sikkim district whose wife happened to be very ill. I have always made my explorers take a supply of medicines with them, mostly of native kinds, with only a few ordinary European sorts to present to people on their journeys. In the present instance the explorer had also provided himself with a Hindi translation of a treatise as to using these drugs, and when he heard of the woman's illness he offered to give her some medicine if he was allowed to see her and hear as to her sufferings &c., his offer was at once accepted and the explorer having seen her searched his book until he came across some disease with the same symptoms as she had and he then boldly prepared the medicines directed and gave them to the woman according to the instructions, and awaited the result in not a little trepidation. In a few days time the woman became wonderfully better and eventually a cure was effected very much to the astonishment of the amateur practitioner. The explorer was treated with marked kindness and hospitality from the day the woman began to improve; he then again urged his request to be allowed to pass into Tibet. The headman said he would be glad to give him permission but that it would be of no use as he would be again stopped by another official before he advanced very far unless he had some one to answer for him. The explorer however continued to urge his point and at last the official said he would himself be his security, and he finally sent one of his own men with the explorer who passed him through the places where he was likely to be stopped.

The explorer consequently marched on without any farther interruption, except the ordinary ones at custom houses, where his baggage was strictly searched; fortunately his instruments were so well concealed that they were never discovered.

From the Tipta-La—the Wallangchoon pass of Sir William Hooker, probably so named from the village south of it, which the explorer gives as Wallungsum—he made his way in two marches to Tashirak. The road was a difficult one, the ground north of the pass being very elevated and barren, so that both food and fuel had to be carried on yáks for the use of the party.

The Tipta-La was covered with snow; it is on the watershed of a very high range that runs nearly east and west forming the boundary between Nepal and Lhása.

Tashirak is a large standing Bhotia encampment on a feeder of the Arun river, which rises in a glacier to the west, and not on the main stream of that river as was formerly supposed; it is 15,000 feet above the sea. Marching north, the explorer crossed the Nila-La pass, and passing a large Lama monastery reached the Shara village of some 50 houses, which is under a Thánahdár of the Tinki or Tinka district, generally known as Tinkijong after its fort (jong). Here his baggage was very closely searched, and it was only by means of the man sent by the Sikkim official that he was able to advance farther. After many inquiries were made he got a pass to travel to Shigatze, and being fairly in Tibet he was never stopped again. He made his way first to Lámádong, a village of 50 or 60 houses, arriving there on the 4th September. Before reaching this place the explorer had latterly seen no cultivation except that of Indian-corn in small quantities, but at Lámádong itself there was a good deal of wheat and pease and round about several other villages could be seen equally well cultivated; all these villages were on or near the banks of the great eastern branch of the Arun river, called—the Khantongiri river, which comes from the east.



The next day he arrived at another small village with plenty of cultivation, all tending to show that he had again reached a warmer climate, Lámádong being 13,100 feet above the sea.

On the 6th September he crossed the Tiuki-La pass and after a trying march reached the village of Tasiichiraug on the bank of the Chomto Dong lake which is a fine sheet of water about 20 miles in length by 16 miles in breadth, at an elevation of 14,700 feet above the sea. This lake has never been shown in any map that I am aware of, but we have notices of its existence in itineraries collected by Mr. Hodgson, Dr. Campbell, &c. The explorer found the water very clear and pure, and very good to drink: he and his party used it and were told that the inhabitants took it in preference to that of the two or three streams which were seen to run into the lake. The explorer was unable to go completely round it, but he could see it fully as he passed along its northern shore and yet could discover no signs of an outlet; the inhabitants declare that it has none: the sweetness of the water, however, is against there being no outlet and if so it must be somewhere to the south-east. The lake forms a portion of the boundary between Sikkim and the Lhása Territories. The Sikkim Territory lying to the east, that of Lhása to the west of the lake. Several very high snow peaks were visible from the lake to the east and south.

On the 7th September he arrived at Ningzi, a Sikkim village which, though it has but 50 houses, boasts of a wonderful number of dogs, the explorer declaring he himself saw at least 200, and was certain that he never met with such a large proportion in a Tibetan village where they are proverbially numerous.

On the 9th September he reached Chajong (or Tatápáni) hot springs where he took latitude and thermometer observations, the latter making it 15,000 feet above the sea. Four reservoirs, each about 30 feet in circumference and 3 feet deep, have been built to catch the water of these springs which appeared to be sulphurous and have a high reputation for their curative properties, being visited by numbers of people. The place swarmed with Tibetan (Hodgsonian) antelope which are quite tame being never disturbed, as they are considered to be dedicated to the deity of these hot springs. The next day the party encamped in a ravine and the day after crossed the Lagulung-La pass which has quantities of glacier ice close down to it, being itself 16,200 feet above the sea. This pass forms the boundary between Sikkim and Lhása, the march terminated at the village of Thak. On the 15th September he passed the village and part of Sai Jong which is surrounded by cultivation and has numerous other villages round about, encamped at Chota-Tápu or Darcha village on the banks of the Sai Jong stream, which comes from a great distance, rising in Sikkim. The next day crossed the Gyaling mountains by a pass covered with snow, and reached the Bálu Koti village of 20 houses; this place has a good deal of cultivation, and numerous other villages are visible round about it. Passing thence through a level and well cultivated country, the explorer reached Shigatze on the 17th of September.

The explorer paid the usual homage to the Láma of Tashi Lambo, making an offering of two rupees. He found the city of Shigatze in much the same state as described by the chief Pandit, he however heard of the serious rebellion which had been raised against the great Láma of Lhása in April 1871, during which hundreds of people were killed.

The explorer remained in Shigatze till the 29th of September, he then made his way south-westwards, towards the Dingri maidán, resuming his route survey on the 30th September from a point he had previously visited. By evening he reached the village of Shimraug and the next day crossed the Shabki-Chu river which was 65 paces wide and 4 feet deep, flowing down into the Sang-po (Bráhmáputra), numbers of villages were seen on and off the road. The harvest was being reaped.

On the 2nd of October he reached the great Shakia monastery (*Gonpa*) which is only second to that of Tashi Lambo. The explorer was unfortunately not able to stop at Shakia to examine the place more closely. He says the Shakia monastery is on a low spur, it is inhabited by about 2,500 monk Lámás, ruled by a great Láma called Shakia-Gangma (king or above all others); he is looked upon as a deity. His Lámás are the only ones in this part of Tibet that are allowed to marry, they are called *Dhukpás*, other Lámás who are not allowed to marry being called *Gálpás*. The town of Shakia lies at the foot of the monastery and is about half the size of the city of Shigatze. About fifty of the shops in the town are kept by Niwars from Nepal, all the other shops are kept by Bhotias. There is a large amount of cultivation around Shakia though it is about 13,900 feet above the sea.

On the 3rd of October the explorer crossed the Dongo-La feet above sea, and again got into ground drained by the Arun river, and on the 5th October reached the Chokuar village, on the left bank of the Plungtu or Dingri-Chu river, the great western branch of the Arun river.

Continuing westwards along the Dingri-Chu river, the explorer reached the Sakar-Chu river a branch of the Dingri-Chu. The Sakar-jong (fort) is about 8 miles north of the junction, and is the residence of a Lhása magistrate. The Ghurkas in 1854 advanced as far as this point when they invaded Tibet.

On the 8th of October the explorer reached the town of Dingri which is generally known as Dingri Maidán from the large open plain in which it stands, it is also sometimes called Dingri-Ganga. The town has but 250 houses supplemented with tents on occasions of fairs &c., it is 13,900 feet above the sea.

Five miles above the junction of the Shakar-Chu river, the explorer crossed the Dingri-Chu river by a wooden bridge 75 paces in length. Showing that even at that point this great eastern branch of the Arun is a very large stream as might be expected from its draining the great Dingri table-land.

North and quite close to the Dingri town stands the Dingri Khar (fort) on a low isolated hill. A high Chinese officer called a *Daipon* who is the chief military and civil officer, resides in the fort, he has a small garrison of Bhotia soldiers with but one gun.

From Dingri there is a very good road which runs north-east to Jong-ka-Jong and thence by Kirong town to Katmándu. Officials are however the only persons who are allowed to travel by this route, traders and all others taking the one followed by the explorer to Nilam, &c.

The explorer did not make any stay in Dingri, being afraid that he might be cut off from India by an early fall of snow, he accordingly pushed on as fast as he could. At first he passed through a wide all but level tract, and then getting into rougher ground reached the Thung-lung-La on the 10th of October; he found the pass covered with old ice and snow, it being 18,460 feet above the sea.

On the 11th October he reached the town of Nilam 13,900 feet above the sea which has about 250 houses. It is ruled by a couple of *Jongpons*, the Lhása Government sending two there so as to be a check on one another. Nilam being the first Tibetan town on the road from Nepal, is considered to demand extra vigilance and consequently the explorer and his party were very closely examined and their baggage was carefully searched before they were allowed to go on.

From Shigatze to the Thung-lung-La pass, the explorer had passed through a moderately level tract though at a very great elevation, but from the Thung-lung-La, where he crossed the Himalayan watershed he again entered on very rugged ground much more difficult than even that south of the Tipta-La (or Wallungsum pass).

Between Nilam and Listi Bhansár he followed the general course of the Bhotia-Kosi river, and though it is but some 25 miles direct distance between the two places, the explorer had to cross the Bhotia-Kosi river 15 times by means of 3 iron suspension, and 11 wooden bridges each of from 24 to 60 paces in length. At one place the river ran in a gigantic chasm the sides of which were so close to one another, that a bridge of 24 paces was sufficient to span it. This was just below or south of the village of Choksum. Near this bridge the precipices were so impracticable that the path had of necessity to be supported on iron pegs let into the face of the rock. The path being formed by bars of iron and slabs of stone stretching from peg to peg and covered with earth. This extraordinary path is in no place more than 18 inches and often not more than nine inches in width, and is carried for more than one-third of a mile (775 paces) along the face of the cliff, at some 1,500 feet above the river which could be seen roaring below in its narrow bed. The explorer who has seen much difficult ground in the Himalayas, says he never in his life met with any thing to equal this bit of path. It is of course quite impassable for ponies or yáks, and but very few sheep and goats even go by it though it is constantly passed by men with loads.

There are several other smaller pieces of paths between Nilam and Listi Bhansár which are nearly as bad but they are fortunately not continuous.

From Listi Bhansár the explorer's route does not call for any special notice here being much the same as that in any other part of the mountains south of the Himalayan watershed, being rugged in the extreme for a considerable distance and then becoming easy in the valleys or Dúns. It may however be noted that the explorer crossed the Indrawati feeder of the Kosi which has 5 small towns near its source called Pauch Pokri. The source is in the snowy mountains to the west as shown on the map.

The lower ground, though not at all noteworthy in itself, had never been surveyed in any way previously, the only land marks being the few great peaks in its neighbourhood that have been fixed from a distance by the Great Trigonometrical Survey; and I consequently consider the survey of it and other portions of the lower ground a very valuable addition to the geography of that part of the mountains.

On reference to the map it will be seen that by this exploration the position of the great Himalayan watershed has been determined in three different places. In each case it proves to be far behind or north of the lofty peaks that are visible from Hindustán, such as Mount Everest, Kanchinjinga, &c.

The explorer it will be seen went completely round Mount Everest, but his route was so hemmed in by great mountains that he never got a view of Mount Everest itself; it seems to have been invariably hidden by the subordinate peaks which are tolerably close to it. Possibly it may have been seen but never continuously so as to be able to recognise it again and to fix it by bearings with a moderately long base. The Kanchinjinga and Jumu peaks were, however, seen from the west of Taplang Jong but only a short base could be secured. The explorer was much impressed by Kanchinjinga (28,150 feet); it is known to the natives near Taplang as *Kumbh Karan Langúr*. The people south of the Himalayas, in Nepal, call all snowy mountains *Langúr*, by which they mean the highest points. They call the peaks that have no snow *Banjung* and the low ground under the said *Banjung* they call *Phedi*. The term Himalayas is not used by uneducated people who only talk of the snowy mountains as "*Barfáni Langúr*."

Neither the Bhotias nor the Ghurkas seem to have specific names for remarkable peaks; the explorer asked all sorts of people but with the exception of the case of Kanchinjinga referred to above, he never got any name for a peak, though in a few cases they gave that of the nearest village.

Several of the other peaks fixed by the explorer were very lofty ones covered with perpetual snow to a great distance below their summits, those north of Mount Everest and Kanchinjinga are perhaps the most interesting as being beyond the Himalayan watershed. One to the north of the road between Shakia and Dingri, the explorer thought was very much loftier than any others.

The explorer's route survey may be said in a rough way to give us a general idea as to how the mountain drainage runs between the Himalayan watershed, north-west of Kirong, and the point where Turner crossed it near Chumalári up to the Bráhmáputra, or Sang-po river on the north from west of Junglache to Shigatze. The route between Kirong, Jong-ka-Jong, and Dingri Maidán is still a desideratum as we are in the dark as to the size of the Palgucho lake, which however it now appears will lie somewhat to the south of the approximate position which I gave it in my map showing the chief Pandit's route to Lhása.

A glance at the map at once shows what a large river the Arun must be, the area it drains being so very great. It is one of the few Himalayan rivers which has its source beyond the Himalayan range as seen from Hindustán, the others being the Indus, Sutlej and Karnáli. The length of the eastern and western upper sources is very remarkable, extending on the one side to the north and east of Kanchinjinga, and on the other to the north and west of Mount Everest.

In the route survey made by explorer No. 9 from Dárjiling to Shigatze, and from Shigatze by Shakia, Dingri Maidán, Nilam &c., to Katmáнду, the value of his pace has in the first instance been derived from the differences of latitude between the various places at which star observations for latitude were taken. A mean value of pace *viz*; 2.45 feet, derived from a mean of the values of each section, was adopted, and this mean value was applied to the number of paces showing the differences of longitude for each section and the value of the same in degrees and minutes was deduced therefrom in the usual way.

Taking the longitude of Dárjiling at  $88^{\circ} 18' 41''$  as determined by the triangulation of the G. T. Survey, and applying the differences of longitude as determined above, the longitude of Shigatze, by Tatápáni, Chota Tápu, &c., vide map, *i.e.*, by the most direct route would be  $88^{\circ} 46' 44''$ .

Taking the longitude of Katmáнду at  $85^{\circ} 17' 45''$  and applying the differences of longitude as above between it and Shigatze by Nilam, Dingri, Pil &c., the longitude of Shigatze would be  $88^{\circ} 32' 45''$ .

On examining the map, however, it is at once apparent that the longitude of Shigatze, as determined by a route survey from Dárjiling, is likely to be more reliable than that derived from Katmándu, because the difference of longitude, between Dárjiling and Shigatze, is but  $0^{\circ} 21'$ , while the difference between Katmándu and Shigatze, is  $3^{\circ} 11'$ , or in other words the longitude of Shigatze would be very much more affected by an error in the value of the pace in the latter case than in the former. I have consequently decided upon using only the value as determined from Shigatze.

At page x of my report on the chief Pandit's exploration to Lhása, I explain that the longitude of Shigatze was determined by the route survey which Mr. Turner made during his journey to Shigatze, combined with the route of the Pandit, Shigatze was computed to be in longitude  $88^{\circ} 48'$ , a very close agreement with the value as determined above independently by Explorer No. 9 *viz.*,  $88^{\circ} 47'$ . It may consequently be concluded that the longitudes of Shigatze and of Lhása which depends on Shigatze, as given in my first map, are very close approximations, and it is gratifying to find that my reliance on Turner's route survey was not misplaced.

The Explorer's work has stood all the usual tests satisfactorily, the average value of his pace, 2.45 feet as determined from the differences in latitude, is about what might be expected from a man of his stature. His latitude observations agree very well *inter se* considering that he used but a small pocket sextant. His observations at Shigatze give much the same latitude as that derived from the chief Pandit's observations with a large sextant at that and other places.

His heights are the weakest part of his work, as owing to the larger thermometers originally sent with him having been broken, he was reduced to take his boiling point observations with a very small thermometer. The heights however are probably fair approximations, and give a good general idea of the great elevation of the upper part of his ground.

His bearings to peaks on either side of his road were more numerous than usual, and on the whole he was fairly successful in fixing the more conspicuous.

The exploration with its bearings &c., opens out the geography of nearly 30,000 square miles of what has hitherto been in many portions *terra-incognita* and in others nearly so; the indications on our maps having been of course mostly conjectural. The exploration more especially elucidates the geography of the basin of the Arun or Arun-kosi river, the great eastern feeder, if not the main source of the great Kosi or Kosiki river, which drains the whole of eastern Nepal. The courses of the upper feeders of the Arun have hitherto been a puzzle to geographers. The explorer's work also defines the course of the great western tributary of the Kosi river *viz.* the Bhotia Kosi of which we had previously no survey.

His route survey is 844 miles in length of which 550 miles may be said to be over entirely new ground, and the remainder (though close to a line along which one European has travelled) had never been regularly surveyed before.

The explorer took latitude observations at 11 points upon which the work depends and determined the height of 31 places. His work I think will prove a valuable addition to the Trans-Frontier geography of India.

T. G. MONTGOMERIE, MAJOR R.E.,  
*Offg. Superintendent G. T. Survey of India,*  
*and in charge Trans-Himalayan Exploring Parties.*

*List of positions of the chief places as determined from the Route Survey  
of explorer No. 9 in Nepal and Great Tibet.*

|                                         | Latitude |    | Longitude |    | Height | Remarks            |                                                                       |
|-----------------------------------------|----------|----|-----------|----|--------|--------------------|-----------------------------------------------------------------------|
|                                         | °        | '  | °         | '  | feet   |                    |                                                                       |
| Dárjiling. . . . .                      | 27       | 2  | 88        | 19 | 7253   | From G. T. Survey. |                                                                       |
| Tatápáni. . . . .                       | 28       | 36 | 88        | 8  | 15025  |                    |                                                                       |
| Chota-Tápu (or Darcha village). . . . . | 28       | 57 | 88        | 27 | 14558  |                    |                                                                       |
| Shigatze (Tashilumbo). . . . .          | 29       | 17 | 88        | 47 | 11822  |                    |                                                                       |
| Pil. . . . .                            | 28       | 37 | 87        | 54 | 13259  |                    |                                                                       |
| Dingri-Maidán town. . . . .             | 28       | 35 | 86        | 40 | 13865  |                    |                                                                       |
| Nilam-Jong (or Kuti). . . . .           | 28       | 9  | 86        | 5  | 13911  |                    |                                                                       |
| Katmánda. . . . .                       | 27       | 41 | 85        | 18 | ..     |                    | From Crawford's<br>to G. T. S. Peaks.<br>No astronomical<br>latitude. |
| Kabiri River, Bank of. . . . .          | ..       | .. | 87        | 33 | ..     |                    |                                                                       |
| Narharia (Naria). . . . .               | 26       | 26 | 86        | 45 | ..     |                    |                                                                       |
| Dhankuta. . . . .                       | 26       | 56 | 87        | 21 | 2927   |                    |                                                                       |
| Lámádong. . . . .                       | 27       | 10 | 86        | 52 | ..     |                    |                                                                       |
| Amtia on bank of Arun River. . . . .    | 27       | 12 | 87        | 12 | 1798   |                    |                                                                       |

The longitude of Shigatze is derived from Dárjiling by the route survey passing through Tatápáni and Chota-Tápu. In the map accompanying this memorandum, 88° 40' was assumed to be the longitude, using a mean between the values derived from Katmánda and Shigatze. In future compilations the positions as given on the map, will require to be corrected to those given above.

*Observations for Latitudes taken in Nepal and Great Tibet by explorer No. 9. with a pocket sextant.*

| No. of Observation. | Astronomical Date.     | Watch Time.     | STATION.       | Object.    | Double Altitude. | Index Error. | Deducted Latitude. | Mean Latitude. | REMARKS.     |
|---------------------|------------------------|-----------------|----------------|------------|------------------|--------------|--------------------|----------------|--------------|
| 1                   | 1871.<br>Sept.<br>11th | h m s<br>12 0 0 | Tatápóni.      | Fomalhaut. | ° ' "            | ' "          | ° ' "              |                | On Meridian. |
| 2                   | "                      | 13 0 0          | "              | β Ceti.    | 62 14 30         | -1 0         | 28 35 44           |                | Ditto.       |
| 3                   | "                      | 12 0 0          | "              | Fomalhaut. | 85 28 30         | "            | 28 34 52           | 28 35 33       | Ditto.       |
| 4                   | "                      | 13 0 0          | "              | β Ceti.    | 62 14 0          | "            | 28 35 59           |                | Ditto.       |
| 5                   | "                      | 12 0 0          | Chota-Tápu.    | Fomalhaut. | 85 27 0          | "            | 28 35 37           |                | Ditto.       |
| 6                   | "                      | 13 0 0          | "              | β Ceti.    | 61 32 30         | "            | 28 56 44           | 28 56 56       | Ditto.       |
| 7                   | "                      | 12 0 0          | Shikache.      | Fomalhaut. | 84 44 0          | "            | 28 57 8            |                | Ditto.       |
| 8                   | "                      | 13 0 0          | "              | β Ceti.    | 60 53 30         | "            | 29 16 14           |                | Ditto.       |
| 9                   | "                      | 12 0 0          | "              | Polaris.   | 84 4 0           | "            | 29 17 7            |                | Ditto.       |
| 10                  | "                      | 12 0 0          | "              | "          | 61 23 0          | "            | 29 17 44           | 29 17 1        | Ditto.       |
| 11                  | "                      | 12 0 0          | "              | Fomalhaut. | 61 24 0          | "            | 29 18 16           |                | Ditto.       |
| 12                  | Octr.                  | 11 0 0          | Pil village.   | "          | 60 54 30         | "            | 29 15 44           |                | Ditto.       |
| 13                  | "                      | 12 0 0          | "              | β Ceti.    | 62 15 0          | "            | 28 35 26           | 28 37 16       | Ditto.       |
| 14                  | "                      | 11 0 0          | Dingri Maidán. | Fomalhaut. | 85 20 0          | "            | 28 39 6            |                | Ditto.       |
| 15                  | "                      | 12 0 0          | "              | β Ceti.    | 62 18 0          | "            | 28 33 55           | 28 34 30       | Ditto.       |
|                     |                        |                 |                |            | 85 28 0          | "            | 28 35 5            |                | Ditto.       |

*Observations for Latitudes taken in Nepal and Great Tibet.—(Continued.)*

| No. of Observation. | Astronomical Date.   | Watch Time.  | STATION.                             | Object.        | Double Altitude. | Index Error. | Deducted Latitude. | Mean Latitude. | REMARKS.     |
|---------------------|----------------------|--------------|--------------------------------------|----------------|------------------|--------------|--------------------|----------------|--------------|
| 16                  | 1871<br>October 11th | 11 0 0       | Nilam or Kuti.                       | Fomalhaut.     | 63 4 0           | — 1 0        | 28 10 54           | } 28 9 24      | On Meridian. |
| 17                  | " "                  | 12 0 0       | "                                    | β Ceti.        | 86 17 0          | "            | 28 10 34           |                | Ditto.       |
| 18                  | " "                  | 12 0 0       | "                                    | Polaris.       | 59 1 0           | "            | 28 6 44            |                | Ditto.       |
| 19                  | 1872<br>January 3rd  | 11 0 0       | Katmandu.                            | Orionis Rigel. | 107 50 0         | "            | 27 44 2            | } 27 43 29     | Ditto.       |
| 20                  | " "                  | 12 0 0       | "                                    | Sirius.        | 91 30 0          | "            | 27 42 55           |                | Ditto.       |
| 21                  | " "                  | 17th 11 0 0  | Lámádong.                            | Orionis Rigel. | 108 58 0         | "            | 27 10 1            | } 27 10 11     | Ditto.       |
| 22                  | " "                  | 12 0 0       | "                                    | Sirius.        | 92 35 0          | "            | 27 10 21           |                | Ditto.       |
| 23                  | " "                  | 22nd 10 30 0 | Amtia village on bank of Arun River. | Orionis Rigel. | 108 54 0         | "            | 27 11 59           | } 27 12 25     | Ditto.       |
| 24                  | " "                  | 11 30 0      | "                                    | Sirius.        | 92 30 0          | "            | 27 12 50           |                | Ditto.       |
| 25                  | " "                  | 29th 10 0 0  | Dhankuta Bazar.                      | Orionis Rigel. | 109 28 0         | "            | 26 54 58           | } 26 56 23     | Ditto.       |
| 26                  | " "                  | 11 0 0       | "                                    | Sirius.        | 93 0 0           | "            | 26 57 48           |                | Ditto.       |
| 27                  | February 7th         | 9 0 0        | Narhari Bazar.                       | Orionis Rigel. | 110 42 0         | "            | 26 17 56           | } 26 18 21     | Ditto.       |
| 28                  | " "                  | 10 0 0       | "                                    | Sirius.        | 94 18 0          | "            | 26 18 45           |                | Ditto.       |

*Observations of the Boiling Point taken in Nepal and Great Tibet by Explorer No. 9.*

| No. of Observa-<br>tion. | Month and date. |        | Watch time. | Station.                                             | THERMOMETER. |                   |         | Reduced Height<br>above Sea in feet. | REMARKS.   |
|--------------------------|-----------------|--------|-------------|------------------------------------------------------|--------------|-------------------|---------|--------------------------------------|------------|
|                          |                 |        |             |                                                      | No.          | Boiling<br>Point. | In Air. |                                      |            |
| 1                        | 1871            | August | 1 8 A.M.    | Darjiling                                            | 7            | 201.15            | 64.25   | 7,253                                | West wind. |
| 2                        | "               | "      | "           | Ditto                                                | 10           | 201.5             | "       |                                      | 13,575 | A point in Darjiling 7170 by G. T. S. |
| 3                        | "               | "      | 5 7 A.M.    | Phalialung Lek...                                    | 10           | 195.2             | 55.2    | 9,100 |  | No wind and rain. |
| 4                        | "               | "      | "           | Ditto                                                | 7            | 196.0             | "       |                                      | 1,677 | Ditto. |
| 5                        | "               | "      | 7 6 P.M.    | Suria Lek                                            | 7            | 198.0             | 63.0    | 10,564 |  | South wind and rain. |
| 6                        | "               | "      | 9 A.M.      | Bank of Kabiri river                                 | 7            | 211.0             | 78.0    |                                      | 15,618 | West wind. |
| 7                        | "               | "      | 15 8 A.M.   | Walungsangola                                        | 10           | 195.3             | 60.0    | 15,025 |  | No wind. |
| 8                        | "               | "      | "           | Ditto                                                | 7            | 196.0             | "       |                                      | 13,983 | Ditto. |
| 9                        | "               | "      | 16 1 P.M.   | Tipta-La                                             | 7            | 187.0             | 46.0    | 13,071 |  | No wind. |
| 10                       | "               | "      | 28 10 A.M.  | Tashirak village                                     | 7            | 188.0             | 47.0    |                                      | 14,734 | North wind. |
| 11                       | September       | "      | 1 9 A.M.    | Shara village                                        | 7            | 190.0             | 68.0    | 15,025 |  | Ditto. |
| 12                       | "               | "      | 4 3 P.M.    | Lamádong thanka                                      | 7            | 191.5             | 67.0    |                                      | 16,201 | Ditto. |
| 13                       | "               | "      | 6 7 A.M.    | Tashichirang village at bank<br>of Chonito Dong Lake | 7            | 188.5             | 48.0    | 14,558 |  | East wind. |
| 14                       | "               | "      | 12          | Tatupáni or Chajong                                  | 7            | 188.0             | 47.0    |                                      | 16,201 | Ditto. |
| 15                       | "               | "      | 14 11 A.M.  | Lagulung-La                                          | 7            | 186.0             | 44.0    | 14,558 |  | South wind. |
| 16                       | "               | "      | 15 4 P.M.   | Chota Tápu or Darcha village...                      | 7            | 189.0             | 64.0 |  |  | East wind. |

NOTE.—Lek signifies a pass.



*Observations of the Boiling Point taken in Nepal and Great Tibet by Explorer No. 9—(Continued).*

| No. of Observations. | Month and date. |                | Watch time. | Station.                                      | THERMOMETER. |        |      | Deducted Height above Sea in feet. | REMARKS.          |
|----------------------|-----------------|----------------|-------------|-----------------------------------------------|--------------|--------|------|------------------------------------|-------------------|
|                      | No.             | Boiling Point. |             |                                               | In Air.      |        |      |                                    |                   |
| 17                   | 1871            | September 19   | 11 A.M.     | Shigatze ... ..                               | 7            | 192.0  | 61.0 | 11,822                             | No wind.          |
| 18                   | "               | " 23           | 7 A.M.      | Ditto. ... ..                                 | 7            | 192.5  | 62.0 |                                    | East wind.        |
| 19                   | October         | 3              | 5 P.M.      | Shakia near Tachuk ... ..                     | 7            | 190.0  | 50.0 | 13,859                             | South wind.       |
| 20                   | "               | 4              | 7 A.M.      | Pil village ... ..                            | 7            | 191.0  | 49.5 | 13,259                             | Ditto.            |
| 21                   | "               | 9              | 6 A.M.      | Dingri maidán ... ..                          | 7            | 190.0  | 51.0 | 13,865                             | West wind.        |
| 22                   | "               | 10             | 8 A.M.      | Thung-lung-La ... ..                          | 7            | 182.0  | 30.0 | 18,460                             | South wind.       |
| 23                   | "               | 13             | 7 A.M.      | Nilam or Kuti ... ..                          | 7            | 190.0  | 57.0 | 13,911                             | Ditto.            |
| 24                   | "               | 15             | 5 P.M.      | Tata Bhansár ... ..                           | 7            | 205.25 | 66.0 | 5,002                              | No wind.          |
| 25                   | December 1872   | 7              | 8 A.M.      | Katmándu ... ..                               | 7            | 208.0  | ...  | ...                                |                   |
| 26                   | January         | 8              | 7 A.M.      | Tribeni bank of Sun-kosi and Tamba-kosi river | 7            | ...    | 50.0 | ...                                |                   |
| 27                   | "               | 9              | 6 A.M.      | Hilla Lek ... ..                              | 7            | 206.0  | 46.0 | 4,620                              | West wind.        |
| 28                   | "               | 11             | 10 A.M.     | Kanjia Lek ... ..                             | 7            | 206.0  | 46.0 | 4,620                              | Ditto.            |
| 29                   | "               | 17             | "           | Kumdia Lek ... ..                             | 7            | 203.0  | 43.0 | 6,302                              | No wind and rain. |
| 30                   | "               | 18             | 7 A.M.      | Lamkhu village... ..                          | 7            | 206.0  | 45.0 | 4,622                              | North wind.       |
| 31                   | "               | ...            | 2 P.M.      | Chakuwa Lek ... ..                            | 7            | 202.0  | 42.0 | 6,869                              | Ditto.            |
| 32                   | "               | 22             | 7 A.M.      | Amtia V. on bank of Arun river                | 7            | 211.0  | 54.0 | 1,798                              | East wind.        |

*Observations of the Boiling Point taken in Nepal and Great Tibet by Explorer No. 9—(Continued).*

| No. of Observation. | Month and date.     | Watch time. | Station.                          | THERMOMETER. |                |         | Deduced Height above sea level. | REMARKS. |
|---------------------|---------------------|-------------|-----------------------------------|--------------|----------------|---------|---------------------------------|----------|
|                     |                     |             |                                   | No.          | Boiling Point. | In Air. |                                 |          |
| 33                  | 1872.<br>January 26 | 0 P.M.      | Chuwa Lek ... ..                  | 7            | °              | °       | Data incomplete.                |          |
| 34                  | " 28                | 7 A.M.      | Sudab village ... ..              | 7            | 208° 0         | 50° 0   | South wind.                     |          |
| 35                  | February 1          | 9 A.M.      | Dhankuta bazar ... ..             | 7            | 209° 0         | 52° 0   | Ditto.                          |          |
| 36                  | " 3                 | 7 A.M.      | Barah chetr ... ..                | 7            | ...            | 55° 0   | West wind.                      |          |
| 37                  | " 7                 | 7 P.M.      | Naria bazar ... ..                | 7            | ...            | 55° 0   | South wind.                     |          |
| 38                  | June 19             | 0 P.M.      | Masuri G. T. Survey office ... .. | 7            | 201.75         | 75° 0   |                                 |          |
| 39                  | August 12           | 11½ A.M.    | Ditto. ... ..                     | 7            | 202.00         | 70° 5   | Mean of six. Cloudy and calm.   |          |

NOTE.—The preceding heights above sea level are computed differentially from height of Masuri observatory taken at 6937 feet to which the observer's boiling point 201.83° and temperature 72.75° have been assumed as corresponding.

## Route Survey from Dárjiling (Thánah) to Shigatze (Market Place).

| No. of Station. | Name of Station. | Bearing to forward station. | Distance in paces to forward station. | REMARKS.                                           |
|-----------------|------------------|-----------------------------|---------------------------------------|----------------------------------------------------|
|                 |                  | ° ' "                       |                                       |                                                    |
| 1               | Dárjiling        | .. 294 30                   | 13963                                 |                                                    |
| 2               | ..               | .. 275 30                   | 4152                                  |                                                    |
| 3               | Kainchalia       | .. 334 30                   | 7279                                  | Thánah.                                            |
| 4               | ..               | .. 285 0                    | 2350                                  |                                                    |
| 5               | Hamaphong        | .. 281 30                   | 10340                                 | Village.                                           |
| 6               | ..               | .. 292 0                    | 15100                                 |                                                    |
| 7               | Phalialung Lek   | .. 274 0                    | 2871                                  |                                                    |
| 8               | ..               | .. 240 0                    | 8100                                  | On boundary between British and Nepal Territories. |
| 9               | ..               | .. 285 0                    | 13010                                 |                                                    |
| 10              | Nablang          | .. 297 0                    | 9580                                  | Village.                                           |
| 11              | Suriabhanjan     | .. 320 30                   | 5425                                  | Hill.                                              |
| 12              | Suria Lek        | .. 299 0                    | 7085                                  | "                                                  |
| 13              | Shikárpur        | .. 290 30                   | 15140                                 | Village.                                           |
| 14              | Kabiri           | .. 340 0                    | 4566                                  | Stream.                                            |
| 15              | Phuwa Village    | .. 311 0                    | 13850                                 | 200 yards from.                                    |
| 16              | Taplang Jong     | .. 17 30                    | 16807                                 | Village.                                           |
| 17              | ..               | .. 42 0                     | 6608                                  |                                                    |
| 18              | ..               | .. 66 30                    | 3859                                  |                                                    |
| 19              | Tabkia Thok      | .. 35 0                     | 11150                                 | Village.                                           |
| 20              | ..               | .. 66 0                     | 17097                                 |                                                    |
| 21              | Ebangkhola       | .. 301 0                    | 7270                                  | Stream.                                            |
| 22              | Tamburu          | .. 11 0                     | 8511                                  | River, on bank of.                                 |
| 23              | ..               | .. 18 30                    | 11800                                 |                                                    |
| 24              | ..               | .. 320 0                    | 8010                                  |                                                    |
| 25              | ..               | .. 335 0                    | 18001                                 |                                                    |
| 26              | ..               | .. 360 0                    | 5938                                  |                                                    |
| 27              | Tashirak Chu     | .. 21 0                     | 10200                                 | Stream, on left bank of.                           |
| 28              | ..               | .. 345 0                    | 12100                                 |                                                    |
| 29              | Nila-La          | .. 20 0                     | 9910                                  | Hill, on top of.                                   |
| 30              | Shara            | .. 40 30                    | 34030                                 | Village.                                           |
| 31              | ..               | .. 90 0                     | 4700                                  |                                                    |
| 32              | ..               | .. 65 30                    | 28530                                 |                                                    |
| 33              | Tashichirang     | .. 270 0                    | 2288                                  | Village.                                           |
| 34              | Chomto Dong      | .. 22 30                    | 2500                                  | Lake, on bank of.                                  |
| 35              | ..               | .. 67 0                     | 21225                                 |                                                    |
| 36              | Nangji           | .. 358 0                    | 6065                                  | Village.                                           |
| 37              | Chajong          | .. 67 30                    | 5450                                  | " Latitude observed.                               |
| 38              | Tinki-La         | .. 75 0                     | 6684                                  | Hill, on top of.                                   |
| 39              | ..               | .. 35 0                     | 20104                                 |                                                    |
| 40              | Lagulung-La      | .. 345 0                    | 11670                                 | Hill. Boundary of Sikkim & Lhása.                  |
| 41              | ..               | .. 16 30                    | 18194                                 |                                                    |
| 42              | Ruksum           | .. 0 0                      | 8955                                  | Stream, on bank of.                                |
| 43              | ..               | .. 53 0                     | 7715                                  |                                                    |
| 44              | Chota Tápu       | .. 26 0                     | 8010                                  | Village. Latitude observed.                        |
| 45              | Gyaling-La       | .. 67 30                    | 5000                                  | Hill, on top of.                                   |
| 46              | ..               | .. 25 30                    | 6393                                  |                                                    |
| 47              | ..               | .. 35 30                    | 9600                                  |                                                    |
| 48              | ..               | .. 30 0                     | 16896                                 |                                                    |
| 49              | ..               | .. 33 30                    | 12000                                 |                                                    |
| 50              | Shigatze         | .. ..                       | ....                                  | City. The Market place. Latitude observed.         |

## From Changma (Village near Shigatze) to Katmandu.

| No. of Station. | Name of Station. | Bearing to forward station. | Distance in paces to forward station. | REMARKS.                                                                                          |
|-----------------|------------------|-----------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------|
|                 |                  | o /                         |                                       |                                                                                                   |
| 1               | Changma ..       | 250 30                      | 14765                                 | Village—10996 paces from station No. 48 on the line from No. 48 to No. 49 of foregoing Numbering. |
| 2               | .. ..            | 252 30                      | 10850                                 |                                                                                                   |
| 3               | .. ..            | 235 0                       | 4300                                  |                                                                                                   |
| 4               | Nangla ..        | 225 0                       | 15125                                 | Hill, on top of.                                                                                  |
| 5               | Sab-Chu ..       | 280 0                       | 1280                                  | River, on right bank of.                                                                          |
| 6               | Lingbochen ..    | 175 0                       | 6800                                  | Temple.                                                                                           |
| 7               | Puksum ..        | 235 0                       | 11383                                 | Stream, on bank of.                                                                               |
| 8               | .. ..            | 212 0                       | 12095                                 |                                                                                                   |
| 9               | Chong-La ..      | 266 0                       | 13790                                 | Hill.                                                                                             |
| 10              | .. ..            | 200 0                       | 2500                                  |                                                                                                   |
| 11              | Ata-La ..        | 270 30                      | 11350                                 | Hill.                                                                                             |
| 12              | .. ..            | 194 30                      | 6500                                  |                                                                                                   |
| 13              | .. ..            | 224 30                      | 7500                                  |                                                                                                   |
| 14              | Dongo-La ..      | 212 0                       | 11100                                 | Hill.                                                                                             |
| 15              | Sinas-Chu ..     | 183 30                      | 19880                                 | Stream, on bank of.                                                                               |
| 16              | Pil village ..   | 206 0                       | 13300                                 | Latitude observed.                                                                                |
| 17              | .. ..            | 230 0                       | 9118                                  |                                                                                                   |
| 18              | .. ..            | 215 30                      | 14712                                 |                                                                                                   |
| 19              | .. ..            | 280 0                       | 13000                                 |                                                                                                   |
| 20              | Chaiokor ..      | 295 30                      | 30760                                 | Village.                                                                                          |
| 21              | Phungtu ..       | 267 0                       | 7600                                  | River, on bank of.                                                                                |
| 22              | Ditto ..         | 275 0                       | 6500                                  | Do.                                                                                               |
| 23              | Ditto ..         | 270 0                       | 10294                                 | Do.                                                                                               |
| 24              | .. ..            | 250 0                       | 9690                                  |                                                                                                   |
| 25              | .. ..            | 265 0                       | 17400                                 |                                                                                                   |
| 26              | Chakor ..        | 260 30                      | 25100                                 | Village.                                                                                          |
| 27              | .. ..            | 279 30                      | 11235                                 |                                                                                                   |
| 28              | Dingri Jong ..   | 232 0                       | 32016                                 | Town, at entrance to. Latitude observed.                                                          |
| 29              | .. ..            | 294 0                       | 6500                                  |                                                                                                   |
| 30              | Thungla ..       | 269 30                      | 17181                                 | Hill.                                                                                             |
| 31              | .. ..            | 225 0                       | 8500                                  |                                                                                                   |
| 32              | .. ..            | 204 0                       | 7870                                  |                                                                                                   |
| 33              | Palgu ..         | 235 30                      | 4050                                  | Stream, on bank of.                                                                               |
| 34              | .. ..            | 205 0                       | 5820                                  |                                                                                                   |
| 35              | Thakialing ..    | 195 30                      | 21921                                 | Village.                                                                                          |
| 36              | Nilam Jong ..    | 210 0                       | 4800                                  | Do. Latitude observed.                                                                            |
| 37              | Kosi River ..    | 135 0                       | 5170                                  | On right bank of.                                                                                 |
| 38              | Ditto ..         | 190 30                      | 3200                                  | Do.                                                                                               |
| 39              | Ditto ..         | 176 0                       | 3540                                  | On Bridge.                                                                                        |
| 40              | Choksum ..       | 184 30                      | 2870                                  | Village.                                                                                          |
| 41              | .. ..            | 195 30                      | 12197                                 |                                                                                                   |
| 42              | .. ..            | 152 0                       | 2775                                  |                                                                                                   |
| 43              | .. ..            | 209 0                       | 13017                                 |                                                                                                   |
| 44              | .. ..            | 207 0                       | 4045                                  |                                                                                                   |
| 45              | .. ..            | 215 0                       | 6182                                  |                                                                                                   |
| 46              | Kanglank ..      | 230 0                       | 3800                                  | Hill, on top of.                                                                                  |
| 47              | Listi ..         | 252 0                       | 3325                                  | Do.                                                                                               |
| 48              | Listi Village .. | 190 30                      | 8725                                  |                                                                                                   |
| 49              | .. ..            | 215 0                       | 2600                                  |                                                                                                   |
| 50              | Bisinkhar Lek .. | 255 30                      | 4942                                  |                                                                                                   |

*From Changma (Village near Shigatze) to Katmánda—(Continued).*

| No. of Station. | Name of Station. | Bearing to forward station. | Distance in paces to forward station. | REMARKS.                         |
|-----------------|------------------|-----------------------------|---------------------------------------|----------------------------------|
|                 |                  | ° ' "                       |                                       |                                  |
| 51              | ..               | 240 30                      | 5480                                  |                                  |
| 52              | Bulefi           | 200 0                       | 5470                                  | Stream, on bank of.              |
| 53              | ..               | 248 30                      | 3210                                  |                                  |
| 54              | Banspati         | 241 30                      | 3600                                  | Village.                         |
| 55              | Choutra          | 228 30                      | 3425                                  | Do.                              |
| 56              | ..               | 231 30                      | 5900                                  |                                  |
| 57              | Ghetar           | 271 30                      | 3360                                  | Village.                         |
| 58              | Sipa             | 241 30                      | 4065                                  | Do.                              |
| 59              | Jherkola         | 260 30                      | 3826                                  | Stream, on bank of.              |
| 60              | Dhankola         | 271 30                      | 7100                                  | Do.                              |
| 61              | ..               | 251 0                       | 9310                                  |                                  |
| 62              | Chantaria Lek    | 226 0                       | 2300                                  | Hill, on top of.                 |
| 63              | ..               | 221 30                      | 3890                                  |                                  |
| 64              | ..               | 270 0                       | 5635                                  |                                  |
| 65              | Kalitar          | 252 30                      | 8210                                  | Village.                         |
| 66              | Chabeli          | 225 0                       | 6170                                  | Do.                              |
| 67              | Katmánda         | ..                          |                                       | At Indar Chaok (centre of city.) |

*From Katmánda (Asan Tol) to Taplang Jong (Station No. 16 of Route from Dárjiling to Shigatze).*

|    |                 |    |        |      |                                                                           |
|----|-----------------|----|--------|------|---------------------------------------------------------------------------|
| 1  | Katmánda        | .. | 112 0  | 7575 | Asan Tol. Latitude observed on this line, 1025 paces from starting point. |
| 2  | Dimi Village    | .. | 110 0  | 2250 |                                                                           |
| 3  | ..              | .. | 106 0  | 3710 |                                                                           |
| 4  | ..              | .. | 115 0  | 6300 |                                                                           |
| 5  | Bist Village    | .. | 109 0  | 2335 |                                                                           |
| 6  | Burapa "        | .. | 129 0  | 4060 |                                                                           |
| 7  | ..              | .. | 113 30 | 5660 |                                                                           |
| 8  | Nabna Lek       | .. | 126 30 | 4700 |                                                                           |
| 9  | Dabchia Village | .. | 122 0  | 3230 |                                                                           |
| 10 | ..              | .. | 118 30 | 4850 |                                                                           |
| 11 | ..              | .. | 66 30  | 2500 |                                                                           |
| 12 | ..              | .. | 123 30 | 4415 |                                                                           |
| 13 | ..              | .. | 135 30 | 6825 |                                                                           |
| 14 | ..              | .. | 112 0  | 5200 |                                                                           |
| 15 | ..              | .. | 110 0  | 4910 |                                                                           |
| 16 | ..              | .. | 127 0  | 7800 |                                                                           |
| 17 | Jhangajholi     | .. | 105 0  | 4786 | Village.                                                                  |
| 18 | Mulkotar        | .. | 127 30 | 6400 | Do.                                                                       |
| 19 | ..              | .. | 74 0   | 2415 |                                                                           |
| 20 | ..              | .. | 144 0  | 5500 |                                                                           |
| 21 | Tribeni         | .. | 92 0   | 7200 | Junction of two streams.                                                  |
| 22 | Bedana          | .. | 110 0  | 3950 | Village.                                                                  |
| 23 | ..              | .. | 100 0  | 5700 |                                                                           |
| 24 | Hilia Village   | .. | 32 0   | 3000 |                                                                           |
| 25 | ..              | .. | 35 0   | 3500 |                                                                           |
| 26 | ..              | .. | 112 0  | 2000 |                                                                           |
| 27 | ..              | .. | 60 0   | 1900 |                                                                           |
| 28 | ..              | .. | 93 0   | 4000 |                                                                           |

*From Katmánda (Asan Tol) to Taplang Jong (Station No. 16 of Route from Dárjiling to Shigatze.)*

| No. of Station. | Name of Station. | Bearing to forward station. | Distance in paces to forward station. | REMARKS.                                                                                      |
|-----------------|------------------|-----------------------------|---------------------------------------|-----------------------------------------------------------------------------------------------|
|                 |                  | o'                          |                                       |                                                                                               |
| 29              | ..               | 103 o                       | 6190                                  |                                                                                               |
| 30              | Kuwapáni         | .. 72 o                     | 4770                                  | Village.                                                                                      |
| 31              | ..               | .. 122 30                   | 4500                                  |                                                                                               |
| 32              | ..               | .. 149 30                   | 3900                                  |                                                                                               |
| 33              | ..               | .. 107 o                    | 11000                                 |                                                                                               |
| 34              | Kanjia Lek       | .. 60 o                     | 6400                                  |                                                                                               |
| 35              | Kanjia Village   | .. 87 o                     | 6615                                  |                                                                                               |
| 36              | Bungnang         | .. 95 o                     | 3400                                  |                                                                                               |
| 37              | Gahatiatar       | .. 42 30                    | 2200                                  | Village.                                                                                      |
| 38              | ..               | .. 126 30                   | 3715                                  |                                                                                               |
| 39              | ..               | .. 95 o                     | 10146                                 |                                                                                               |
| 40              | Charkhu          | .. 74 30                    | 5870                                  | Village.                                                                                      |
| 41              | ..               | .. 117 30                   | 5481                                  |                                                                                               |
| 42              | Dudh-kosi        | .. 55 o                     | 6225                                  | River, on bank of.                                                                            |
| 43              | Rakola Pasal     | .. 120 o                    | 9680                                  | Shop.                                                                                         |
| 44              | Kumdia Lek       | .. 45 o                     | 4726                                  |                                                                                               |
| 45              | Do.              | .. 117 o                    | 6500                                  |                                                                                               |
| 46              | Nerpa Village    | .. 136 30                   | 5790                                  |                                                                                               |
| 47              | Dorpa „          | .. 85 30                    | 8500                                  | Latitude observed at Lamádong Village 5600 paces from Dorpa on line from Dorpa to Station 48. |
| 48              | Lamakhu          | .. 100 o                    | 7025                                  | Village.                                                                                      |
| 49              | Chakuwa Lek      | .. 77 30                    | 5900                                  | Hill.                                                                                         |
| 50              | Dilpa Village    | .. 61 30                    | 4400                                  |                                                                                               |
| 51              | ..               | .. 140 30                   | 10780                                 |                                                                                               |
| 52              | Bhojpur Village  | .. 82 o                     | 6597                                  |                                                                                               |
| 53              | ..               | .. 37 o                     | 4600                                  |                                                                                               |
| 54              | ..               | .. 40 30                    | 5210                                  |                                                                                               |
| 55              | Soria Village    | .. 57 30                    | 5425                                  |                                                                                               |
| 56              | ..               | .. 48 o                     | 4600                                  | Latitude observed on line 56 to 57 at Village Amtia, 2500 paces from station 56 towards 57.   |
| 57              | Arun River       | .. 74 o                     | 7290                                  | On bank of.                                                                                   |
| 58              | Chainpur Lek     | .. 55 o                     | 5700                                  | Hill.                                                                                         |
| 59              | Do. Village      | .. 77 30                    | 8590                                  |                                                                                               |
| 60              | ..               | .. 92 o                     | 10610                                 |                                                                                               |
| 61              | Nundhakia        | .. 65 30                    | 6400                                  | Pati. Small Bazar and Dharmasála.                                                             |
| 62              | ..               | .. 110 o                    | 4200                                  |                                                                                               |
| 63              | Milkia Lek       | .. 87 30                    | 4410                                  |                                                                                               |
| 64              | Do.              | .. 70 o                     | 8625                                  |                                                                                               |
| 65              | ..               | .. 62 30                    | 13645                                 |                                                                                               |
| 66              | Taplang Jong     | ..                          |                                       | Same as Station No. 16 of Route from Dárjiling to Shigatze.                                   |

*From Kabiri, Dharmśāla (Station No. 14 of Route from Dārjiling to Shigatze)  
to Naria Bazar (Kotwāli).*

| No. of Station. | Name of Station.   | Bearing to forward Station. | Distance in paces to forward station. | REMARKS.                          |
|-----------------|--------------------|-----------------------------|---------------------------------------|-----------------------------------|
|                 |                    | o /                         |                                       |                                   |
| 1               | Kabiri ..          | 125 o                       | 3900                                  |                                   |
| 2               | Tamru River ..     | 199 30                      | 7310                                  | On left bank of.                  |
| 3               | Chua Pahār ..      | 267 30                      | 7600                                  |                                   |
| 4               | Sambua ..          | 210 30                      | 5300                                  | Village.                          |
| 5               | Tukma ..           | 135 o                       | 2700                                  | Hill.                             |
| 6               | Do. ..             | 216 o                       | 7520                                  |                                   |
| 7               | Majhwa ..          | 210 o                       | 4525                                  |                                   |
| 8               | .. ..              | 201 o                       | 9470                                  |                                   |
| 9               | Kalamati ..        | 225 o                       | 4597                                  | Hill.                             |
| 10              | .. ..              | 172 o                       | 2000                                  |                                   |
| 11              | Sudab Hill ..      | 225 o                       | 3370                                  |                                   |
| 12              | Do. ..             | 241 o                       | 3800                                  |                                   |
| 13              | Telia khola ..     | 201 30                      | 7820                                  | Stream.                           |
| 14              | Hamjung Hill ..    | 249 30                      | 8315                                  |                                   |
| 15              | Dhankuta ..        | 187 o                       | 6660                                  | Bazar, Latitude observed.         |
| 16              | .. ..              | 246 o                       | 5670                                  |                                   |
| 17              | Tamru River ..     | 211 o                       | 8860                                  | On bank of.                       |
| 18              | .. ..              | 241 30                      | 4370                                  |                                   |
| 19              | Dhārapāni ..       | 272 o                       | 6040                                  | Village.                          |
| 20              | Barah Chetr ..     | 191 o                       | 8466                                  | Worshipping place.                |
| 21              | Chatria ..         | 215 o                       | 23400                                 | Thānah.                           |
| 22              | Megjin ..          | 177 o                       | 23300                                 | Ka Thāuah.                        |
| 23              | Chapri Village ..  | 275 o                       | 4100                                  |                                   |
| 24              | .. ..              | 206 30                      | 11476                                 |                                   |
| 25              | Kotia Village ..   | 220 30                      | 8170                                  |                                   |
| 26              | Thakia Village ..  | 261 o                       | 5210                                  |                                   |
| 27              | Sikrata „ ..       | 251 o                       | 5676                                  |                                   |
| 28              | .. ..              | 272 o                       | 10085                                 |                                   |
| 29              | Dhānsia Village .. | 267 o                       | 6650                                  |                                   |
| 30              | Arāha „ ..         | 251 o                       | 4270                                  |                                   |
| 31              | Naria „ ..         | ..                          | ..                                    | Bazar, Thānah. Latitude observed. |

**GENERAL REPORT**  
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1871-72,

Prepared for submission to the Government of India.

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BY  
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