GENERAL REPORT

ON THE

GREAT TRIGONOMETRICAL SURVEY OF INDIA,

AND THE

TOPOGRAPHICAL SURVEYS

OF THE

BENGAL PRESIDENCY,

FOR

1864-65.

BY

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AND OFFICIATING SURVEYOR GENERAL.

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GREAT TRIGONOMETRICAL SURVEY OF INDIA.

Introductory.

(47.) As this branch of the Survey Department has been recently transferred from the Military to the Home Department of the Government of India, it may be considered desirable that, in the present report, my first to the Home Department, I should give a brief sketch of the Rise, Progress, and Future Operations of the Great Trigonometrical Survey.

The origin of the Trigonometrical Survey.

(48.) In the year 1800, it was generally surmised that the Maps of the Southern portion of the Madras Presidency, which had been constructed during the course of the preceding century, were exceedingly erroneous; they had been based, to a considerable extent, on Astronomical observations, which had been taken at some of the most important places in the Presidency, to define their positions. On the termination of the War with Tippoo, Captain Lambton made a proposal to throw a Series of triangles across the Peninsula, from Madras to the opposite Coast, for the purpose of determining its breadth with accuracy. His suggestions were approved of, and he was directed to carry them out in person; his operations detected an error of no less than 40 miles in the breadth of the Peninsula, as previously laid down by Astronomical observations; all the principal places on the old maps which had been similarly fixed, were found to be considerably out of position; for instance, Arcot was out 10 miles, and Hyderabad no less than 11 minutes in latitude by 32 minutes in longitude.

Astronomical observations, unassisted by triangulation, are not sufficiently accurate as a basis for the juxtaposition of Topographical maps.

(49.) This will not be thought at all surprising, when it is considered, that to obtain accurate results from Astronomical observations, it is necessary to employ very first-rate instruments, and that even with such instruments the results will be unreliable, unless the positions of the heavenly bodies, which are observed, are known with accuracy. The Astronomical Instruments which were constructed in the 18th century were incomparably inferior to those of the present day, and the tables for predicting the places of the heavenly bodies, though fairly accurate for the Stars, were exceedingly inaccurate and unreliable for the Moon. With good instruments, latitudes might have been determined, with very tolerable approximation, but longitudes, not within several miles of the truth; for the latter element, an accurate knowledge of the Moon's movements is indipensably necessary, and very minute errors, either of observation, or of tabular place, may cause very large errors in the results. Even at the present day, with superior Instruments, and greatly improved tables, it would be scarcely possible to ascertain the longitude of any place, by purely Astronomical observations, within a mile of the truth, and only then if the observations were carried over a period of several weeks, if not months. Besides which, modern improvements, in instruments and methods of observation, have brought to light the presence of a disturbing element of almost universal existence, in the deflection of the plumb-line from the true perpendicular to the Earth's surface. The amount and direction of this displacement of the plumb-line cannot be measured at all, at any one place, and can only be approximately ascertained by comparing the Astronomical with the triangulated positions of a variety of places on the Earth's surface. Some idea of the influence it exerts may be derived

from the latest results of the Ordnance Survey, in which it is demonstrated that the probable effect of local attraction upon an observed latitude, is ± 1·75 seconds. If to this is added the probable effect of errors of observation and of the Star's tabulated places, the total uncertainty in the resulting value of the latitude, will not be much less than ± 2 seconds, which is equivalent to ± 200 feet.

Captain Clarke's account of the Principal Triangulation of the Ordnance Survey of Great Britain and Ireland, page 771.

(50.) If these large errors in latitude, and much larger in longitude, are contrasted with the small errors, even of the Topo-triangulation, which are given in the table appended to para. 7 of this report, and if further it is borne in mind that, great as is the superiority of Triangulation to Astronomical operations, as a basis for Topography, at the present time, it was considerably greater at the time when Colonel Lambton commenced his labors, the wisdom and utility of his suggestions will at once be apparent. Notwithstanding this, they at first encountered much opposition, and it was not until he had obtained the support of the Astronomer Royal of the day (the Rev. N. Maskelyne) that the Hon. the Court of Directors were convinced of the important practical utility of the work; but from that time they became its firm and powerful supporters.

Triangulation adopted as the basis of the Indian Survey.

(51.) The operations thus commenced were the nucleus of the Great Trigonometrical Survey of India. As they advanced, a desire was felt that, while affording a basis for future topographical operations, they should also be made to ascertain the lengths and amplitudes of Meridional Arcs in Indian latitudes, to combine with similar measures in European latitudes, for the determination of the figure of the Earth. This question then excited great interest, Geodetical operations having very recently been set on foot by all the great European nations; special expeditions were fitted out and despatched to remote parts of the globe, in order that the requisite measures might not be restricted to Europe only. Colonel Lambton's triangulation presented an admirable opportunity of obtaining, for the Savans of Europe, information which they would consider of the greatest value, and were eagerly searching for in other quarters. This could be accomplished without further trouble than selecting, from his net work of triangulation, certain Series of consecutive triangles, which trend in a meridional direction, without any break of continuity; computing their meridional lengths, from the existing data of the triangulation; and ascertaining their amplitudes, by taken Astronomical observations for latitude, at their extremities, and at certain intermediate stations. These operations were therefore set on foot; they furnished two Arcs, one near the meridian of Madras, of an amplitude of 1° 35′, extending from Trivandeporum to Pandree, the other near the meridian of Bangalore, of an amplitude of nearly 16°, extending from Cape Comorin, the southernmost point of the Peninsula, to Sironj in Central India, and forming a portion of what is generally known as the Great Arc of India.

Geodetical operations commenced, in conjunction with the Triangulation.

Commencement of the Great Arc of India.

(52.) On the death of Colonel Lambton, he was succeeded by Captain Everest, who, shortly afterwards, was permitted to proceed to England, where he was engaged for some years in superintending the construction of new instruments, Astronomical as well as Geodetical, with all the latest improvements, for the further operations of the Trigonometrical Survey. During his absence, the few Surveyors who then formed the establishment of this Department, were employed in carrying a longitudinal Series of triangles from Sironj to Calcutta. This Series is unfortunately

The Longitudinal Series from Sironj to Calcutta.

the least accurate portion of the Great Triangulation; executed under manifold difficulties, with very inferior instruments, it most inadequately fulfils the object for which it was intended, namely, to serve as the basis of the several Meridional Series between Sironj and Calcutta, the Himalaya Mountains and the East Coast of the Madras Presidency. There is therefore much reason to regret that the Surveyors were not employed, instead, in executing one or more of the Meridional Series, which are simply based on, and are not needed as the basis of, other Series, and which, even with the inferior instruments at their disposal, they might have completed, with all the accuracy desirable for future Topographical requirements.

Extension of the Great Arc to the Himalayas, and revision of the section between Sironj and Beder.

(53.) On Colonel Everest's return to India, his attention was first directed to the completion of the Great Arc, by its extension northwards, from Sironj to the Himalayas. It was also found necessary to revise the portion of Colonel Lambton's Arc, between Sironj and Beder, the amplitude of which is 6° 4′; for it must be remembered that Colonel Lambton's operations were originally intended as a basis for Topography only; the selection of a portion of his triangles for Geodetical purposes was an afterthought; consequently, these triangles were not measured originally with the exactitude which Geodesy requires, and which had been attained in the European Surveys. Proposals were made to the Hon. Court of Directors to revise the southern portion of Colonel Lambton's Arc, as well, but the Hon. Court considered that it was expedient to postpone this measure, until the triangulation had been extended over those portions of the Empire which had not yet been entered.*

Adoption of the gridiron system of meridional and longitudinal series of triangles, instead of the net-work system of triangulation.

(54.) Colonel Lambton's system of operations was to cast a net work of triangles over the whole face of the country; this was carried out over the greater portion of the Madras Presidency, and a part of the Bombay Presidency. But Colonel Everest was of opinion that such a measure was unnecessarily laborious, and that nothing more was requisite than to execute certain Meridional Series of triangles, at distances of about 1° apart, and to tie their extremities together by other Series, several degrees apart, following the parallels of Bombay and of Calcutta, and, on the north, the line of the British Frontier. This is termed the gridiron system of Triangulation, and is analagous to the method of the French and the Russian Surveys; in Great Britain and Ireland, and on several parts of the Continent, the net work system has been followed. Colonel Everest's opinion that the smaller amount of work required by the gridiron system would suffice as a basis for topography, has been amply verified by the results; they have furnished all the requisite data for the correction and juxtaposition of the maps, which have been constructed by detail Surveyors, whether of the Revenue, or Topographical Departments.

(55.) The gridiron system, commenced by Colonel Everest, was continued

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* At the request of the President and Council of the Royal Society, a Committee, composed of the following distinguished Fellows of the Royal Society:—Professor Airy (Astronomer Royal), Dr. Miller, and Professor Stokes, drew up a report on certain proposals regarding Colonel Lambton's Geodetical operations, which were made by Colonel Sir George Everest, C.B., in a letter dated 8th April, 1861. This report concludes with the following suggestions:—

"The committee think it right, however, to call the attention of the President and Council to the general quality of Colonel Lambton's Surveys, which, though executed with the greatest care and ability, were carried on under serious difficulties, and at a time when instrumental appliances were far less complete than at present. There is no doubt that at the present time the Surveys admit of being improved in every part. The standards of length are better ascertained than formerly, and all uncertainty on the unit of measure can be removed. The base measuring apparatus can be improved. The instruments for horizontal angles used by Colonel Lambton were inferior to those now in use, and one of them was most severely injured by an accidental blow, the result of which was more distinctly injurious because the circle was read by only two Microscopes. Allusion has already been made to the circumstances of observation affecting the altitude of stations. Though the Astronomical observations were probably good for their age, yet new observations, conducted with such instruments and on such principles as those adopted by Sir George Everest, would undoubtedly be better. The committee therefore express their strong hope that the whole of Colonel Lambton's Survey may be repeated with the best modern appliances. No Arc of Meridian yet measured has such claims on the attention of the patrons of science as the Indian Arc, from its proximately equatorial position, and from its anomalies and the reference of them to the attraction of the Himalaya Mountains."

by Colonel Waugh, under whose administration the greater portion of the area comprised between the meridian of Calcutta, on the East, and the Trans-Indus Frontier, on the west, the parallel of Calcutta, and the northern ranges of the Himalayas, was triangulated, at the intervals originally determined on. The greater portion of the Bombay Presidency was also triangulated. There is still a considerable gap between Ajmeer and Sind, over which it has not yet been practicable to carry the Principal Triangulation.

Topographical operations commenced in conjunction with the Great Triangulation.

(56.) In anticipation of the time when the operations of the Trigonometrical Survey will come to an end, Colonel Waugh took steps to train a number of the Members of this Department to execute Topographical Surveying, as well as Triangulation, in order that, on the completion of this Survey, their services might be available to the State, for filling in the details of some of the numerous districts, which, though triangulated, have not yet been Surveyed in detail. Thus, certain parties of this Survey, which are performing the duties of the Great Triangulation, are also employed in detail operations similar to those of the regular Topographical Parties. As Surveyor General, Colonel Waugh also supervised the Topographical Surveys, and, in his time, the two Departments were closely allied, transfers of Officers from the Trigonometrical to the Topographical branch of the Survey Department being of frequent occurrence.

No. $\frac{59}{344}$, dated 18th June, 1862.

Statement of the out-turn of work and cost of the Trigonometrical Survey, exclusive of Military Pay and allowances.

(57.) This will be an appropriate place for me to give a brief abstract of a report which I had the honor to submit to the Government of India in the Military Department, on the out-turn of work and the cost of the Trigonometrical Survey. In the first 49 years of its existence, viz., from 1800 to 1849, the area triangulated by the several field parties, amounted to 477,044 square miles, at a cost of Rs. 34,12,787, or Rs. 7-2-5 per square mile. In the following 12 years, the out-turn and cost of the work executed were as follows :—

Triangulation, 332,123 square miles, at a cost of Rs. 20,83,765, or Rs. 6-4-5 per square mile, inclusive of the expenditure incurred in measuring two base lines, whereby two parties were diverted for two field seasons from triangulation to operations of which the cost cannot be contrasted with that of the triangulation, and which, though indispensably necessary for verification, make no show, by increasing the area, and cheapening the cost per square mile.

Topography, in the Himalaya Mountains, on the geographical scale of four miles to the inch, 89,895 square miles, at a cost of Rs. 2,25,641, or Rs. 2-8-2 per square mile.

Spirit Leveling, 1,620 linear miles, at a cost of Rs. 52,254, or Rs. 32-4 per mile, of which the first 312 miles were equivalent to a treble line, having been executed by three independent Surveyors, the remaining 1,308 miles, were done as a double line, by two Surveyors; the cost has thus been equivalent to Rs. 14-11-5 per mile of single line.

The cost of the Survey inclusive of Military Pay and Allowances.

(58.) These returns are exclusive of the Military pay of the Military men employed in the several operations, as it is only of late years that the Indian Surveys have been debited with this charge. Such charges are known not to be debited against the English and the American Surveys, nor, it is believed, against any of those on the Continent. To ascertain their precise amount, in the first of the two above periods, would now

be impossible; but I have given details in the report from which the above figures have been taken, showing that the actual amount of the Military pay, drawn in the 12 years from 1849 to 1861, if included in the expenditure for that period, would increase the given rates by about 21 per cent.

Statement of the present, and Programme of the future operations of this Survey.

(59.) I proceed to indicate the present operations, and to give a programme of the future operations which will be required to complete the Trigonometrical Survey of India. I must premise that the accuracy of the detail Surveys, which are executed by Topographical and Revenue Surveyors, is now so much greater than it was when Colonel Everest drew up his design for the triangulation, that the distances between the Meridional Series of triangles may in future be made twice as great as it has been hitherto, and thus the amount of work will be considerably reduced. The several Series, which are in progress, and which will be needed, are clearly exhibited in the following tabular statement, which will be readily understood with the aid of the published charts of the Triangulation :—

Meridian.	Districts.	Limiting Parallels. South.	Limiting Parallels. North.	Remarks.
	Meridional Series.	°	°	
69¼°	Eastern Sind, ...	25	28	Not commenced.
71¼°	Rajpootana, ...	25	29	Do.
73¼°	Rajpootana, ...	25	30	Do.
75°	Ahmednuggur to Mangalore, ...	13	18	In progress, two-thirds completed.
80°	Jubbulpore to Madras and Ceylon, ...	9	24	In progress, one-fourth completed.
82°	Eastern divisions of Central Provinces, ...	17	24	Not commenced.
84°	Palamow and Sumbulpore to Calingapatam, ...	18	24	Commenced.
78°	Southern Section Great Arc, ...	8	18	Revision necessary, *vide* para. 53.
	Oblique Series.			
	Eastern Frontier. Assam to Tenasserim, ...	10	27	In progress, one-third completed.
Parallel.		Limiting Meridians. West.	Limiting Meridians. East.	
	Longitudinal Series.	°	°	
24°	Central India to Calcutta, ...	78	88½	Revisionary; *vide* para. 52, two-thirds completed.
23°	Calcutta to Eastern Frontier, ...	88½	91	Nearly finished.
18°	Beder to Vizagapatam, ...	78	83	Not commenced.
9°	Madras to Mangalore, ...	75	80	One-half completed.
	Oblique Series.			
	Assam, ...	92	96	

The future base lines of verification.

(60.) In connection with the above triangulation, verificatory base lines will have to be measured at Bangalore, at Cape Comorin, in Rangoon, and in Tenasserim, with Colby's compensating apparatus, which was brought out to India by Colonel Everest. These base lines are so laborious, and take up so much time, that the number has been fixed at about one-half of what would be considered necessary, for a similar extent of triangulation, in European Surveys.

(61.) The total amount of work remaining to be executed, at the present time, is about 61 degrees of Meridional and 17 of Longitudinal triangulation, in all about 78 degrees, which may be expected to be completed in 13 years, as the average annual out-turn of work of this description at present exceeds 6 degrees; adding one more year for the four base lines, the whole of the field work may be expected to be finished in 14 years.

14 years will probably suffice to complete the triangulation and the base lines.

(62.) The future Topographical operations of this Department will embrace the Provinces of Kattiawar, Kutch, and other districts in the northern portion of the Bombay Presidency, which have not hitherto been Surveyed Topographically. The districts of Kumaon and Gurhwal have also to be Surveyed in detail; we shall then possess a complete Survey of the Himalayas, from the frontiers of Nepaul on the east, to the Indus on the west, and extending as far into Central Asia as Europeans can penetrate with safety. It is much to be desired that the Nepaulese Government should be induced to follow the example of all the Native States under British protection, and allow the Survey operations to be carried over their territories, of which little more is known at present, than of the unexplored regions in the hearts of Africa and Central Asia.

The future Topographical operations.

(63.) The future spirit-leveling operations will consist in the connection of the various lines of levels which have been executed for Canal and Railway operations, with the view to their reduction to a common datum. The main line of levels, on which all others will be based, has already been carried from the mean sea level of Karachi harbour through Sind, the Punjab, North-West Provinces and Bengal, to Calcutta, with a branch to Central India. Sufficient data does not at present exist for ascertaining the extent to which future operations will be necessary, for the connection of all the several valuable lines of levels, which have been executed in different parts of India, the utility of which will be greatly enhanced, when they have been reduced to a common datum.

The future spirit leveling operations.

(64.) The preceding programme embraces all the more purely practical work that is required to be executed. But this Survey would not be considered complete, unless, following the example of all the European Surveys, it also furnished a certain number of Astronomical Observations, to combine with the triangulation, for Geodetical purposes. These will consist of absolute determinations of Latitude at Stations situated about 1° apart, on the best Meridional Series of triangles, and differential determinations of Longitude, with the aid of the Electric Telegraph, at points whose distances apart must be regulated by the positions of the Telegraph Stations. The Latitude observations are now in progress, at a rate which will ensure their completion *pari passu* with the triangulation; but the Longitude Observations cannot be commenced until the arrival of the necessary instruments, which are at present being constructed for them, under the orders of the Secretary of State for India. It is in contemplation to carry the Longitude Observations along the Persian line of Telegraph, until they are connected with similar operations which are being executed by Officers of the Russian Survey, on certain of the European lines of Telegraph; for this purpose instruments of a lighter class than the former, and better adapted for transport through Persia, are under construction. Another operation of a scientific nature is now in progress, and may be expected to be completed in four or five years, viz., the determination of the number of vibrations of a pendulum at different points

The future Geodetical operations.

along the Great Arc, for ascertaining the ratio of the Earth's axes, in compliance with a proposal which recently emanated from the President and Council of the Royal Society, and met with the assent of the Secretary of State for India.

(65.) I now proceed to report on the operations of this Department in the year 1864-65. It was administered by Lieutenant-Colonel Robinson, R.E., from the 9th November, 1863, to the 29th January, 1865, during my absence from India, on furlough to Europe.

(66.) The various operations may be classified as follows:—

Classification of the several operations of this Survey.

I. *Trigonometrical;* carrying a Longitudinal Series of triangles between Calcutta and the Eastern Frontier.

II. *Trigonometrical;* carrying a Series of triangles along the Eastern Frontier, from the southern border of Tipperah to the south of Chittagong.

III. *Trigonometrical;* revising the Calcutta Longitudinal Series of triangles, and commencing the northern section of the Meridional Series, which will connect Jubbulpore with Madras.

IV. *Trigonometrical;* revising the portion of the Calcutta Longitudinal Series of triangles, lying between the Singrowli District and the meridian of Jubbulpore.

V. *Trigonometrical;* carrying a Meridional Series of triangles from the neighbourhood of Nellore to Madras, in completion of the southern section of the Series which will connect Madras with Jubbulpore.

VI. *Trigonometrical;* carrying a Series of triangles on the meridian of Mangalore, from a point a little north of Indapoor, to the borders of the Belgaum Collectorate.

VII. *Trigo-Topographical;* completing the Geographical Survey of Ladak and Thibet, and commencing the triangulation and topography of Kumaon and Gurhwal.

VIII. *Trigo-Topographical;* triangulation and topography in the District of Nassick, Bombay Presidency.

IX. *Astronomical;* observing the Latitudes of certain stations on the Longitudinal Series between Calcutta and Karachi.

X. *Astronomical;* observing the Latitudes of certain stations on the Great Arc, between Dehra Doon and Cape Comorin.

XI. *Leveling;* carrying a line of levels from Agra to Mirzapore, in completion of the great line of levels extending from Karachi to Calcutta.

XII. *Pendulum;* in process of formation, on the suggestion of the Royal Society of London, to execute Pendulum observations at certain stations on the Great Arc.

XIII. Computing, Drawing, and Corresponding Offices.

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(67.) The out-turn of work during the year under review has been as follows:—Principal triangulation with the Great Theodolites, 24 to 36 inches in diameter, 22,200 square miles, completing 598 miles in length of the several series of triangles. Principal triangulation with Vernier theodolites, 14 inches in diameter, for the Topographical operations, 2,227 square miles. Secondary triangulation, 9,190 square miles. Topographical sketching in Ladak and the northern portions of the territories of the Maharajah of Kashmir, 8,300 square miles, on the scale of 4 miles to the inch. Owing to circumstances which will be hereafter explained, little or no Topography has been executed on the scale of one mile to the inch. Of Spirit Leveling, 422 linear miles have been completed.

Out-turn of work in 1864-65.

(68.) In the following Tabular Statement, this out-turn of work is contrasted with that of the two preceding years:—

Out-turn of 1864-65 contrasted with that of preceding years.

Year.	Areas in Square Miles.					Lengths in Linear Miles.	
	Principal Triangulation.		Secondary Triangulation with Theodolites of various sizes, both small and great.	Topography.		Of the Principal Triangulation.	Of the Spirit-Leveling.
	With the Great Theodolites.	With 14" Vernier Theodolites.		1 Mile = 1 Inch.	4 Miles = 1 Inch.		
1862-63, ...	10,954	...	18,139	...	10,400	490	242
1863-64, ...	13,952	901	11,481	333	7,530	504	360
1864-65, ...	22,200	2,227	9,190	45	8,300	598	422

It will be seen that there has been a great increase in the area and length of the principal triangulation, notwithstanding the circumstance, which will be subsequently explained, that one of the six Parties employed on the triangulation could not execute any final work, and was only able to perform the preliminary, known departmentally as "the approximate operations." The explanation of the apparent increase of work, is to be found in the circumstance that the ground over which the operations were carried, was entirely of a hilly nature, stations could therefore be readily established on the hill summits, so as to form large triangles, adapted for getting over the ground more quickly, and with greater accuracy, than if the number of intermediate links, in the chains of triangles, were multiplied. In the plains, on the other hand, it is essentially necessary to construct high tower stations, in almost every instance; their distance apart is regulated by the height to which it is possible to raise towers, constructed of the cheapest materials procurable, to overtop the earth's curvature, and thus become mutually visible. The most convenient distance has been practically ascertained to be from 11 to 12 miles, giving triangles of an area of 60 to 70 square miles; whereas the average area of the triangles, measured by Mr. Keelan, the Officer in Charge of No. IV Party, which has this year achieved the greatest area, exceeds 388 square miles. Such matters have to be borne in mind, in examining the statistical returns illustrative of the progress of the operations, which will otherwise be found to be very deceptive, in contrasting the work of the respective Survey Parties.

Explanation of apparent increase of work.

(69.) The quality of the Principal triangulation executed during the year under review, with the Great Theodolites whose Azimuthal Circles are 24 to 36 inches in diameter, is tested by the probable errors of the observed angles, and by the triangular

Analysis of the quality of the triangulation.

errors. The nature of the "probable error" may be defined as being such, that the chances of the actual error exceeding or falling short thereof are equal. The probable errors are determined by a formula which takes into consideration the accidental errors of each single observation, and of the graduations of the circles on which the measures are made; in all 297 angles were measured, with an average probable error of ± 0″·25. The triangular error is the amount by which the sum of the observed values of the three angles of each triangle exceeds, or falls short of 180° + the spherical excess; 99 triangles were measured, with an average error of 0″·52. No data exist for contrasting the different values of common sides, as it is customary, before computing the sides, to apply small corrections to the observed angles of the several figures (Quadrilaterals, Polygons, &c.), which are formed by the triangles, in order that the angles may satisfy the Geometrical equations of condition, and the further condition that the sum of the products formed by multiplying the square of each correction by the theoretical weight of the angle to which it appertains, shall be a minimum; when these corrections have been applied to the angles, the values of the common sides are exactly coincident.

Party.	Angular probable errors.		Triangular errors.	
	Number.	Amount.	Number.	Amount.
II ...	63	± 0″·30	21	0″·48
III ...	69	0·19	23	0·43
IV ...	60	0·25	20	0·43
V ...	72	0·22	24	0·51
VI ...	33	0·31	11	0·98
Averages		± 0·25	...	0″·52

(70.) I now proceed to report on the general operations of the respective Parties. Further details will be found in Appendix B., which contains selections from the Annual Narrative Reports of the Executive Officers, and a valuable paper by Captain Godwin-Austen, giving descriptive and geological notes, on the Pangong Lake District of Ladak, from his journals in 1863, when he was employed on the Kashmir Survey.

EXECUTIVE OPERATIONS.

No. 1 PARTY—TRIGONOMETRICAL.

(71.) This Party was employed in carrying a longitudinal Series across the Districts of Jessore, Furreedpore, Dacca and Backergunge, from the Meridian of Calcutta, to the Eastern Frontier. A more difficult tract of country to triangulate over can scarcely be met with; perfectly level, and devoid of hills, covered with malarious swamps, and intersected by great rivers, whose banks are lined with very heavy forest and jungle, the Surveyor, who has to follow obligatory lines of operation, meets with hindrances and embarrassments at every step, and is often liable to have to re-model his programme of work, and alter what has already been done, in order to

The difficulties met with on the East Calcutta Longitudinal Series.

PERSONNEL.

Lieutenant H. R. Thuillier R.E., 1st Assistant.
Mr. E. C. Ryall, Civil 2nd Assistant.
„ G. A. Harris, Sub-Assistant 2nd Class.
„ W. J. O'Sullivan, Sub-Assistant 3rd Class.
„ J. Mendes, Sub-Assistant 3rd Class.

overcome new obstacles, and carry his triangles across the country, without any break of continuity. At each station, a Tower has to be built, with materials which have either to be brought from a distance, or fabricated on the spot. The climate is so moist that the bricks, which have invariably to be moulded at the Tower, take a long time to dry sufficiently before they can be burnt; and rain often falls to destroy them, and retard the progress of the operations. In every instance, the rays, or lines, have to be cleared of forest and jungle, as a preliminary to obtaining the requisite mutual visibility between the contiguous stations; one or more trial lines have also to be cut, in the process of selecting each station. The rivers, and their numerous channels, form the usual lines of communication, but for this purpose they are well nigh useless to Surveyors, whose lines cross them at right angles; there are few, if any, roads to facilitate communication. In such a country, the preliminary operations of selecting and building stations, and clearing the lines between them, are far the most difficult portion of the work. Lieutenant Thuillier, having to depute his Senior Assistant to execute certain triangulation, for the connection of Port Canning with Calcutta, was obliged to select all the stations in person, and ascertain their relative directions, leaving his Junior Assistants to build the Towers and clear the final lines. These duties occupied him during the whole season, and prevented him from undertaking any of the final angular measurements, on the amount of which, and the area they embrace, it is customary to reckon the annual out-turn of work. The actual operations consisted in the selection of 24 stations, involving 174 miles of trial lines, mostly through dense forest, the construction of 12 Towers, and the clearance of 314 miles of final lines.

Unsuccessful attempt to carry a series of triangles from Calcutta to Port Canning.

(72.) Mr. Ryall, the Senior Assistant attached to this Party, was deputed to carry a series of triangles from Calcutta to Port Canning, mainly with a view to ascertaining the difference of longitude between the two Ports, in order that, by the transmission of Electric Currents from the Observatory in the Surveyor General's Office at Calcutta, a time ball might be dropped at Port Canning, to give the local time there, for the convenience of the Captains of Ships visiting the Port. Owing to the numerous gardens of fruit trees, in the environs of Calcutta, it became necessary, either to open lines through the trees, or to construct lofty Towers to overtop them. The former plan, whenever practicable, is invariably adopted, being very much cheaper and more expeditious than the latter. Compensation for the damage that may be done is always paid when asked for; the operations have usually been clearly understood to be indispenable to the progress of the Survey, consequently their propriety has not been questioned, nor has opposition been offered. This is perhaps due in some measure to Act VI. of 1857, which, legalizing operations of a similar nature, when performed by Officers of other branches of the Public Service, has been supposed to afford similar protection to the Survey Officers. Unfortunately it does not do so, as was soon discovered by a few litigious persons, through whose gardens the lines had to be opened, who created so much opposition, that Mr. Ryall was obliged to spend the greater portion of the season in the Law Courts, in combating their proceedings, and in protecting himself and his Native subordinates, from the actions which were brought against them.

Necessity for legislation, for the protection of the Officers of this Department, when compelled to clear lines in the performance of their duties.

(73.) Having already submitted a full report on this subject, in my No. 11, dated 2nd March last, it is only necessary for me to state in this place that it appears to be indispensably necessary, in the interests of the Public Service, that the provisions of Act VI. of 1857 should be extended to Officers of the Survey Department, who will otherwise be liable to

encounter much opposition and delay; also that some rules should be laid down, to define the proper amount of compensation to be paid for trees, &c., which have to be removed in the course of the operations.

Want of a proper scale of compensation.

In the present instance, Mr. Ryall was unable, after five months incessant labour, to complete more than one-third of a series of triangles, the whole of which might, under ordinary circumstances, have been finished in three months. Moreover, in consequence of the fanciful scale of compensation which was drawn out by Deputy Magistrate Moulvie Dulleeloodin, who was deputed to make a special report on Mr. Ryall's operations, one of the claims for compensation still remains unadjusted, namely that of a man called Durga Pershad, whose original demand of Rs. 90 was raised to Rs. 5,750 on the publication of the Moulvie's report, in a supplement to the *Gazette of India*.

No. 2 PARTY—TRIGONOMETRICAL.

(74.) This Party was employed in carrying a Series of triangles along the Eastern Frontier, between the Meridians of 91° 35′ and 92° 22′, and the parallels of 22° 3′ and 23° 11′ from the southern border of Tipperah, to below Chittagong. This country is for the most part, especially in the Northern and Eastern Portions, similar to the wild tracts of Hill Tipperah, of which the physical geography, and the manners and customs of the inhabitants, have been already described in the reports of this Department for the years 1862-63 and 1863-64. The out-turn of final triangulation consisted of 21 Principal Triangles arranged in quadrilaterals and polygons for mutual verification; they embrace an area of 1,675 square miles, and stretch over a direct distance of about 80 miles; this portion of the work was executed by Mr. Lane, who also took a set of Star Observations, for the determination of an Azimuth of verification, and supervised the clearance of about 160 miles of road through the forests, for the passage of the Great Theodolite. The preliminary operations were carried 93 miles in advance by Mr. Rossenrode, who selected 18 sites for new stations, cleared 50 miles of lines, and built 22 Platform Stations.

The operations on the Eastern Frontier.

PERSONNEL.

Mr. C. Lane, Chief Civil Assistant.
„ W. C. Rossenrode, Civil Assistant.
„ H. Beverley, Civil 2nd Assistant.
„ W. C. Price, Sub-Asst. 3rd Class.

(75.) Much embarrassment was caused by rumours that the Kookie Chiefs had assembled their clans, and intended to commit a raid into the District where the Survey operations were in progress; fortunately no raid was perpetrated, but such rumours always have the effect of disturbing the minds of the inhabitants, causing them to desert their villages, and thus preventing them from aiding the Surveyors in the work of clearing the roads and lines. Fears have sometimes been felt for the safety of the Survey Parties, but the prudence and tact, displayed by Messrs. Lane and Rossenrode, have hitherto been instrumental in preventing any collisions, between the Survey Parties and the contiguous hill tribes.

Embarrassment caused by rumours of raids by hill tribes.

No. 3 PARTY—TRIGONOMETRICAL.

(76.) Mr. George Shelverton, the Officer in executive charge of this Party succeeded during the field season of 1863-64 in revising the portion between the meridians of 78° and 80° of the old Calcutta Longitudinal Series, the defects of which have already

The operations on the Jubbulpore Meridian.

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been indicated in para. 52 of this report. He was thus able to secure an accurate basis for the commencement of the Northern Section of the Jubbulpore Meridional Series, on which operation he and his Party were employed during the whole of the year under review. The out-turn of work of all descriptions, both final and approximate, has been most creditable, resulting in the measurement of 23 principal triangles, forming three hexagons and one pentagon, which cover an area of 5,167 square miles, and extend over a direct distance of 150 miles; azimuth observations were also taken at two of the principal stations; the approximate operations were carried 175 miles in advance, and 24 sites were selected for new stations; the further operations will be detailed in the tabular statement of out-turn of work, at the end of this report.

PERSONNEL.

Mr. George Shelverton, Civil Assistant.
„ A. W. Donnelly, Civil 2nd Assistant (Senior Grade).
„ M. C. Hickie, Civil 2nd Assistant (Junior Grade).
„ F. A. Bell, Sub-Assistant 1st Class.
„ L. J. Pocock, Sub-Assistant 3rd Class.

No. 4 PARTY—TRIGONOMETRICAL.

Revision of East Calcutta Longitudinal Series.

(77.) In order that this Party should be furnished with a basis of sufficient accuracy for the Triangulation of the Sumbhulpore Series, on the meridian of 84°, Mr. Keelan, the Executive Officer, was directed to revise the portion of the Calcutta Longitudinal Series, intervening between the meridian of 82° 40′, on which his operations of 1863-64 had terminated, and that of 80° 20′, up to which the revision had already been carried Eastwards, from the Great Arc, by Mr. Shelverton. Since much of the old work on this Series consisted of single triangles, Mr. Keelan was directed to introduce additional Stations, to form polygons, or other verificatory figures, inco mbination with the single triangles. The out-turn of work has been most satisfactory, and is exceedingly creditable to Mr. Keelan; it consists of 20 principal Triangles, arranged so as to form two double polygons, which cover an area of 7,765 square miles (of which 5,067 were old, and 2,698 new ground), and extend a direct distance of 168 miles. It is worthy of notice that though a period of nearly 40 years had elapsed since the former operations on this Series, the marks of all the old stations were found undisturbed.

PERSONNEL.

Mr. H. Keelan, 1st Assistant.
„ L. H. Clarke, Civil 2nd Assistant.
„ H. Peychers, Sub-Assistant 3rd Class.
„ J. F. Trotter, ditto, ditto.

No. 5 PARTY—TRIGONOMETRICAL.

Madras Meridional Series.

(78.) This Party was employed in the Districts between Nellore and Madras, on the Southern Section of the Meridional Series which will connect Jubbulpore with Madras, and be extended down to Ceylon. Its progress was rapid, and most satisfactory, until it reached the neighborhood of Madras, when similar difficulties were met with, to those which had baffled Mr. Ryall's operations in Calcutta, though, fortunately, in this case with the result of only retarding, and not stopping

PERSONNEL.

Captain Branfill, Bengal Cavalry, 1st Assistant.
Mr. F. Ryall, Sub-Assistant 1st Class.
„ J. W. Mitchell, Sub-Assistant 2nd Class.
„ J. R. L. O'Neill, Sub-Assistant 3rd Class.

the work. It was imperatively necessary that the triangulation should be connected with the Madras Observatory, the origin from whence all the longitudes of the Indian Survey are deduced. There is no other Observatory in India in which systematic observations, for determining the longitude, have been taken over a series of years; consequently the same necessity exists for the accurate connexion of our triangulation with the Madras Observatory, as for that of the British triangulation with the Greenwich Observatory, the origin of all English longitudes. But, it unfortunately happened that several trees intervened between the nearest Stations of the Triangulation and the Madras Observatory, and on attempting to clear a line through them, such extravagant compensation was demanded,—*e.g.*, Rs. 300 for a single branch of a Casiurina tree,—that it was necessary to suspend the triangulation, until a pillar could be raised to a sufficient height, on the Observatory, to overlook the intervening trees.

Additional instance of the need of legal powers for Survey Officers.

(79.) Here again the want of legal powers for our Officers was productive of much embarrassment and delay; and it is worthy of notice, that the operations of this Department are carried on with far greater rapidity and economy, in the wildest regions, where the physical obstacles are greatest, than in the vicinity of the Presidency Towns, where they are least; in these Towns, the head-quarters of the Lawyers, a few cantankerous individuals are always to be met with, whom it is more difficult to manage, than to combat any physical obstacle.

Arrangements at the Madras Observatory.

(80.) With the permission of the Governor, Sir William Denison, K.C.B., whose cordial co-operation and support I must here acknowledge, as the operations could not otherwise have been completed, the pillar, that is intended for a new equatorial instrument, in the eastern dome of the observatory, at 33 feet above the ground level, was raised 30 feet in height, to receive Captain Branfill's Theodolite, which was thus mounted 63 feet above the ground level; a scaffolding was raised around the pillar, for the observer and his assistants to stand on, and to carry the observatory tent; resting on the roof of the observatory, it had to be constructed of the lightest possible materials, and was therefore somewhat fragile and dangerous; fortunately the weather was favorable, and the observations were completed in two days, without misadventure.

Out-turn of work.

(81.) The out-turn of work was very creditable to Captain Branfill, who was not only exposed to unusual annoyances and difficulties, but had such bad health that I am surprised at his having been able to persevere in his work, for a field season of unusual duration. In all, 24 triangles were measured, embracing an area of 3,973 square miles, and extending a direct distance of 112 miles; one azimuth of verification was determined by star observations.

No. 6 PARTY—TRIGONOMETRICAL.

The Mangalore Series.

(82.) In para. 29 of my report for the year 1862-63, it was stated that the great Theodolite, attached to this Party, had met with such serious injuries, in consequence of the fall of a tower on which it had been set up for observation, that it had to be sent to England for repair.

On examination by Messrs. Troughton and Simms', the celebrated Mathematical Instrument makers, by whom it had originally been constructed, the injuries were found to be more serious than had at first been supposed, necessitating an almost entire reconstruction of the instrument. Being then in England, I fortunately succeeded in having the repairs performed with unusual rapidity; and the Secretary of State for India was pleased, at my suggestion, to order the instrument to be sent to Bombay by the overland route, to be available for work during the field season. It reached Bombay safely in November, but unfortunately its stand was not received from Calcutta until the end of February, so that much of the field season was lost. The out-turn of work by Captain Haig, the Officer in Executive charge, consisted of 11 Principal Triangles, covering an area of 3,620 square miles, and extending a direct distance of 88 miles; one azimuth was observed, and observations for latitude were taken at one station, pending the arrival of the travelling stand of the large theodolite. Mr. McGill conducted the approximate operations with most creditable vigor, selecting all the stations (28 in number) required for the further extension of this Series, over a distance of 90 miles, in a southerly direction to Mangalore, and thence eastwards, a distance of 110 miles to the Bangalore base line.

PERSONNEL.

Captain C. T. Haig, R.E., 1st Assistant.
Mr. J. McGill, Civil Assistant.
„ G. Anding, Sub-Assistant 1st Class.
„ A. Christie, Sub-Assistant 3rd Class.
„ C. McA'Fee, Sub-Assistant 3rd Class.

No. 7 PARTY—TRIGO-TOPOGRAPHICAL.

Kashmir and Ladak Survey.

(83.) The field operations in Kashmir and Ladak are not synchronous with the similar operations in all other parts of India, as those regions can only be visited during the summer months, and are inaccessible in the cold season, the ordinary time of field work. Thus the annual reports of this Party are usually received six months before those of the other Parties; the report for 1864-65 reached Colonel Robinson when he was completing his general report for 1863-64, and will be found in the Postcript thereto. It is here only necessary to repeat that an area of 8,300 square miles was sketched Geographically, on the scale of four miles to the inch, in Ladak and Thibet.

PERSONNEL.

Captain T. G. Montgomery, R.E., Astronomical Assistant.
Lieutenant T. T. Carter, R.E., 1st Assistant Junior grade.
Lieutenant A. Pullan, 2nd Assistant.
Mr. W. H. Johnson, Civil Assistant.
„ W. Beverley, Civil Assistant.
„ W. Todd, Civil 2nd Assistant.
„ C. Neuville, Civil 2nd Assistant.
„ J. Low, Senior Sub-Assistant.
„ C. Wood, Sub-Assistant 1st Class.
„ C. Braithwaite, Sub-Assistant 2nd Class.
„ W. F. Trotter, Sub-Assistant 3rd Class.

Kumaon and Gurhwal Survey.

(84.) The Kashmir and Ladak Survey being nearly completed, some of the Surveyors attached to this Party were deputed to commence the triangulation of the districts of Kumaon and Gurhwal, with a view to the future topography. Lieutenant Carter, R.E., was entrusted with these operations, and, in the month of February, 1865, he was nominated to the Executive charge of both sections of this Party, vice Captain Montgomerie, who, after 10 years of uninterrupted labor, in the Kashmir and Ladak Survey, was compelled to take leave of absence to Europe, on Medical Certificate. The out-turn of work consists of 10 Principal, 93 Secondary, and 980 tertiary triangles, covering an area of 2,580 square miles, and fixing 602 points; of topography, on the scale of one mile to the inch, 270 square miles were completed.

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No. 8 PARTY—TRIGO-TOPOGRAPHICAL.

Northern Bombay Party.

(85.) This Party was formed in 1863-64, for the topographical delineation of Kattiawar, and other Provinces, in the northern portion of the Bombay Presidency, of which no detailed Survey at present exists, though their triangulation has long since been completed. The first year's operations were carried on in Kattiawar, and are described in paras. 15 to 21 of Lieutenant-Colonel Robinson's Report for 1863-64. It was of course intended that the Party should return, in the following field season, to Kattiawar, to resume operations. But meanwhile a grievous famine had arisen in that and the adjoining Provinces, the result of the scanty rains which had fallen in 1864. The Political Agent in Kattiawar recommended that the Survey Party should be employed elsewhere, for a time, returning to his Province, when the famine had ended. The Bombay Government were solicited to indicate the district to which the Surveyors should be transferred; it was decided that they should proceed to the portion of the Nassick District, which lies immediately above the Thull Ghat.

Captain D. J. Nasmyth, R.E.
Lieutenant C. A. M. Skinner, R.E., 2nd Assistant.
Mr. A. D'Souza, Civil 2nd Assistant.
„ N. Gwinne, Sub-Assistant 3rd Class.
„ W. Waite, Sub-Assistant 3rd Class.
„ T. H. Rendell, Sub-Assistant 3rd Class.
„ C. D'Souza, Sub-Assistant 3rd Class.

Native Surveyors

Wassaji Ruggonath.
Narrayen Ruggonath.

Embarrassments caused by the sudden rise of prices in the Bombay Presidency.

(86.) The greatly increased cost of living and travelling in the Bombay Presidency, bore very heavily on all the members of this Party, and more particularly on the Uncovenanted Subordinates. At the commencement of the field season, the latter Officers were stated to be destitute of the means of defraying the expenses of keeping up tents and horses, and marching about, to perform their respective duties. In consequence of Captain Nasmyth's representations on this subject, the travelling allowances were increased by 50 per cent., and small local allowances, in no case exceeding Rs. 30, were granted, to meet the enhanced cost of living. With this assistance, Captain Nasmyth was able to push on the work with suitable rapidity, but he reports that much time was lost at the commencement of the season "from an absolute want of means of meeting current and travelling expenses." All this time too, that the Surveyors were in such a state of pecuniary embarrassment, the speculating mania, for which Bombay has become so notorious, and which was one of the chief causes of the rise of prices, was then at its highest; the most tempting inducements were held forth, to all who would, to join one of the numerous schemes which were started, and at once become rich. Those who could not buy shares, could generally obtain employment under the newly started Companies, with double or treble the salaries, usually granted to persons in corresponding situations, in the service of the Government. The demand for Surveyors far exceeded the supply, and each of our trained subordinates might, any day, have trebled his income, by resigning his appointment, and accepting employment elsewhere. Under these circumstances, I am gratified to be able to state that none of our European Assistants left us; a few men absconded from the Native Establishments, and much embarrassment was caused by the probability that all would desert *en masse*.

(87.) In several parts of the Bombay Presidency, Revenue Survey operations have been and are being carried on, which furnish village maps on the scale of 200 feet to the inch, a scale nearly as great as those of the Cadastral Surveys of Great Britain, and parts of the Continent. But whereas, in Europe, these operations are conducted with a view to the employment of the several field measures and other details, in forming Topographical, as well as Fiscal maps, in the Bombay

Presidency they have hitherto been used for fiscal purposes only; it is a singular circumstance that no general maps, of any value, exist, of the parts of Bombay which have been thus minutely surveyed. This is partially owing to the mapping being considered of less importance than the fiscal arrangements, and the consequent absence of the necessary measures to collate and juxtapose the detailed Surveys of the separate villages; and partly to the circumstance that the Revenue operations are restricted to the Revenue paying portions of the country, and therefore are not continuous. I am of opinion that, even now, it is not too late to take steps to turn the fiscal operations to account, in the construction of excellent topographical maps; for this purpose it will be necessary to connect them together, by a system of triangulation, and to fill up the blanks between them, by special topographical operations. I therefore directed Captain Nasmyth to keep this end in view, and to fix the positions of all the Revenue Survey stations that fell within the reach of his operations, in the anticipation that the large scale village maps might at least be found capable of combination, on being reduced to the Ordnance Survey scale of 6 inches to the mile, which is about one-fourth of their present scale. Consequently, Captain Nasmyth restricted his operations to an area of 647 square miles, which was covered with small triangles of 1 to 3 mile sides, after the method of the Ordnance Survey. Some delays were experienced in getting the maps of the Revenue Surveyors, and Captain Nasmyth fell ill, and was unable to devote as much of his attention to this subject as would otherwise have been desirable. I am therefore, at present, unable to report on the result of the tentative efforts which have been made, to ascertain whether the details of the fiscal Surveys may be used, for the construction of topographical maps.

No. 9 PARTY—ASTRONOMICAL.

(88.) Mr. Taylor reached Calcutta on the 31st October, 1864, on the termination of his leave of absence to Europe, on Medical Certificate. The operations of this Party had been suspended, during his absence, because there was no Officer available to take his place. It was last employed for the determination of the position of Port Blair, in latitude, and longitude. Mr. Taylor was directed to observe the latitudes of a Series of stations at about a degree apart, on the Longitudinal Series which connects Calcutta with Karachi. At Calcutta he had to put the Astronomical Circle, which was intended for his operations, into good working order, and to construct a temporary observatory, in the compound of the Mathematical Instrument Department, as the Astronomical Circle was much too large to be set up in the observatory attached to the Surveyor General's Office. He commenced his observations on the 8th December, but was unable to complete them until the 14th February, having been much retarded by rainy weather.

PERSONNEL.

Mr. H. Taylor, 2nd Assistant.
„ G. Atkinson, Sub-Assistant 1st Class.
Baboo Dwarkanath Dutt, Recorder.

Astronomical observations on the Calcutta Longitudinal Series.

(89.) In conformity with his original instructions, which were drawn out with the object of assimilating these operations as much as possible to those of the Ordnance Survey, he observed no less than 90 stars, which were selected from the Greenwich six-year Catalogue. I have however now come to the conclusion, that a far smaller number of stars, will amply suffice for the determination of a latitude, provided that the stars selected are those whose places have been fixed by an

appropriate number of observations at Greenwich. We now observe only 30 to 40 stars at each station, and get on twice as fast as formerly, without impairing the accuracy of the final results.

(90.) Mr. Taylor's observations at Calcutta are excellent; the probable error of the resulting latitude is ± 0″·07, exclusive of the effect of local attraction, which cannot yet be estimated. At his next station he was unfortunate; for several days, violent gusts of wind prevented him from taking any observations, and at last, a heavy gale carried away the roof of his observatory, which was thus completely destroyed; before a new roof could be constructed, with the necessary apertures and shutters, the season for field work had terminated.

No. 10 PARTY—ASTRONOMICAL.

(91.) This Party was employed in determining the latitudes of certain stations, about a degree apart, on the Great Arc. Lieutenant Campbell completed no less than five stations, in the course of the field season; the average number of stars employed at each station, was 100, each star being observed on four nights. Great credit is due to Lieutenant Campbell for his skilful arrangements to make the most of the time at his disposal; he displayed much ingenuity in constructing a portable roof for his observatory, which is capable of being set up, or taken down, in a few hours, and, while light enough to be carried about with ease, is strong enough to stand the wildest weather. Lieutenant Campbell has also taken much pains to investigate the sources of certain minute instrumental errors, and the proper steps to be taken to eliminate them, that they may not affect the final results. His probable errors are not yet computed, but will be communicated in my next report.

PERSONNEL.

Lieutenant W. M. Campbell, R.E., 2nd Assistant.
Mr. J. Wood, Sub-Assistant 2nd Class.
„ G. Belcham, ditto.

Astronomical observations on the Great Arc.

No. 11 PARTY—LEVELING.

(92.) In previous field seasons, the great line of levels, connecting Calcutta with the mean sea level of Karachi Harbour, had been carried from Karachi to Agra, and from Mirzapore to Calcutta. The gap between Agra and Mirzapore remained to be done, and this has now been completed by Lieutenant Trotter, R.E. During the field season of 1864-65, 422 miles were leveled over, of which 342½ miles appertain to the main line, and 79½ to branch lines carried for the purpose of connecting Railway, Canal, and other levels with our operations. Lieutenant Trotter has done his work right well, and has taken much pains to enhance its utility, by connecting it with other lines of level. He followed the rigorous system of procedure which has already been briefly described in previous reports, and is fully explained in the introduction to the volume of Tables of Heights in Sind, the Punjab, N.-W. Provinces and Central India, which was published in 1863.

PERSONNEL.

Lieutenant H. Trotter, R.E., 2nd Assistant.
Ram Chund, Native Surveyor.
Narsing Doss, Buldeo Pershad, } Recorders.

Completion of the line of levels between Karachi and Calcutta.

(93.) Thus this line of levels, the longest, and probably the best ever executed, has now been completed; the length of the main line connecting Karachi with Calcutta, is about 2,200 miles; the aggregate length of the branch lines is 830 miles, the principal branches running from Mittenkote to Attock, and from Agra to Sironj, in Central India. The origin or *datum*, is the mean sea level of Karachi Harbour; the present terminus is the sill of the Kidderpore Dock, in Calcutta. The final terminus should be established at some point, on the coast of the Bay of Bengal, which is suited for the true determination of the mean sea level of the Bay. Tidal observations have been taken at Kidderpore Dock, but it is now evident that they only give local results, and do not indicate the mean sea level of the Bay, as was formerly supposed; for the tide guage at Kidderpore Dock, in the Hoogly, has been recently connected with the gauge at Port Canning, in the Mutlah, which is quite as favorably situated for ascertaining the mean sea level of the Bay of Bengal, and a large discrepancy has been found to exist between the respective determinations. The Kidderpore observations would make the mean sea level 8·58 feet above the sill of the Kidderpore Dock, while those at Port Canning make it less than 4·5 feet above the said sill. By our own operations, the mean sea level of Karachi Harbour is 6·25 feet above the same sill, a result which is curious, in that it falls nearly midway between the two local values of the mean sea level. For the present, our levels may therefore be considered to furnish a more reliable reference, to the *datum* of the true mean sea level, though brought all the way from Karachi, than either of the local determinations. Detailed information on this point, will be found in Lieutenant Trotter's introduction, to the recently published Volume of Tables of Heights, in the N. W. Provinces and Bengal.

Existing uncertainty as to the mean sea level of the Bay of Bengal.

No. 12 PARTY—PENDULUM.

(94.) Captain J. P. Basevi, R.E., 1st Assistant G. T. Survey, while on furlough to Europe in 1864, was directed, by the Right Hon. the Secretary of State for India, at my suggestion, to proceed to the Kew Observatory, to learn the use of the apparatus which had been employed by General Sabine, in the course of his well-known Pendulum Experiments. Captain Basevi had also to assist in the arrangements necessary for preparing the apparatus to be sent out to India, and making the improvements and additions thereto, which had been suggested by the Council of the Royal Society. After spending two months at Kew, Captain Basevi returned to India, hoping that the apparatus would soon follow him; but a series of what are called "base experiments" had first to be taken at Kew; and these were so much retarded by bad weather, and by defects in the new vacuum cylinder, in which the Pendulums were to be swung, that the apparatus was not ready for despatch to India, until the month of March, 1865; it was then sent out to Calcutta, by the overland route, under the charge of Mr. Hennessey, 1st Assistant G. T. Survey, who happened to be returning to India; consequently it did not reach Dehra Doon, until the season was too far advanced for field operations.

Captain Basevi deputed to the Kew Observatory.

(95.) The Pendulum Party was therefore not formed until after the commencement of the following official year. Meanwhile, Captain Basevi, who had reached Dehra about the end of January, was employed in testing a newly invented instrument, called a Telemeter, for measuring distances, and in commencing the reduction of the observations for determining the Longitude of Port Blair, which had

been set aside for upwards of a year, as there was no available officer, who had sufficient leisure to undertake the intricate and laborious calculations. These will be described in my next report.

13.—THE COMPUTING, DRAWING AND CORRESPONDING OFFICES.

The Computing Office.

(96.) Lieutenant Herschel continued to supervise the operations of the Computing Office. But he experienced much difficulty, in consequence of the paucity of his computers, and the inefficiency of some of them, who have subsequently been pensioned, or removed. When the question of the re-organization of the Survey Establishments was under consideration, Lieutenant Herschel represented the inadequacy of the Computing Office to grasp the extensive arrears of computations which had accumulated; he applied for a small increase to the existing establishments. His proposals, having been strongly backed up by Lieut.-Colonel Robinson, and subsequently by Colonel Dickens, met with the approval of the Government of India, and were sanctioned in the Financial Resolution No. 3,996, dated 22nd December, 1864. But, as it takes some time to secure the services of men who are qualified for admission into the Computing Office, and then to train them to perform their duties efficiently, the advantages arising from the increased strength of the Office, are only now becoming apparent; the first results had merely the effect of adding the selection and training of suitable candidates, from among the numerous applicants, to Lieutenant Herschel's ordinary duties.

PERSONNEL.

Lieutenant J. Herschel, R.E., 1st Assistant.

Computing Branch.

Baboo Bholanauth Mojoomdar, Deputy Computer.
Baboo Gungapershad.
8 Native Computers.

Printing Branch.

Mr. T. Keightley.

The Computing Office increased.

Lieutenant Herschel writes a pamphlet on the treatment of Geodetic figures.

(97.) Nevertheless, a goodly amount of computation was completed; besides which Lieutenant Herschel drew up, and printed, a pamphlet "on compound Geodetic figures, and their reduction, according to the principle of least squares," the practical value of which is very considerable; for it exhibits the process of reduction, in a purely mechanical form, so that persons, of ordinary intelligence, need find no difficulty, generally speaking, in the reduction of the most complicated figures, that are met with in the several series of triangles. Lieutenant Herschel also wrote several valuable papers, on other points connected with the calculations of this Survey.

Mr. Hennessey's studies at Cambridge, and in the Ordnance Office, Southampton.

(98.) Mr. Hennessey, 1st Assistant G. T. Survey, was absent from this Country, on furlough to Europe, during almost the whole of the year under review; he spent the greater portion of his term of leave in undergoing a course of Mathematical Studies at Cambridge, and also in studying the various processes of the Ordnance Survey of Great Britain and Ireland, both in the field, and in the Office at Southampton, with a view to increasing the extensive information he already possessed on professional matters, and qualifying himself still more highly for the work he has to do. When I was in England, I had the gratification of submitting for the consideration of the Secretary of State for India, a certificate which Mr. Hennessey had received from Mr. Walton, Moderater to the University of Cambridge,

bearing testimony to his profound reading, unsurpassed industry, and capacity to educate other men in the Mathematical Departments in which he had labored. The Secretary of State was pleased to express to myself, and to intimate to the Government of India, his great satisfaction "as to the creditable exertions of Mr. Hennessey, in going through a course of mathematical study at Cambridge." In my next report, I shall have the further gratification of describing the valuable results, which have already been secured to the public service, by Mr. Hennessey's professional studies, in the Ordnance Survey Office, at Southampton.

The Drawing Office.

(99.) The Drawing Office, which is attached to the head-quarters of the Trigonometrical Survey, has been fully employed, under the admirable supervision of Mr. W. H. Scott, Civil Assistant. On my return from Europe I desired Mr. Scott to draw up Annual Returns, showing, not only the actual out-turn of the work of his office, but the cost of each Map and Chart, reckoned on the time it had taken to complete, and the salaries of the persons employed to execute, examine, and supervise it. Mr. Scott's return for the year under review, will be found at the end of this report.

(100.) The Corresponding Office was efficiently supervised by Mr. Duhan, Civil Assistant G. T. Survey, whose intelligence, and intimate knowledge of all the official documents, greatly facilitates the work with which he is connected; his duties were much increased, during the current year, by the preparation of a variety of returns, to accompany the propositions which were submitted to the Government of India, first by Colonel Dickens, and subsequently by Colonel Thuillier and myself, conjointly, on the question of the re-organization of the Survey Department.

J. T. WALKER, *Lieut.-Colonel R.E.*,
Superintendent Great Trigonometrical Survey of India.

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ABSTRACT OF THE OUT-TURN OF WORK EXECUTED BY THE TRIGONOMETRICAL AND TRIGO-TOPOGRAPHICAL PARTIES OF THE G. T. SURVEY DURING THE OFFICIAL YEAR 1864-65.

Description of Details.	1 East Calcutta Longitudinal Series 24-inch Theodolite.	2 Eastern Frontier Series 24-inch Theodolite.	3 Jubbulpore Meridional Series 36-inch Theodolite.	4 West Calcutta Longitudinal Series 24-inch Theodolite.	5 Madras Coast Series 24-inch Theodolite.	6 Mangalore Series 24-inch Theodolite.	7 Kumaon and Gurhwal Series 14-inch Theodolite.	8 Northern Bombay Party 14-inch Theodolite.	Total Out-turn of Work.
Number of Principal Stations, ...	...	14	21	18	24	11	9	17	114
„ „ Triangles completed, ...	...	21	23	20	24	11	10	33	142
Area of Principal Triangulation, in square miles, ...	...	1,675	5,167	7,765	3,973	3,620	1,580	647	24,427
Lengths of Principal Series, in miles, ...	...	80	150	168	112	88	70	...	668
Average triangular error, in seconds, ...	...	0·48	0·43	0·43	0·51	0·98	3·18	3·08	...
Average angular probable error, in seconds, ...	...	0·30	0·19	0·25	0·22	0·31	0·87	...	...
Azimuths observed, ...	...	1	2	...	...	1	...	...	4
Number of Secondary Triangles of which all three angles have been observed, ...	15	...	32	...	11	6	93	82	239
Area of Secondary Triangulation in square miles, ...	44	980	4,000	...	1,250	1,692	1,000	224	9,190
Lengths of Secondary Series in miles, ...	30	...	184	...	65	136	...	...	415
Number of intersected points, ...	...	38	40	...	40	41	521	20	700
Number of Secondary stations whose heights have been fixed, ...	...	24	2	...	11	12	263	27	339
Area Topographically surveyed on scale of 1 mile = 1 inch, ...	...	...	...	...	...	...	270	45	315
Area Geographically surveyed on scale of 4 miles = 1 inch, ...	...	...	...	...	...	...	8,300	...	8,300
Number of Principal stations selected in advance, ...	24	18	...	...	...	28	8	45	123
Lengths of Approximate Series in miles, ...	126	93	175	...	...	200	120	...	714
Number of Towers constructed,...	12	...	...	...	9	...	...	...	21
„ Platforms constructed for Principal Stations, ...	...	22	24	14	10	8	13	29	120
Number of Platforms constructed for Secondary Stations, ...	15	...	46	...	...	...	...	...	61
Number of miles of Rays cleared, ...	314	50	...	...	80	...	...	...	444
„ „ Roads made, ...	...	160	61	26	...	...	...	...	247
„ Hill tops cleared of forest and jungle, ...	5	...	22	...	...	...	...	...	27
Number of Principal stations whose elements were computed,...	16	30	15	35	24	17	5	...	142
Number of Secondary and Tertiary stations whose elements were computed, ...	50	45	...	...	17	105	264	...	...
Number of Preliminary Charts of Triangulation, ...	...	1	1	1	1	1	...	...	5

APPENDIX B.

EXTRACTS FROM THE NARRATIVE REPORTS

OF THE

EXECUTIVE OFFICERS OF THE TRIGONOMETRICAL SURVEY;

ALSO

NOTES, DESCRIPTIVE AND GEOLOGICAL,

ON THE

PANGONG LAKE DISTRICT,

BY CAPTAIN GODWIN-AUSTEN.

EXTRACT FROM THE NARRATIVE REPORT OF LIEUTENANT THUILLIER, R.E., 1ST ASSISTANT, IN CHARGE EAST CALCUTTA LONGITUDINAL SERIES, NO. 69, DATED 3RD AUGUST, 1865.

(2.) Owing to the peculiar nature of the country in which our operations commenced, viz., the unhealthy swamps of the Backergunge and Furreedpore districts, it was deemed advisable not to take the field until the effects of malaria, which exists for some time after the breaking up of the rains, had subsided. I therefore consulted Lieut.-Colonel J. E. Gastrell, of the Revenue Survey, who had surveyed these districts, and was well acquainted with their peculiarities, as to the period when one might safely proceed into these parts. By his advice the party did not leave recess quarters until 8th December.

(3.) Mr. Ryall was placed under my orders for special work, viz., for laying down Port Mutlah, Mymensing, Dacca, &c., and joined the Eastern Calcutta Longitudinal Series on the 13th November. Before leaving Calcutta, therefore, I deputed him to carry a minor triangulation from a side of a coast series a little below Calcutta to Port Mutlah. He started on this undertaking on the 6th December. Messrs. Harris and Mendes I sent with detached parties to build towers, and Mr. O'Sullivan accompanied me to carry on the approximate series, from the point where Mr. Beverley had stopped work the former season.

(5.) About the middle of January, perceiving that the towers could not be ready for observations until late in the season, owing to the peculiar difficulties in conveying materials to the sites selected, I wrote to Lieut.-Colonel Robinson, asking for sanction to postpone the final observations till next season, and to continue the approximate series, and put forward the following reasons for my proposition :—

1st—Having no Senior Assistant to whom I could entrust the approximate series, (Mr. Ryall being detached on special duty, unconnected with the Eastern Calcutta Longitudinal Series) that work would have to be stopped, and consequently the towers for the next season could not be put in hand until after the time occupied in selecting the sites, a matter of much importance, as our towers being paka throughout, and all the materials having to be prepared, take considerable time to erect.

2nd—In the month of March, before which time I should be unable to commence observations, considerable difficulty would be experienced in moving about the camp, and more especially in carrying about the big theodolite, owing to the peculiar nature of the country in which my observations would commence. This part of the country (district of Backergunge) consists of extensive jheels, intersected by a net work of khals, most intricate in their windings. These swamps, during the rainy season, cover the greater portion of the district, the only really dry land being on the banks of the channels, and the inhabitants are obliged to raise their houses on artificial mounds. In the dry weather these swamps become reduced to the extent of the central portion, from which the channels take their rise, and the means of communication is necessarily much restricted.

3rd—The eastern portion of the district is cut up by very large rivers, such as the Aryal Khan and Megna, the latter river being 8 miles wide where my Series crosses. Had I returned in March for final observations, I should have been travelling about these big rivers in April and May, when there are incessant storms and continuous bad weather, and, in small country boats, much risk would have been incurred, as I subsequently underwent in returning to quarters.

4th—By confining myself to the approximate series I should be able to complete the junction with the Eastern Frontier Series, and on taking the field next season would be able to start at once with the principal observations, and continue without a break to the conclusion of the series, involving observations from 24 stations, and 2 sets of circumpolar observations.

(6.) On these considerations Lieut.-Colonel Robinson was pleased to approve my plan of arrangements, pending your arrival, and which you subsequently sanctioned; I therefore sent instructions to Messrs. Harris and Mendes to make proper arrangements for the protection of the towers as they were finished, while I continued the selection of stations across the Megna into British Tipperah.

(7.) Owing to the very heavy forest jungle on both banks of the Megna, and other large rivers running into it, our operations were much retarded, and on the 15th March, after selecting six stations in continuous order, I marched to the eastern frontier with the intention of working back from the frontier series, with which my series was to join. After selecting the most convenient side for junction, I proceeded to carry back thence a series of triangles to connect with the points to which I had brought up the series. The hills are low, and covered to their summits with dense jungle, to overcome which I was obliged to have recourse to machans. I was unable to effect a more symmetrical junction, owing to the low spur on which the Chikania station is situated. This spur did not allow of two stations being selected on it mutually visible. On this same spur I found some old machans, which had been erected by

the Frontier Series party for the same object, but with similar want of success. Therefore, after reconnoitering for ten days, I selected the Chikania station, and proceeded to select the intermediate stations. On the 24th April I completed the triangulation with some difficulty, owing to the heavy rain which had set in, and the consequent difficulty in moving the camp.

(8.) After making arrangements for boats at Raipur, on the left bank of the Megna, the camp left for Calcutta on the 29th April, and experienced very bad weather; so much so that it took us 8 days to reach Burrisal, an ordinary trip of 2½ days. It was nervous work also, in country boats, crossing these big rivers, the Megna being 8 miles wide where the Series runs. Next season, in returning, I propose to proceed to Dacca, and thence take the camp by steamer to Kooshtea, and from there by rail to Calcutta, as I do not consider it safe in the month of May, when there are storms almost daily, to risk valuable Government property in small country boats, which are the only means of conveyance in these parts.

(9.) In the Tipperah and Noacolly districts I met with great trouble and inconvenience in procuring carriage. Carts are not to be seen in the district, the country being impracticable for them, and, having only two elephants attached to the party, I had to resort to coolies, which I had the greatest difficulty always in procuring, though travelling as lightly as possible, and alone. When carrying on the principal observations next season, I anticipate the very greatest difficulty on this account, unless I am furnished with more elephants.

(11.) Mr. E. C. Ryall was employed during the whole season in laying out a minor series from Calcutta to Port Mutlah, a distance of about 38 miles. For a short period he was employed in fixing the observatory in the Mathematical Instrument Department compound. During the entire season he observed 15 triangles, comprising an area of 44 square miles. His out-turn of work is small, and though he remained out in the field till 26th May, he was unable to complete his observations.

(12.) Mr. G. A. Harris was employed in building towers and clearing the final rays, and during the season completed 9 paka towers, and cleared 129 miles of rays. Taking into consideration the very difficult country in which he was employed, Mr. Harris deserves great credit for the very satisfactory manner in which he completed the work entrusted to him. Mr. Harris returned to quarters on the 24th May.

(13.) Mr. W. J. O'Sullivan accompanied me for the greater portion of the field season, and made himself most useful in assisting me in the approximate series and the current office duties. At the end of March, owing to the difficulties in procuring carriage, I left him to help Mr. Mendes in the tower building, and he was progressing favorably when an untoward circumstance occurred which much delayed him in his subsequent labors. At a village in the Noacolly district, where he was making arrangements for building a tower, the villagers attacked him with latties, and seriously hurt him, and from his report it was with difficulty he escaped. The matter was represented to the officials at Noacolly, and I am glad to be able to report that the crime was brought home to nine men, who were punished. Subsequent to this, Mr. O'Sullivan was attacked with fever, and was not able to return to quarters until 21st May. He showed great energy and aptitude for his work while with me, and I have every reason to expect he will prove himself a useful member of the Department.

(14.) Mr. J. J. Mendes was entrusted with the building of the towers in advance of those Mr. Harris was engaged on, and completed three towers and the materials for four others, when sickness unfortunately put a stop to his progress, and he was obliged to return to Burrisal for medical advice. This occurred on the 1st of April, and he was unable to revert to his duties during the whole of that month. His progress, while he was at work, was very satisfactory.

EXTRACT FROM THE NARRATIVE REPORT OF C. LANE, ESQ., CHIEF CIVIL ASSISTANT, IN CHARGE EASTERN FRONTIER PARTY, NO. 7, DATED 11TH JULY, 1865.

(3.) The party took the field on the 23rd and 24th November, 1864. The main camp marched to Nagarkhana H.S., to commence final observations, and Mr. Civil Assistant W. C. Rossenrode proceeded by water to Sitapahar H.S., to resume the approximate triangulation.

(4.) The country traversed this season by the final operations, between the parallels of latitude 22° 3′ and 23° 11′ and longitude 91° 35′ and 92° 22′, is for the most part along the northern and eastern portions especially, similar to Hill Tipperah. The remainder, though hilly, is intersected by strips of level plains of various length and breadth. The principal stations range in altitude from about 225 to 1,835 feet above the sea.

(5.) Mr. Civil Assistant W. C. Rossenrode carried on the approximate triangulation in advance throughout the season. He has succeeded in accomplishing a large amount of work in a most difficult country, viz., selection of 18 principal stations, construction of 22 pillars from 2 to 6 feet high, surrounded with platforms made of wooden posts and bamboos, and the clearance of 7 difficult rays between principal stations.

(6.) Mr. Civil 2nd Assistant H. Beverley, for reasons given in the report for November, 1864, assisted in the observatory, in current office work, and transcription of the duplicate vertical angle book. In the observatory he took microscopes *D* and *E* in the horizontal angles, changed zeros, and occasionally took some vertical angles. At the beginning of the season he took some secondary angles at Batali H.S., to points in Chittagong. On arrival of the main camp at Moratong H.S., in consequence of my prostration from the severe fever of the country, Mr. B. had to take the whole of the angles, horizontal and vertical, at this station. Of the goodness of these observations I satisfied myself at the time. But for Mr. B.'s presence on this occasion, much time would have been lost, before he or Mr. Rossenrode could have come for the purpose, in a country where travelling is tedious and difficult, and where a long stage constitutes a very short direct distance. Mr. B. also observed some secondary angles at Sitapahar H.S., to points in Chandarguna.

(7.) Mr. 3rd Class Sub-Assistant W. C. Price assisted in the observatory in recording the observations, and kept up transcription of the duplicate horizontal angle book. His figures are remarkably clear and good, and he very rarely makes a single mistake in his means and angles. He can use the 12-inch theodolite, with which instrument he took some secondary observations at Sajidhala H.S., and also observed the required angles at Batali H.S. to Sundip secondary station, on the island of this name, for its determination.

(8.) The roads for the large theodolite this season were constructed by different men, detached chiefly from the main camp. Some of the roads to stations near Chittagong were begun during the latter portion of last rains; others were carried on during the field season, under my orders; whilst those to Kurla, Sitalsari, Sitapahar, Gilasari, Bhattitong and Jangalia hill stations, with the expection of about two-thirds the distance, Sitapahar to Gilasari, were executed under Mr. Rossenrode's orders.

(9.) There was a great deal of sickness experienced in the main camp among the signallers at different principal stations, and on the approximate series. Of the signallers, several had to be relieved. I was prepared for this, and had enough of trained men to take their places. In the main camp myself, Mr. Price, the Native doctor, and several of the men suffered repeatedly from jungle fever, attributable chiefly to excess of tree over bamboo jungle. Shortly after return of the party to Chittagong, Mr. Beverley also was attacked with the fever, and several of the natives have been since prostrated. In April and May cholera committed some havoc among the people of the country, in the vicinity of Poáng hát, and out of four cases that occurred among men belonging to the main camp, two attacked away from camp died, and two others in camp recovered. Mr. Rossenrode also states that cholera, which commenced and ended about Ramú, raged from about the end of February to the end of April near the sea coast from Tek Náf to Dulahazra, being from about latitude 20° 50′ to 21° 40′, and it is remarkable that it did not cross to east of the Náf river. During its prevalence all the háts and ferries in the tract were closed.

(10.) Most of the last rice and cotton crops in the Chittagong hill tracts and contiguous districts, having been destroyed by field rats, caused great scarcity of food among the inhabitants throughout the hills. While at Semutong H.S., in January, I was informed by Mau Raja that he had just received

authentic news from his emissaries of the assemblage of seven Kookie chiefs at the village of Ratan Púi, against whom Major Raban commanded an expedition a few years ago. These Kookies were said to be making preparations on a large scale for a marauding expedition, intended either to attack some other savage tribes, or some place or places unknown,* and in consequence that inhabitants of the country between Semutong H. S. and Barkal were, with their families and chattels, deserting their villages, and seeking safety in sequestered spots in the dense jungles. Coupling this information with the significant fact that Ratan Púi had a short time previously refused the presents sent to him by the Commissioner, I lost no time in applying to the Commissioner for a police guard, of strength as per margin,† to attend my camp for about a month, or less, till completion of the final observations at Bhattimoin, Moratong and Kurla hill stations, on the eastern flank of the operations, as well to instil confidence into the people of the country, and facilitate obtainment of coolies,‡ as by increasing the number of fighting men, to diminish the chances of any attack. Of the barkandaz guard of the party there are some 10 to 16 effective men present in the main camp, some being detached with signal parties for protection from wild animals, others with men making roads, some sick, and some sent to fetch money from the Chittagong treasury. Every possible precaution was taken in camp to act on the defensive, in case any sudden attack might be made for the sake of plunder, and myself, and Messrs. Beverley and Price kept watch by turns nightly, when dense mist precluded observations; and afterwards at Bhattimoin H. S., the most likely of all places, being situated on a pass or ghat, on the road used by the Kookies in their occasional visits to Máu Raja's hât. The Commissioner replied that none of the police could be spared. Fortunately, no raid was attempted by the savages, owing, in all probability, to the circumstance of fifty of the police having been, unknown to myself till now, despatched at the time, over my said letter to the Commissioner, by the Magistrate, to strengthen the outposts. Working as this party is on a frontier infested with many savage tribes, and in Burmah with dacoits also, it might be desirable to possess authority for assistance for defence from the nearest police station in case of emergency.

* These are the people who had the audacity on a former occasion, in November, 1862, to send the following message to the Political Agent :— "We have a plentiful harvest, and will be glad to fight and feed your sepoys, as you find it so difficult to feed them in our hills."

† 1 Havildar, 3 Naicks and 20 Privates.

‡ At this time coolies for the camp were obtained with difficulty, and Máu Raja assured me none would be procurable at all to accompany the party to stations eastward over the least visible signs of the approach of the dreaded Kookies.

(11.) During field season 1863-64, some time in April, the Commissioner received a letter from the Maha Raja of Hill Tipperah, informing him that it was necessary to discontinue the surveys then going on in his territory, as his ryots would have no crops, since their júms (fields) required their immediate attention. I received the communication from the Commissioner on the subject during the first week in May. Again this last field season the superintendent of hill tracts, so early as the 4th March, wrote to the Commissioner, requesting that I might be ordered not to use the hill people as coolies, as it was time for the preparation of their fields for the next crops. In the middle of April last the Poang Raja also objected to furnish coolies for our roads for the large theodolite to stations in advance, on the plea that his people's jums would suffer, if not attended to immediately. Hill coolies are the only people who will act as such in the interior of the hills, where our stations mostly are, and Bengalis, as hired coolies, are unwilling to proceed beyond a single march into the hills, unless perhaps on monthly pay, when, however, they have been found unruly, lazy, unmanageable, and very much given to desertion. Hence it will be seen that field operations will have to terminate about the middle of April. It is customary with all the hill people to clear and fire their jums in all March, and no sooner the first heavy showers occur, during the first week of April, than they commence sowing, and otherwise tending their fields.

EXTRACT FROM THE NARRATIVE REPORT OF G. SHELVERTON, ESQ., CIVIL ASSISTANT, IN CHARGE JUBBULPORE MERIDIONAL SERIES, NO. 17, DATED 1ST AUGUST, 1865.

(1.) When the party reached ground (by the end of November, 1864), Mr. A. W. Donnelly was detached to continue the selection of principal stations; the reconnoissance that he had made of the ground the year previous materially helped his progress, as it enabled him to select, during field season 1864-65, 24 principal stations, arranged in a series of hexagons and quadrilaterals, along the meridian of 80°, and extending from the parallel of 23° 0′ to the parallel of 20° 30′. Mr. Donnelly deserves great credit for some of his selections during the early part of the season. The country through which he was then working consists of a succession of densely-wooded plateaux, presenting no easily recognizable features. Mr. Donnelly suffered much in health while prosecuting his field duties; he is still too unwell to help in the office computations. It is the opinion of the civil surgeon of Jubbulpore that Mr. Donnelly should be removed to a better climate.

(2.) Mr. Hickie was employed during the greater part of the season in building platforms, cutting roads, and clearing hill tops of jungle and forest. About the end of April, 1865, Mr. Hickie was directed to triangulate on the western flank of the main series; he observed angles at 13 stations in the course of five weeks; his triangulation embraces an area of 1,000 square miles. Mr. Hickie's exertions were unremitting; his progress was very satisfactory. Mr. Hickie returned to recess quarters on the 15th of June, 1865.

(3.) Mr. F. Bell was employed at first in connecting with the main series the stations of the Jubbulpore Revenue Survey triangulation, and afterwards in conducting southwards a minor series of triangles along the meridian of 79° 15′. Mr. Bell during the field season observed angles at 35 stations; his triangulation embraces an area of 2,600 square miles; his out-turn of work was very satisfactory.

(4.) Mr. L. J. Pocock helped me in current business, and in the observatory; he has invariably been of great assistance to me. I had no opportunity of employing him on independent work.

(5.) The final observations at the principal stations were begun on the 15th of December, 1864, and closed on the 30th April, 1865. During the early part of the field season I was engaged in inspecting the stations selected during season 1863-64.

EXTRACT FROM THE NARRATIVE REPORT OF CAPTAIN B. R. BRANFILL, 1ST ASSISTANT, IN CHARGE MADRAS MERIDIONAL SERIES, NO. 76, DATED 14TH JUNE, 1865.

The principal computations were finished early in October, and the whole party left for Madras, resuming office there on the 1st November.

I took the opportunity of visiting Bangalore, where, after much search, the ends of Colonel Lambton's base, measured there in 1800, were discovered, and measures taken for their preservation. The month of November was stormy and rainy, and was spent in organizing the field parties, repairing instruments, and in completing the secondary computations and the charts.

The entire party took the field on the 5th of December, as follows :—

Mr. Ryall to take up the approximate series near the Pullikat Lake, to select one or two stations on the east flank, clear the rays, and arrange to build the necessary towers.

Mr. Mitchell, after building the Ghurram-dwarf tower, was directed to proceed to the Kistna district, and proceed with the Masulipatam and Point Divy Minor Series.

With Mr. O'Neill and Native Recorder Gangadram Mudh I proceeded to Nellore, to fix that place, and resume the principal triangulation in the neighbourhood. After recording the azimuth observed at Kistama H.S. in December, and assisting for a few weeks in the observatory and office, until the native recorder had become efficient in his duties, Mr. O'Neill was sent to assist Mr. Ryall in the approximate series, by superintending the tower building, &c. In the meantime, arrangements had been made for the erection of a pillar at the Madras Observatory, of sufficient height to overcome the obstructions offered by the surrounding houses and gardens, from which to connect the Observatory with the principal triangulation. This arrangement was readily sanctioned by the Madras Government, and agreed to by the Government Astronomer; and, as I had no one whom I could spare to superintend the work, it was undertaken, at my solicitation, by the Public Works Department, but, through sundry misunderstandings and unforeseen delays it was not completed until the 5th or 6th of June.

During February the Gonagapaliam tower fell, but was rebuilt in time to obviate more than a few days delay.

In March and April, the progress of the work was very seriously delayed by the cloudy weather which is so prevalent along this coast, and also from the haziness of the atmosphere, as also from the deficiency of positive or excess of negative refraction, rendering the rays which, though perhaps grazing, had been quite practicable in January, quite out of the question now in April, so that the Rattambér, Chambér and Madras Observatory pillars all had to be raised from 8 feet to 12 feet higher, and the signals raised still higher on scaffolds erected for the purpose at 4 or 5 stations.

Final observations were completed at St. Thomas' Mount H.S. on the 27th May, and the party arrived in Madras on the 29th idem. I had been out of health, and suffering from slight fever and indigestion during the first half of May, when I was attacked by an eruption of boils and carbuncles on one leg, so that I could only stand on one foot during the work at the three last stations.

I was laid up completely for a week by them, till the end of the first week in June, after which I resumed the work at the Observatory, connecting the pillar station with the meridian circle, and determining the difference of heights between the pillar station and the Public Works Department bench-mark below.

Messrs. Ryall and O'Neill had held on at their work until the Chambér tower was finished, and the ray thence to Madras was cleared of obstructions, but they were then both knocked up, and went into hospital.

On the 9th June the 24-inch theodolite was hoisted in its case 33 feet, on to the roof of the Astronomer's dwelling, and on the 10th, by means of a second hoist, on to the top of the pillar and scaffold 30 feet higher. Final observations were completed on the 12th of June, and the instrument, to my great satisfaction, lowered to the roof the same evening, and next day to the ground without accident.

I beg to state my obligations to Colonel A. Boileau, R.E., Superintending Engineer 4th Division, for the courteous and ready manner in which he afforded me his support in carrying out our plans, and

the aid of his department to execute them; and also to Captain Beckley, R.E., Executive Engineer, under whose immediate supervision and orders the pillar and scaffold were built, and who uniformly met my wishes and requirements with ready acquiescence, and whose method of executing them left me nothing further to wish for.

Mr. Ryall, 1st Class Sub-Assistant, selected three principal stations in very difficult ground, and cleared the adjoining rays, which passed through groves of very heavy timber. Being new to this part of our field duty, his progress was not so rapid as it might possibly otherwise have been; but he was more than once prostrated by illness, and has been in consequence unfit for work most of the season.

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EXTRACT FROM THE NARRATIVE REPORT OF H. KEELAN, ESQ., 1ST ASSISTANT, IN CHARGE WEST CALCUTTA LONGITUDINAL SERIES, NO. 221, DATED 14TH JULY, 1865.

(2.) In revising the Calcutta Longitudinal Series the previous season, in the Sirgúja district, the party suffered so much from jungle fever that, in continuing the revision of the triangulation to the westward (between longitude 80° 45′ and 82° 15′), ordered by the officiating Superintendent G. T. Survey, great caution was necessary in entering the wild tracts south of the river Sôn too early. The tract in question being most unhealthy, except during only a few months in the year, the party did not take the field from Chunar before the 7th December, and reached Aouri hill station on the 19th, where the revision commenced, and was carried westward to its junction with the side Amua H.S., to Lora H.S., revised from the Seronj base.

(4.) Final angles were completed at Aouri and Lúl hill stations by the end of December, and during the month of January the station of Koria was selected by myself, on the Kaimúr range, across the river Sôn, to form the double polygon round Gúrwáni and Marwás hill stations, and final angles were completed at the hill stations of Múrérgarh, Gurwani, Pokrá and Chaprí.

(5.) At Pokrá hill station Mr. Trotter relieved Mr. Peychers in the observatory, to enable me to detach a party under Mr. P. to select stations, to form the double polygon round the hill stations of Rámpúr and Púnchí. Mr. Peychers performed this task, until relieved by Mr. Clarke, in a very satisfactory manner, in having selected the hill stations of Chítalwáni and Singpúr, and Mr. Clarke, on joining, selected the remaining hill station of Banjári, thus completing a double hexagon of very symmetrical triangles by the end of February, in a rather difficult and extremely wild country, in pergunnah Sohagpúr.

(6.) During the month of February final angles were completed at the principal hill stations of Koria, Marwás, Kharárá and Chamkí.

(7.) In March final angles were completed at the hill stations of Rámpúr, Chitalwáni, Singpúr, Punchí and Banjári, and by the 11th of April final angles were completed at the remaining 3 hill stations of Lakanpúra, Amúa and Lora, closing the season's operations on the side Amúa to Lora, revised from the Sironj base.

(8.) The principal observations were begun on the 21st December, and closed on the 11th April. During this time, eighteen principal stations were visited; the sides of the triangulation were of such length that three, sometimes four, days were occupied in marching from one station to another; added to this, the weather being very unsettled, the observations, both horizontal and vertical, were retarded at every station.

(9.) No secondary work, was undertaken, as the series under revision, embraces very extensively, operations of this nature.

(12.) In closing this report, I beg to bring to your favorable notice the services of Messrs. Clarke, Peychers and Trotter, attached to this Series, for their zeal and intelligence in the performance of their respective duties.

EXTRACT FROM THE NARRATIVE REPORT OF CAPTAIN C. T. HAIG, R.E., 1ST ASSISTANT, IN CHARGE BOMBAY PARTY, NO. $\frac{2}{6}$, DATED 10TH APRIL, 1865.

(2.) The stand of the 2-foot instrument not having been sent from Calcutta, I determined to take some observations for latitude at Alsunda H.S., a station of the Bombay Longitudinal Series, and one of those from which the Mangalore Meridional Series emanates. I therefore had three small brass chairs fitted on to the stand of the 18-inch instrument, just outside the old chairs, by which I was enabled to put the 2-foot instrument upon it, but it would not admit of any change of zero. This stand was nearly a foot too high, so I had the outer work of the station raised a foot above the top of the pillar, and on the 16th December I left Poona, and reached Alsunda on the next day. I there took prime vertical transits to 83 Canori on 21 mornings, and I then determined to take a number of meridian altitudes to 6 different stars—two close to the zenith, two about 6° north and south of zenith, and two about 12° north and south of zenith,—intending to take observations on 12 nights to 6 pairs of zeros; but I had only taken two nights observations, when I heard that the stand was expected daily in Bombay, and I therefore took no more star observations, but proceeded to Bori H.S. I here received the stand on the 4th February, but, owing to rainy and cloudy weather, I could not complete observations till the 8th. I then went to Bombay for two days (the 9th and 10th), to meet you, and then returned and resumed the work at Kallas on the 12th, and proceeded without any material interruption till the 20th March, when I closed work at Koondal, having completed observations at 10 stations, and taken a set of azimuth observations at Pachwar H.S.

(3.) The station of Palwan is about a mile to the east of the old station, at which the accident happened two years ago. I had the new station built on its present site, as it obviated the necessity of a high pillar. The observations at Kallas and Kem to Lulki I had taken before two years ago, but I this year repeated them. I have also embodied in my work 4 old G. T. Stations, as secondary points, excepting one which is a principal station.

(4.) Mr. McGill having been compelled by urgent private affairs to apply for leave of absence, did not take the field till the 3rd December. I enclose a chart of his approximate triangulation, which you will perceive he has carried as far as Bangalore. He is now on his way back to Poona, which I expect he will reach about the 18th instant. His chart speaks for itself.

(5.) Mr. Anding, too, took the field very late. He was, in the month of November, laid up with a very severe attack of fever, which so much reduced him that I did not send him off with his party till the 15th January. I, however, previously took him to Alsunda, where he executed some trial triangulation under my supervision, a step which I considered necessary, as his previous season's work was not so successful as I could wish. The work I allotted to him was to lay down all points of importance along the west coast, commencing from Bombay, and proceeding south.

(6.) Messrs. Christie and McA'Fee have been employed in the observatory, and on current office work.

EXTRACT FROM THE NARRATIVE REPORT OF LIEUTENANT T. T. CARTER, R.E., 1ST ASSISTANT, IN CHARGE KUMAON AND GURHWAL SERIES, NO. $\frac{178}{842}$, DATED 28TH JULY, 1865.

The Kumaon and Gurhwal Survey being a new undertaking, and having no points fixed for topographical purposes, only a small portion of the establishment, comprising the Kashmir party, could be employed at first (as per margin), the head-quarters and remaining Assistants being retained in quarters to bring up the computations and General Report of the Kashmir Series.

Lieut. Carter, R.E.,
Mr. W. G. Beverley,
„ W. Todd.

The Kumaon party, as above, took the field on the 3rd November, 1864. Lieutenant Carter was deputed to carry a principal longitudinal series through the centre of Gurhwal and Kumaon, the side of continuation being Ranigarh H.S., Ghandial H.S. of the North-West Himalaya Series, and to make the necessary arrangements with the Civil Officers for the carrying on of the work.

On arriving at Ghandial H.S., in the Teeree Raja's territory, on the 7th of November, no sign of platform or pillar could be found. On enquiry, it appeared that within the last few years the temple which stands on the hill had been enlarged. After carefully digging in several places to see if any trace of a pillar could be found, the question as to existence of pillar was settled by finding a mark-stone in the wall surrounding the temple. The destruction of mark at Ghandial necessitated falling back on another side of the North-West Himalayan Series, viz., Mabegarh H.S. to Ranigarh H.S., the pillars and platforms of which had luckily been left undisturbed. The delay thus occasioned prevented the observing being begun before the 1st December, by which time Lieutenant Carter was joined by Mr. Braithwaite, 2nd Class Sub-Assistant, who was sent to assist him in the observatory. The observations at this station were completed by the 6th December, and the camp then moved to Manaknath H.S. The weather was very unfavorable, but a snow storm on the 18th cleared away the clouds, and the station was completed, and the next, viz., Ranigarh H.S., reached by the 24th, and finished by the 30th. At these three stations observations were taken to several snowy peaks of the Himalayas, and a few secondary points.

Mabegarh H.S., the fourth station of the first quadrilateral, was completed by the 9th of January, and Devitouk H.S. by the 24th. At this last station the weather was bad. After completing Devitouk, Lieutenant Carter had to proceed by dâk to Dehra, to take over charge of the party from Captain Montgomerie, Royal Engineers, proceeding to England on medical certificate. Captain Montgomerie left Dehra on the 20th of February. The head-quarters of the native establishment, under Mr. Neuville, Civil 2nd Assistant, were now directed to proceed to join Lieutenant Carter's camp, the gentlemen, as per margin, being left at Dehra, to continue bringing up the Kashmir work. Mr. Low had been deputed to take Mr. Braithwaite's place, that officer having fallen sick at Ranigarh H.S., but joined too late to be of assistance in the observatory; he was, however, left in charge of Lieutenant Carter's camp during his absence; but, on his rejoining the camp, Mr. Low at Captain Montgomerie's suggestion, was directed to return to Dehra, to be in readiness to join Mr. Johnson, should it be determined that that officer should again proceed to Ladak. On rejoining the camp, Lieutenant Carter found that there was a rumour that two men, who had been sent to signal from Jatropani H.S., had been snowed up (the station being between 13 to 14,000 feet high). No time was lost in sending them assistance. Snow had fallen from the 28th February to 5th March. After a fortnight, news was brought that, though badly frostbitten, the men had managed to escape with their heliotrope, leaving everything else behind. On the 24th, Gwanagarh H.S., the centre station of the next figure, was reached, where the snow lay four feet deep, and the station was not finished till the 8th of April, owing to no heliotrope being shewn at Jatrapani for some time. On subsequent enquiry, it appears that the classie had to cut a ray through the snow 60 yards long and 10 feet deep. A similar ray had to be cut to Ragshi, the next station visited, which was also well covered with snow. A delay of 15 days was caused here, owing to the bad cloudy weather, during which time it was impossible to get three clear hours, which was all that was wanted to complete the observing, the first two days after reaching the station having been fine. Kankra H.S. was finished by the 4th of May, and Jatropani H.S. reached on the 8th. A snow storm lasted till the morning of the 10th; the snow lay over three feet deep; however, the next three days being fine, the work was completed; this finished the second figure. The heat in the valleys was getting great, and it was thought advisable to return to Dehra, which place was reached on the 25th of May. The health of the men had been good, notwithstanding the bad weather and great changes of temperature; from the nine stations observed from, 56 snowy peaks were fixed, with common sides to each, and three observations for altitude, also 24 secondary points, in addition to the principal work, and their altitudes observed from three stations.

Mr. W. H. Johnson,
„ C. Wood,
„ H. E. T. Keelan,
„ Braithwaite.

Approximate work.

The approximate work was carried on very successfully by Mr. Todd, Civil 2nd Assistant, who built stone pillars, set in lime, at each station, with a rubble platform isolated from the pillar. The two terminal stations on the left bank of the Kali river are well situated for extension into the Nepal country at any time. Great credit is due to Mr. Todd for the efficient way in which he carried out the duty deputed to him, and his choice of stations.

Mr. Todd, in building the platform and pillar at Jatrapani H.S. (13 to 14,000 feet high), at the end of January, shewed great energy. He was once driven down by a snow storm, but taking advantage of a few fine days afterwards, he succeeded, when a less energetic officer would have given in. The natives were, with difficulty, persuaded to accompany him, being frightened of getting caught in a snow storm, when it would have been difficult to have got down from the peak, the ascent being difficult at any time.

Secondary Triangulation.

The secondary triangulation, under Mr. Beverley, was exceedingly satisfactory, and that officer was able to supply sufficient points for Lieutenant Pullan to take up a plane table by the end of November, and two plane tables subsequently, at the end of February. Two elephants were placed at Mr. Beverley's disposal, as it was found that the natives would not go about the jungles on the low hills skirting the plains (called the Baba) to erect staves, on account of tigers, &c. Mr. Beverley was enabled, with the assistance of the elephants, to clear places to observe from, and in the next December will be able to give the topographical assistants points on the low hills, and in the bamboo jungle outside. These points will chiefly be marked by flags, and it will be necessary to observe and compute them out immediately, before the plane tablers take the ground, otherwise the flags would be liable to be blown down or lost. Mr. Beverley is well able to undertake this piece of work, both on account of the rapidity with which he works, and the accuracy of his computations.

Topography.

Lieutenant Pullan took up his first plane table at the end of November, and continued in the field till the 20th of April (with the exception of the month of February, when he was called in to Dehra by Captain Montgomerie). Lieutenant Pullan's plane table is very accurate. Boiling point observations were taken at villages, fords of rivers, passes, &c., and, in addition, Lieutenant Pullan noted much useful information, with reference to inhabitants, winter crops, &c.

The above remarks will, I hope, prove that the work in Kumaon and Gurhwal was pushed on satisfactorily with the small party in the field.

I have dwelt in detail on the work performed by Lieutenant Pullan, Messrs. Beverley and Todd. With reference to the rest of the party employed in Kumaon :

Mr. Neuville, Civil 2nd Assistant, was employed by Captain Montgomerie during the recess, and till the 4th of February, 1865, when he proceeded to join Lieutenant Carter's camp, to assist in recording, and the current duties connected with the party. Mr. Neuville being a Civil 2nd Assistant, this was not the work for him, but there was nobody else available.

Mr. J. Low, Senior Sub-Assistant, on return from Kashmir in the beginning of December, 1864, was employed finishing up his field season's sketching in the Shayok till 12th of January, when he was deputed to join Lieutenant Carter's camp, in place of Mr. Braithwaite, sick.

He joined too late to assist in the observatory before Lieutenant Carter went to Dehra, but took charge of the camp during his absence, and on his return proceeded to Dehra, to be in readiness to join Mr. Johnson, in case that officer went again to Ladak. Mr. Johnson did not start till the end of May, when Mr. Low accompanied him. The amount of sketching done by Mr. Low in Ladak and Shayok valley amounted to 1,400 square miles, on scale of 4 miles to the inch.

Mr. C. Braithwaite, 2nd Class Sub-Assistant, though unfortunate in being sick, has since, being in office, worked very well, and I hope next season (after a little practice) will be able to turn out a good season's topographical work.

In conclusion, I beg to state that during the seven months the party was in the field, no difficulty of any kind was experienced in carrying on work ; and though the out-turn of topographical work is small, I trust that next season having more topographical assistance, and a sufficiency of points fixed, the quantity of sketching will be considerable.

The instrument employed for the principal work was the new 14-inch, No. 2, by Troughton and Simms', with five verniers on the horizontal circle, and four verniers for the vertical circle, which is complete.

The instrument was lately received from England, and it is the first time it has been used.

The instrument employed for the secondary triangulation was a 12-inch, No. 12, by Troughton and Simms', with three verniers on the horizontal circle, and two on the vertical circle.

Observations for principal work were taken on four pair of zeros, 6 observations on each, for horizontal angles, and for vertical angles 2 pair of observations, face right and face left on each day at the station. For secondary work, observations were taken on two pair of zeros, 4 observations on each, and for intersected points on 1 pair of zeros. Heights were taken on face right and face left.

The above relates entirely to the proceedings of those of the party actually employed in Gurhwal and Kumaon, in addition to which a large portion of the Kashmir party (as per margin) were employed on work chiefly connected with Kashmir, and did not take the field in Kumaon.

KASHMIR SERIES.
Mr. W. H. Johnson,
„ C. Wood,
„ H. E. T. Keelan,
„ J. Low.

Mr. W. H. Johnson, Civil 1st Assistant, returned from Kashmir in the beginning of December, 1864, having completed 6,900 square miles of sketching, on the scale of 4 miles to the inch. Mr. Low also returned with Mr. Johnson, the number of square miles sketched by Mr. Low being 1,400.

Captain Montgomerie has already expressed his great satisfaction with the result of Messrs. Johnson and Low's field season's work of 1864-65. Mr. Johnson, accompanied by Mr. Low, has again proceeded to Ladak, with sanction of Superintendent G. T. Survey, at the suggestion of Captain Montgomerie. From the time of Mr. Johnson's return, to his leaving again for Ladak, he was employed in bringing up the computations connected with the General Report Kashmir Series. Mr. Low was also similarly employed while in recess.

Mr. Wood, 1st Class Sub-Assistant, was employed during recess of 1864, till 1st May, 1865, in bringing up Kashmir work and General Report, and gave satisfaction. Mr. Wood was transferred to Computing Party from 1st May, 1865.

Mr. Keelan was attached to the Kashmir Series, particularly that he might have rest from field duties. Mr. Keelan has not been employed in the field, but his work in office has been very satisfactory. Mr. Keelan was, however, employed in fixing points at Mussoorie for survey, on scale of 12″ to the mile, and performed his work very creditably.

This party, consisting of two Bhooteahs, Mani and Nain Sing, arrived in Nepaul in March, 1864, and at the end of the month endeavoured to proceed to Lassa. Though they were provided with a perwannah from Maharajah Jung Bahadoor, they were stopped nine marches from Nepaul, and obliged to return. They have since determined to try to reach Lassa by going different roads with merchants. The chance of their reaching Lassa is doubtful; but Major Smyth, Inspector of Schools, Kumaon and Gurhwal, who, I believe, recommended the two men, holds the opinion that, if the project is feasible, the two Bhooteahs will carry it out.

Trans-Himalayan Party No. 2.

EXTRACT FROM THE NARRATIVE REPORT OF CAPTAIN NASMYTH, R.E., IN CHARGE NORTHERN BOMBAY PARTY, NO. 139, DATED 23RD AUGUST, 1865.

(2.) The party having been called into existence in the previous November, had been employed in the Peninsula of Kattiawar, under the orders of Captain Haig, R.E. Mr. A. D'Souza, the Civil Assistant appointed to it, had been entrusted with the training of Mr. Nathaniel Gwinn and Mr. William Waite, Sub-Assistants, and 254 square miles were sketched of the country round about, and to the westward of the town of Gogo.

(3.) The rains of 1864 were scanty, and in Guzerat to such an extent that the Government of the Presidency had the matter under its consideration, for the purpose of alleviating a threatened famine. Kattiawar was naturally in the same straits as Guzerat; and as I had become aware, moreover, that a delay in the execution of the survey would suit the views of the Political Agent of the Province (on account of boundaries that had not yet been defined), I proposed to the officiating Superintendent that the survey party should be temporarily employed in some other locality.

There was no part of the Presidency that had been topographically surveyed by the G. T. Survey. The maps in existence were understood to be, for the most part, compilations from the Revenue Survey, or from surveys of detached districts, or from combinations of both, and the facility therefore of getting a favorable trigonometrical basis for the work ruled the choice of the new district. I recommended the western portion of the Ahmednuggur Collectorate, my idea being less to produce materials for the map of India, as to promote the training of my establishment, while Kattiawar was getting over its hard times.

It appeared to the officiating Superintendent to be undesirable to make a mere temporary change of the field of survey, and he accordingly, before adopting my proposal, directed me to put myself in communication with the Bombay Government, in respect to the selection of a new district. The field season having already commenced, I proceeded immediately, in person, to see His Excellency the Governor of the Presidency, and, in due course, I was instructed that, for revenue purposes, surveys were required of the following three districts, viz.: that above the Bhore Ghat, that above the Thul Ghat, and that of Indapore.

The second of these being the district which I myself had recommended to the officiating Superintendent, as presenting facilities in the way of triangulation already executed, was the one which I took in hand, and I at once removed the establishment to it from Poona.

(4.) The greatly increased cost of living in this Presidency had borne very heavily during the recess upon the European Uncovenanted Assistants both of Captain Haig's party and my own. The juniors were drawing Rs. 107 a month, and that was not sufficient, at that time, to feed, lodge and clothe them. The contracts which the Sub-Assistants had signed on joining the Department, and by which they became bound to remain in the Survey for three years, restrained the juniors from leaving me; but Mr. A. D'Souza, whom I could ill afford to lose, representing to me that his position on the Survey was a less advantageous one than he could secure elsewhere, begged that I would submit his application to resign for favorable consideration. The case of the Uncovenanted Assistants of the Survey had been fully reported to the officiating Superintendent, and by him laid before the Supreme Government, but nothing had yet been done. Mr. A. D'Souza being then near to his promotion, the officiating Superintendent recommended his advancement to the grade of Civil 2nd Assistant at once, and, on the promotion being granted, Mr. D'Souza withdrew his resignation, and has remained with the party, the same cheerful and hard-working Assistant I had before found him to be. With the Sub-Assistants, whose number had now, by the appointment of Mr. Thomas Henry Rendell and Mr. Conception D'Souza, been increased to four, the evil of too low pay bore full fruit. I had advanced to each as much of their pay as I considered myself warranted in doing, but my orders at this time to the Sub-Assistants were not carried out, and the advancement of the work was stopped, from an absolute want of means of meeting current and travelling expenses. By degrees, the addition to their pay which the Sub-Assistants receive as travelling allowance, mended matters a little, but the loss to the work in the early part of the season, by reason of inefficiency from the above cause, was considerable, and very particularly inconvenient.

(5.) In October, Lieutenant Skinner, R.E., was appointed to the party, and in December he joined it. But his zeal was early checked, for he found that, with cost of carriage, and the cost of everything else so much enhanced as it is in these days, his salary was inadequate to meet his expenses if he moved about as much as his duty required. He submitted an application for travelling allowance, with the request that if it were not found convenient to grant it, he might be allowed to return to the position he had quitted in the Public Works Department.

I was happy in having Mr. A. D'Souza, when there was so much that was discouraging to contend with, for he never tired, but was always ready to add to his own already large share of the burden.

(6.) The G. T. Survey triangles in the district, which we had taken up, were very large. One of them Bowargarh H.S., Sindhar H.S., Kalsobahi H.S., was, however, symetrically broken up, first into triangles of from 10 to 12 mile sides, and from that into others of from 5 to 8, 3 to 4, and finally to 1 mile sides.

(7.) The largest of these triangles were observed with the 14-inch instrument, and those next in magnitude were disposed of incidentally at the same time. Both had regularly constructed stations, with hollow centre pillars of masonry, and isolated platforms round about, for the observer.

The height of the stations varied from 2 to 4 feet, according to its importance, and all had a mark engraven on the rock, or a mark-stone set in the lower course of the foundation, and another on the surface of the ground, besides the one at the top of the pillar.

(8.) At the old station of Bowargarh a small round hole was found cut into the rock, about 2 inches in diameter, and about $1\frac{1}{2}$ inches in depth, and in that the station mark had remained secure from injury, although there was no trace to be found of mark-stones. At Sindhar there had been a "meyla" on the hill since the observations had been taken, and the station was said to have been destroyed, but the position was recovered by Lieutenant Skinner so skilfully, that, in re-observing the old triangles as a check, the new values of the angles were much the same as the old. At Kalsobahi, the station, which is one of the highest points in the Dekhan, had not been disturbed at all.

The angles of the triangles, down to 5 miles, were observed at 4 zeros, viz., 0°, 30°, 180° 210°. The triangles of shorter sides were observed with 7-inch instruments, while the 1 mile triangles were disposed of with 5-inch instrument.

(9.) Under my instructions the object contemplated was the completion of triangulation sufficient for the employment of all the plane tables that could be brought into the field in the following season, but your visit to Bombay having resulted in the proposal to employ the Northern Bombay Party in a survey of the Island of Bombay, I reduced the area I was working upon, and concentrated my establishment nearer to the ghat, that I might be able to finish some portion of the district out of hand, and have something, at least, to produce for our season's expenditure. I assigned to Mr. A. D'Souza to Mr. Gwinn and to Mr. Waite, to each of them a set portion of the reduced area. Each in the area assigned to him selected minor points, observed them from the stations already fixed, protracted them, and finally, with the plane table, filled in the detail and shading of the hills. Mr. Rendell accompanied Mr. D'Souza, and when he had gained confidence sufficient, he carried on by himself the minor triangulation. Wissagee Ruggoonath, the Native Surveyor, was similarly employed. Lieutenant Skinner was withdrawn from the Northern Bombay Party on the 7th April, that he might take charge of the Bombay Party during Captain Haig's absence in England.

(10.) The duties above detailed were only completed by the beginning of June, and the result of our work has been—

17 stations visited with the 14-inch instrument,

46 stations visited with 7-inch instrument, and 29 stations visited with 5-inch instrument.

With large triangles there has been completed an area of 647 square miles, and 45 stations have been selected, covering a further area of 3,240 square miles. Of these selected stations, 5 fall within the area quoted, and 29 of the number have been built.

With triangles of from 5 to 8 mile sides, an area of 302 square miles has been disposed of.

With triangles of 1 to 3 mile sides the total area completed is 224 square miles.

EXTRACT FROM THE NARRATIVE REPORT OF H. H. TAYLOR, ESQ., 2ND ASSISTANT G. T. SURVEY, IN CHARGE NO. 1 ASTRONOMICAL PARTY, NO. 54, DATED 26TH JULY, 1865.

On my return from leave to England on the 31st October last, in Calcutta, I was placed in charge of Astronomical Party No. 1 by Department Orders, and took immediate steps to have the instruments transferred from the Mathematical Instrument Department, in whose care they had been placed by Mr. Armstrong, on his giving up charge of the Astronomical Party the year previous. I also took the necessary steps for the reconstruction of a temporary observatory on the original site chosen by Lieutenant Thuillier, in the compound of the Mathematical Instrument Department, as also to prepare a list of stars in pairs north and south of the zenith, in conformity with instructions contained in your No. $\frac{6}{689}$, dated Dehra Doon, 14th October, 1863, to Lieutenant Campbell.

(2.) The list of stars was chosen from the Greenwich Six-Year Catalogue, the only one which was then at my disposal, from which I had some difficulty to select 90 well-known stars, the number required by the instructions aforesaid. To complete this number I could not avoid, in some cases, choosing 3 or 4 stars following so close after one another in transit, that it was impossible to observe them all in one evening, so that this was a great cause of delay in completing the observations in Calcutta. The weather also was unfavorable in January and February last, which caused a further delay in the operations.

(3.) I commenced taking observations on the 8th December, and completed on the 16th February following. During the interim, Mr. G. W. Atkinson, attached to Astronomical Party No. 1, was despatched to the next station of observation at Maluncha, for the purpose of constructing an observatory over the station platform. I also took steps for the construction of a portable roof, which was sent by coolies, accompanied by a tindal and 8 khalasees, by road to Maluncha.

(4.) On my arrival at Maluncha, on the 2nd March, I found that the roof had arrived, and that the observatory was ready for the reception of the instrument. The observatory was built chiefly of stone, with a few pucka bricks for the cornices, and with four walls 2 feet thick.

The collimator pillar was composed entirely of pucka bricks, as also the pillar for the distant meridian mark. The weather was unfavorable from the very first of my arrival, and I had no opportunity to get observations of Polaris, to determine my meridian, for nearly a month; and, when at length I succeeded in this, I am sorry to report I had no opportunity of doing anything; the bad weather still continued, and when it cleared, the wind blew in such gusts that I was really unable to take satisfactory observations. I have actually commenced observing on a fine clear night, with a full expectation of doing a good night's work, and after observing two or three stars, it has suddenly come on to blow, with a fine clear sky, and without any apparent cause. The few observations that were taken have been rejected.

(5.) On the 4th April a heavy gale blew the whole day. In the forenoon a shed, in which the barometer and thermometer were deposited during the day for safety, was blown down, and I was just in time to rush in and save the contents. In the afternoon a very heavy north-wester, which lasted two or three hours, swept across the country, and unfortunately carried the roof of the observatory with it. Such was the force of the wind that several native houses, even in the plains below, were destroyed (as I was informed by the villagers), and there was no wonder that the roof of a building so exposed as the observatory, and without the slightest protection from the elements, should have suffered. I could not stand upright, on account of the force of the wind, and it was only after three or four attempts that I at length succeeded in reaching the observatory (a distance of less than 10 yards), when I proceeded at once to dismantle the instrument (with no small difficulty, since the dust was enough to blind one, and found it impossible to keep my eyes open).

The roof was secured by no less than 16 ropes, tied to strong wooden pegs let into the wall. The whole construction was blown away to atoms, and its pieces could not be found.

(6.) Previous to the destruction of the roof, Mr. Atkinson was despatched to Chendwar to construct the observatory for that station. He built the observatory, but, owing to the hazy weather, was unable to see the heliotrope at Parasnath hill station, to determine the meridian sufficiently exact to erect the meridian mark or collimator pillars. The distant meridian mark at Maluncha was satisfactorily determined by Mr. Atkinson, whose health, I am sorry to report, was very indifferent.

EXTRACT FROM THE NARRATIVE REPORT OF LIEUTENANT W. M. CAMPBELL, R.E., 1ST ASSISTANT, IN CHARGE ASTRONOMICAL PARTY NO. 2, DATED 21ST JULY, 1865.

(2.) During field season 1864-65 observations have been made at the stations of Usira, Kasri, Pahargarh, Kalianpur and Ladi. The dates of commencing and closing work at each station are given in the following Table :—

Names of Stations.	Geodetic Latitudes.	Dates of			Remarks.
		Arrival.	Commencement of Observations.	Completion of Observations.	
		1864.	1864.	1864.	
Usira H.S., ...	26° 57′ 0″	7th November.	17th November.	2nd December.	
Kasri, ...	25° 46′ 34″	13th December.	17th December.	7th January.	
		1865.	1865.	1865.	
Pahargarh, ...	24° 56′ 7″	14th January.	17th January.	31st January.	
Kalianpur, ...	24° 7′ 12″	6th February.	10th February.	16th March.	
Ladi, ...	23° 8′ 44″	22nd March.	29th March.	15th April.	

(3.) At Kalianpur the work was greatly retarded by the sickness of Mr. Belcham, whom I was obliged to send to Goona on 23rd February, for medical assistance.

Mr. Belcham's illness unfortunately occurring just after Mr. Wood had proceeded to Ladi (according to custom, to prepare for observations there), I was left without any one to act as recorder, and the work was consequently brought to a close, until Mr. Wood's return from Ladi, on 12th March.

(4.) I closed the field season's work at Ladi on 15th April, and proceeded to Schore, where I purposed leaving the instrument and stores during the recess. On 20th April, the office marched from Schore, *en route* to Mussoorie, where it arrived on 24th May, since which date the party has been employed on the computations of the season's work.

(5.) I am glad to be able to report that these computations are now in a much more forward state than was the case last year.

Owing to a new arrangement of forms, by which the labor has been greatly reduced, and also to the greater experience of the party in the work, I was enabled to complete more than one-fourth of the whole work in duplicate in the field.

(6.) The computations of Usira H.S. are now completed. The results arrived at shew, I think, an improvement on those of last year in the accordance of observations on the same face.

(9.) With regard to my two Assistants, Messrs. 2nd Class Sub-Assistants J. Wood and G. Belcham, I am glad to be able to repeat the good opinion which I offered last year.

The willingness and perseverance with which they went through very hard work during the first half of the field season, for the completion of last year's work, reflect great credit upon them both.

I fear this extra work told on Mr. Belcham's health, for, as I have already stated, he broke down in February, and had to go to Goona, where he remained under treatment for fever for about an onth, after which he rejoined me at Ladi, but remained quite unfit for duty during the remainder of the season.

EXTRACT FROM THE NARRATIVE REPORT OF LIEUTENANT H. TROTTER, R.E., 2ND ASSISTANT, IN CHARGE LEVELING OPERATIONS, NO. 330, DATED 31ST JULY, 1865.

(1.) The party left head-quarters at Dehra Dhoon on the 4th October, 1864, and marched the whole distance to Agra (whence work had to be commenced), where they arrived on the 26th of the same month. The weather having been very hot, no less than eleven khlassies (out of a total of twenty-six) were down with fever on arrival, and I accordingly kept the camp stationary until the end of the month, to give the khlassies a chance of recovering their health. This policy was, in a great measure, successful, as the greater part of the invalids were able to proceed with the camp on the 1st November.

(2.) Meanwhile I endeavoured to find the old G. T. S. bench-mark on the Agra goods' station platform, connected by Mr. Carty some years before, in order that I might start my season's work from it. A mark was pointed out to me as such, but as I could not, with any certainty, identify it as being the original mark, I was obliged to go back five miles on the Allyghur road, and run a check line from the top of the 46th mile stone from Allyghur, *vid* Nandlalpore bench-mark, up to the point in question. The differences of height exactly coincided (2nd place of decimals of a foot), with the differences taken from the published table of heights, and I therefore felt justified in assuming it to be the actual point connected by Mr. Carty, and in adopting it as the datum for our season's operations.

(5.) I continued working along, or close to, the railway, as far as Skekoabad (36 miles), which I reached on the 15th November. I then determined to follow the Grand Trunk Road to a point just short of Mynpoory, whence I should turn down the Cawnpore branch Ganges Canal, and follow its banks until I reached Cawnpore.

(6.) On the 26th November, I had reached Singhpûr, the point of junction of the Grand Trunk Road with the canal. Here I turned down the latter, and working along it, I arrived at Cawnpore, a further distance of 106 miles, by the end of December.

(7.) From Cawnpore, the Grand Trunk Road to Allahabad runs nearly parallel to, and only at a short distance from, the East India Railway. As I found the former more convenient for work than the latter, I worked along it almost constantly, taking care, however, to connect the railway levels at intervals.

(8.) I was delayed for a few days in the neighbourhood of Cawnpore by a smart attack of fever.

(9.) I reached Allahabad on the 18th February, and while there endeavoured to level across the Jumna, to connect the levels of the Jubbulpore Branch Railway with our own. There was so much difficulty and risk however in lifting the instruments on to the bridge piers that, after one trial, I resolved to postpone the attempt until my return to Allahabad, when I should have more leisure, the bridge would be further advanced, and the consequences of an accident would not be so disastrous, for the completion of our long line of levels, the main object of so many season's work, would then have been effected.

(10.) I therefore continued our main line, crossed the Ganges at Allahabad, and working along the Grand Trunk Road, reached Patka Gerouli (where I had closed the line from Calcutta, the previous season) on the 20th March.

(11.) The values of height of Patka Gerouli, as brought up from Karachi and Calcutta, differed by $2\frac{1}{2}$ feet, this being the amount by which the assumed mean sea level at Calcutta is higher than the corresponding level at Karachi.

(12.) Throughout the whole of these operations the *modus operandi* given in the introduction to the printed table of heights was rigidly adhered to, with the following exception :—In the previous season's work, the total length of the forward sections had been allowed to exceed that of the back sections by about fifty miles. This was done in order to get through as much work as possible during the season, it being easy to take advantage of a fine cloudy day to continue working from sunrise to sunset at a forward section, when as much as seven or eight miles can sometimes be got over ; whereas, the length of a back section is always limited to a moderately good day's work, say four miles, which amount must always be fixed before work is begun for the day). In order to compensate for the excess of forward over back sections the previous season, I reversed matters in this, by making the corresponding back sections exceed the corresponding forward sections by the same amount, thus making the forward and back sections throughout the two season's work exactly balance each other.

(13.) The maximum divergence during the season's operations between results obtained by different observers, with different staves and levels, did not exceed one-seventh of a foot. This difference had gradually accumulated up to the close of operations at Patka Gerouli.

(14.) The special work on which the party at my disposal had been employed for so many years having now happily been brought to a conclusion, I had to determine how the party could most usefully be employed for the remainder of the field season.

(15.) Being in the neighbourhood of Mirzapore, I determined, as a commencement, to carry a branch line across to the latter place, to connect the E. I. Railway there (which had not been connected on either side for a considerable distance), and to lay down a bench-mark, so that, should it be determined on any future occasion, to run levels across India, a good starting point might be ready at Mirzapore. I also hoped to be able to connect the levels, if existing, of the Great Deccan Road, but as none of the P. W. authorities at Mirzapore were able to give me information as to the existence or non-existence of such levels, I was, perforce, obliged to give up the latter idea.

(16.) This branch section (9 miles) was finished on the 15th March, the River Ganges having been crossed without much difficulty.

(17.) I then proceeded to Benares, where, I had hoped, from information received from the Executive Engineer, 3rd Division Grand Trunk Road, to find several sets of levels in the D. P. W. Offices. In this also I was disappointed, but the time was not lost, as, when there, I effected a careful connection with the river level at Benares, which may be of much use in relation to the Soane Canal project. I also connected a set of cantonment levels.

(18.) From Benares I marched back to Allahabad, where I arrived on the 29th March, having connected, *en route*, the ends of the three small branch roads from Mirzapore, joining the Grand Trunk Road at Maharajgunje, Ooraie and Gopeegunje, respectively, (all of which had been leveled over by the D. P W).

(19.) On arriving at Allahabad, I found that the bridge over the Jumna had progressed so rapidly that I was able to get my instruments up to the top of the piers without difficulty, and run a line across to the junction of the Jubbulpore Branch, with the main line of the E. I. Railway. I connected three of the original bench-marks of the Jubbulpore Railway, and laid down one of our own bench-marks in the neighbourhood of the junction. This was finished on April 1st, on which day I recrossed the Jumna, and on the 2nd I commenced a branch line, to connect the levels of the Allahabad and Fyzabad road. In order to effect this I had to level to a place called Malaka, on the west bank of the Ganges. A connection was made on the 6th, a bench-mark laid down, and on the following day the party started marching to head-quarters, where they arrived about the middle of May, myself and office having arrived some days sooner.

(20.) The following table shows the total distance, leveled over during the season :—

Month.	Main Line.	Branch Line.	Total.
October, ...	...	(Check.) 5	5
November, ...	77½	14½	92
December, ...	90½	12	102½
January, ...	75	5	80
February, ...	69	10	79
March, ...	30½	25	55½
April, ...	...	8	8
Total, ...	342½	79½	422

Grand Total, ... 422 miles.

(21.) Permanent stone bench-marks (consisting of large pyramidal-shaped blocks of stone, weighing 4 or 5 maunds each, and with the letters G. T. S. bench-march cut into the upper surface) have been laid down at all stations of importance along our line of operations, such as Agra, Mynpoory, Cawnpore, Futtehpore, &c., besides at intervals along the whole line of from ten to twenty miles. The total number laid down during the season amounting to twenty-seven.

(22.) Besides these, more than 350 pucka points, such as bridges, mile-stones, railway platforms, &c., have been connected, and their heights determined.

(23.) Our main line of levels passed through several of the G. T. Survey Meridional Series, lying between the N.E. and the Calcutta Longitudinal Series, and satisfactory connection has been made with the following nine principal stations:—

Badhon Series,	Ferozabad	S.
	Baragoan	S.
Rangir Series,	Bisangarh	S.
	Kalsan	S.
Amua Series,	Jhajmao	S.
Karara Series,	Majilgaon	S.
	Karra	S.
Gurwani Series,	Ganespur	S.
	Baripur	S.

(24.) At most of the G. T. Survey stations visited by me during the past season, either the lower or upper mark-stones have been found in a good state of preservation.

(25.) Connection has been made in several places with the Ganges Canal and E. I. Railway levels main line, also with the Jubbulpore Branch Railway, the three small branch roads running from Mirzapore to the Grand Trunk Road, the Allahabad and Fyzabad road, and at Cawnpore, with the Oudh Railway Company levels.

(26.) I applied during the past season to the Consulting Engineer, Bombay Government, for details of the Bombay Railways, and requested him to take measures to connect their datum with the mean sea level. These details have not yet been supplied.

(27.) I also applied to Mr. Le Mesurier, Chief Engineer of the Jubbulpore and Allahabad Railway, for details of the levels of the railway under his charge, and also for data whereby these levels could be connected with the Bombay Railway. With the exception of one small section, these details have already been supplied, as also the required data.

(28.) From the Chief Engineer, Oudh Railways, I have obtained some useful information regarding the railway levels of that province.

(29.) It appers that Oudh is now intersected by a network of levels. The main railway line runs from Buxar (where we have a bench-mark) to Moradabad, with branch lines running to Benares, Cawnpore (*vid* Lucknow) and Allyghur, at all of which places we have bench-marks; other branch lines run to Kat godown (near Nynee Tal) and Fyzabad. Besides these, the D. P. W. have more levels from Lucknow, as a centre, to Byramghat, Fyzabad and Seetapore. There are also levels between Fyzabad and Allahabad. The railway levels are in process of being connected together The D. P. W. levels are, I believe, all independent of each other, and not all complete, even in themselves. From a general connection of all of these levels, a very valuable table of heights might be prepared.

(30.) I have the honor to bring to your notice the readiness with which Mr. Sibley and Mr. Le Mesurier, Chief Engineers, E. I. Railway, of N. W. Provinces and Jubbulpore branches, respectively, always gave me any information and assistance in their power.

(31.) I have also to bring to your notice, generally, the co-operation I have almost always received from the various Government and railway officers that I have come across in the performance of my work.

(32.) Comparisons between our own leveling results and those of the East India Railway and Ganges Canal will be given hereafter.

(33.) In conclusion, I would bring to your notice the good services of my native leveler, Ramchund, who has been present throughout almost the whole of the G. T. Survey leveling operations, and of my recorders, Nursing Doss and Buldeo Pershad, who were entertained at the commencement of last field season.

ANNUAL RETURN OF AMOUNT AND TOTAL COST OF WORK EXECUTED IN THE DRAWING BRANCH OF THE OFFICE OF THE SUPERINTENDENT OF THE G. T. SURVEY FROM 1ST MAY, 1864, TO 30TH APRIL, 1865.

No.	Description of Work.	Remarks.	Cost. Rs.	As.	P.
	Sheet No. 1 (Jamoo Territories) scale 2 miles = 1 inch, ...	For Lithography, *vide* return for 63-64, ...	176	6	0
	Do. No. 2 do., do., ...	Do. do., ...	322	3	0
	Do. No. 3 do., do., ...	Do. do., ...	252	0	0
	Reduction of Rough Map of parts of the Bustar and Jeypoor Territories on the scale of 8 miles = 1 inch, ...	For Photography, do., ...	152	0	0
	Sheet No. 6 or Section No. 12 new Kashmir Map, ...	For Home Government do., ...	756	0	0
	Section No. 12 new Kashmir Map,...	For Photography, do., ...	800	4	0
	Do. No. 2 do., ...	Do. do.. ...	158	10	0
	Do. No. 5 do., ...	Do. do., ...	199	10	0
	Do. No. 1 do., ...	For Photography, ...	187	0	0
	Reduced and Incorporated Coast Series, Eastern Frontier Series, Kashmir Meridional Series, Sutlej Series season 1861-62 and Madras Meridional Series 1863-64 in the Lithographed Index Chart to the G. T. Survey of India scale 96 miles = 1 inch, ...	... ...	46	10	0
	Preliminary Chart of revised portion of West Calcutta Longitudinal Series season 1863-64 scale 4 miles = 1 inch,...	For Surveyor General, ...	27	0	0
	Ditto, ditto, ditto, ...	For Home Government, ...	37	0	0
	Synopsis of ditto, ditto, ditto, ...	For Surveyor General, ...	11	15	0
	Ditto, ditto, ditto, ...	For Home Government, ...	12	0	0
	Gurhagarh Meridional Series G. T. Survey, Chart of a reconnoissance made during field season 1861-62 in Beekaneer and Jodhpoor scale 4 miles = 1 inch, ...	For Surveyor General, ...	27	0	0
	Ditto, ditto, ditto, ...	For Home Government, ...	32	0	0
	Preliminary Chart of the Astor Triangulation season 1863 scale 4 miles = 1 inch (original), ...	For Office use, ...	44	0	0
	Ditto, ditto, ditto, ...	For Surveyor General, ...	40	10	0
	Ditto, ditto, ditto, ...	For Home Government, ...	42	0	0
	Inserted distances in feet in Trace of a portion of N. E. Longitudinal, Ranghir and Budhaon Series, received from Captain Thomason, Executive Engineer, Rohilcund Canals,	... ...	113	0	0
	Inserted distances in miles in Kashmir Meridional Series Chart season 1861-62, ...	For Office use, ...	16	0	0
	Extract from the Assam Longitudinal Series Chart (on linen),	For Captain Austen, ...	28	10	0
	Preliminary Chart of the Kashmir Meridional Series seasons 1861-62-63 scale 4 miles = 1 inch, ...	For Home Government, *vide* return for 1863-64, ...	54	8	0
	Do. of the Laskar Triangulation season 1863 do. (original),	For Office use, ...	68	0	0
	Ditto ditto ditto ...	For Surveyor General, ...	32	0	0
	Projected Khagan Triangulation season 1863 scale 4 miles = 1 inch (original), ...	For Office use, ...	56	0	0
	Map of a portion of Bisahir, enlarged from the original plane table sections of the N. W. Himalaya Survey from 2 miles to 1 mile = 1 inch, ...	For use of the Forest Department,	452	0	0
	Preliminary Chart of the Eastern Frontier Series season 1863-64 scale 4 miles = 1 inch, ...	For Surveyor General, ...	26	0	0
	Ditto ditto ditto ...	For Home Government, ...	49	0	0
	Preliminary Chart of the Madras Meridional Series season 1863-64 scale 4 miles = 1 inch, ...	For Surveyor General, ...	53	5	0
	Ditto ditto ditto ...	For Home Government, ...	73	10	0
	Extract from Mr. Johnson's plane table sections season 1864 (Kashmir Survey), ...	For Captain Montgomerie, ...	27	10	0
	Prepared a Trace of Mr. Johnson's plane table section season 1864 Kashmir Survey (on linen), ...	Do., ...	30	0	0
	Do. of Mr. Johnson's 2nd plane table section ditto, ...	Do., ...	32	0	0
	Do. of Mr. Low's plane table section ditto, ...	Do., ...	30	0	0
	Section No. 10 Kashmir Survey for Home Government, ...	Outline and Hill Shading finished,	1,420	0	0
		names remaining to be printed,	1,768	13	0
	Do. No. 11 do., do., ...	Do., do., ...	1,052	0	0
	Do. No. 13 do , do., ...	Do., do., ...	1,566	10	0
	Do. No. 14 do., do., ...	Half of the printing finished, ...	1,587	0	0
	Do. No. 15 do., do., ...	Outline finished, ...	300	0	0
	Do. No. 15 Kashmir Survey (for Photography), ...			0	0
	Printed names in 12 Diagrams of the Great Longitudinal Series Triangles scale 8 miles = 1 inch, ...	For the use of Computing Office,	22	0	0
	Printed names in 8 Diagrams of the Gurhagarh Meridional Series Triangles scale 8 miles = 1 inch, ...	Do., ...	20	0	0
	Printed names in 10 Diagrams of the Rahoon Meridional Series Triangles scale 8 miles = 1 inch, ...	Do., ...	22	0	0
	Printed names in 2 Diagrams of the Jogi Tila Series Triangles scale 8 miles = 1 inch, ...	Do., ...	4	0	0
	Prepared 3 Copies of the Alphabet, ...	Do., ...	10	0	0
	Telemeter Scale, ...	For Captain Basevi, ...	6	0	0
	Preliminary Chart of the Tillail, Khagan and Astor Triangulation, seasons 1861-62-63 scale 4 miles = 1 inch, ...	For Surveyor General, ...	114	0	0
	Colored Lithographed Map of Jamoo Kashmir (in 4 sheets),	For Office use, ...	16	10	0
	Reduced Sutlej Series Chart from 4 to 16 miles = 1 inch, ...	For the use of the Computing Office, ...	14	3	0
	Made 4 Copies of Budget for 1864-65, ...	... ...	18	0	0
	Examination of 25 Preliminary Charts, &c., ...	... ...	22	0	0
		Cost Rupees, ...	12,429	3	0
		Add Cost of 9 Apprentices learning Drawing, &c., ...	503	0	0
		Total Cost Rupees, ...	12,932	3	0

Office of Superintendent G. T. Survey.
Dehra Doon, 1st May, 1865.

W. H. SCOTT,
Civil Assistant G. T. Survey of India,
In charge Drawing Office.

NOTES ON THE PANGONG LAKE DISTRICT OF LADAKH, FROM JOURNAL MADE IN 1863, BY CAPTAIN H. H. GODWIN-AUSTEN, F.R.G.S., TOPOGRAPHICAL SURVEYOR.

To the *north* of the Indus from its junction with the Dras river, lie a high range of mountains which separate the Indus drainage from that of the Shayok or Nùbra river. The axis and great mass of this range is granitic; on the west this extends to within a very short distance of the river, while at Pitùk below Leh, the granite hill on which that large and well-known monastery stands abutts on the Indus itself, and thence towards the east for a considerable distance it holds the same position. The great mass of coarse sand-stones, red clays, grits, and conglomerates seen on the right bank of the Indus, west of Pitùk, are now seen on the left or south bank, thence to the east in the direction of Stock and Himis. On the above granite range are several passes leading into the Shayok valley, all of great elevation, and on the direct road from Leh to the Pangong lake are two, viz., the the "Chang La," and the "Kay La," both high, being respectively 17,470 and 18,250 feet above the level of the sea.

The ascent to the first is gradual from the village of Tagar in the Chimray valley, which there divides into two large ravines, the western branch leading to the Wuri La, while the eastern runs up to the two passes above-mentioned. On the 15th July, when our party crossed the Chang La, the snow that had fallen in the early part of the month still lay, covering about three miles of the road, and being fresh, it was glaringly white in the sun, and much affected the eyes of our servants and the coolies, while all suffered more or less from the effects of the rarified air; curious to say, on the return journey *viâ* the Kay La, 800 feet higher, scarcely a man suffered from this cause, we had then been living for some time at a high altitude, which very probably had not a little to say to our immunity from the fatigue and headache engendered at high elevations. The mountains on the northern side are perfectly bare, a little grass growing only along the bottom of the valley which had a steady easy slope the whole way to Dùrgo; a small tarn lies near the encamping ground below the pass, and another somewhat larger is passed about a mile further down the valley, and the scenery is not remarkable save for its huge scale and bleakness. Before reaching the village of Dùrgo, one emerges out of the narrow valley upon the level surface of one of those large accumulations of alluvial sands and shingles that are seen along the large valleys of these mountains; the powerful force that accumulated the materials that form them is now extinct, and the circumstances attending their formation, and more wonderful, subsequent denudation, are as yet but little understood. At this spot the vast scouring process was well exemplified, the level of the plateau on which I stood could be traced across the valley in and out of its numerous ravines in a perfectly horizontal line of a different color, where very small portions of the alluvium still adhered to the slopes and precipices; and I do not think I am exaggerating when I state that its thickness at the junction of the streams below Dùrgo was over 1,500 to 2,000 feet. Traversing the level surface of this plateau for about a mile, its edge is reached, and Dùrgo with the valley up to Tanksè is then clearly seen, a narrow green belt near the river with barren easy slopes thence to the foot of the hills.

The whole valley is very open,—low cliffs of alluvial sands and clays can be traced the whole distance on both sides,—and it is self-evident that at no very distant period this presented a long reach of water, an after sojourn on the Pangong fully confirmed this. It was in fact a drained portion of that line of lake; perhaps caused by some local alteration in the levels of the country.

From Dùrgo to Tanksè is a distance of eight miles and the road quite level. The stream is considerable and contains a small kind of fish, of which I saw numbers at the Dùrgo bridge. The road follows the right bank for nearly the whole distance, mountains rise to a great height on either side, and at the southern end of the valley, towering above Tanksè is the fine snowy peak, called in the survey, Tankse, No. 1. The village of this name is large and a very fair area is under cultivation—lucerne grass grows luxuriously. Many of the houses are built close under a large mass of conglomerate, the stones firmly cemented in it, and to this cause it must owe its present existence at the mouth of the narrow gorge towards the Pangong, out of which the soft beds have been washed away. The remains of an old fortified post still covers the upper portion of this conglomerate bed. The main stream comes from the southward, and drains the Lùng Yùghma valley and the mountains on the north of

the Indus river. It is joined at Tanksè by the small stream that drains the valley up which the road to the Pangong runs; this is at first rather shut in and confined by the mountains that rise in cliffs on either hand, but where it takes the more direct easterly direction it opens out considerably; high cliffs of the alluvial shingly deposits again occur, forming a belt at foot of the mountains of the northern side about 300 feet high and some 400 yards distant from the stream. Mùglib, where I halted, about 11 miles from Tanksè, is a very small place. At this point a broad belt of green pasture land extends along the valley, and through it the little clear stream finds its way in a very tortuous course, but above Mùglib this green belt becomes very swampy, and on it several Brahmini duck were seen. The stream above flowed over a stoney dèbris from the hills, with occasional patches of grassy and watery ground, and at about three miles the road passes two little tarns; these had been evidently larger at that season of the year when the snows are melting, or after an extra amount of rain has fallen. The physical appearance of the whole length of this valley showed unmistakable signs of its having

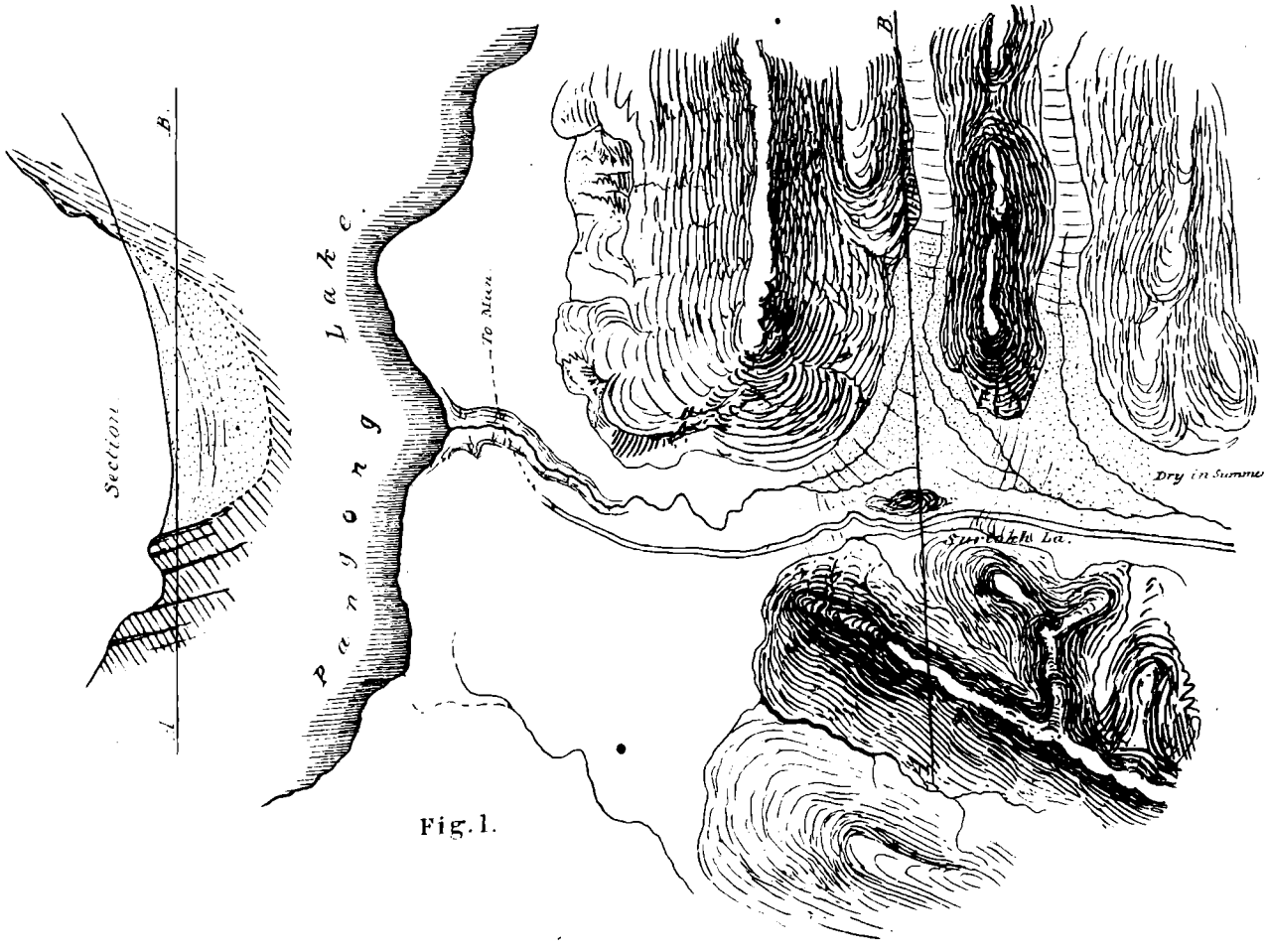

Fig. 1.

at one period been the bed of a lake, and I am induced to think for a portion of that time continuous with the portion below Tanksè, and that the mass of alluvial above Dùrgo was contemporary with that above Mùglib. Above the two lakes, Tragùmè Bur Tso, there is no longer any water in the bed of the stream save at intervals here and there, where it breaks out in a small rill to lose itself in the loose gravel a few yards lower down. Over distances of more than a mile it is deep white sand, the collection of which is a good deal due to the wind. Down to this sand the talus from the mountains extends tending every year to increase the height of level. At the low pass of Surtokh, whence one obtains the first view of the Pangong lake, this action is nowhere so well seen; this ridge of Surtokh forms the watershed across the natural exit for the waters of the great lake, and is entirely formed by the loose shingle brought down a somewhat large lateral ravine from the snowy peaks to the south: this bed of talus actually divides, part to the eastward, part to the west, as exemplified in the sketch annexed (Fig. 1.), so that the waters may in some years flow one way, in others another. If the supply of water to the Pangong lake were equal to what it must formerly have been when the glaciers were double their present size, the continual flow of water would soon carry off these talus accumulations from the mountains above Surtokh, there being now no force in action for this purpose; the snows of winter and the waters of the side ravines tend to raise the main valley level every year. The

Pangong Tso (lake) is about two and a half miles distant from the low ridge of the Surtokh La, or more properly speaking, its natural bar or bund, but the level of the old lake bed extends up to within a very short distance of the pass. A rise of 150 feet in the waters of the present lake would find them again an exit down the valley to Tanksè. A Trigonometrical station lies close to the water's edge, it bears east-south-east from a rock, a quarter mile distant out in the lake, and is marked with a stone having the usual dot and circle cut on it; its height has been determined Trigonometrically to be 13,931 feet above the sea. From this mark-stone, a fine view of the first long reach of this elevated and interesting piece of water is obtained. Its color is of an intense blue, the water as clear as crystal, but far too saline to be drinkable; there was quite a true salt water feel in the air as the wind blew off it. This was a good site from which to form a commencement of my survey work, as knobs and peaks were seen for many a mile along the spurs that descended from the ranges bounding the northern shores. From the height at which one stood, these all appeared comparatively low, only on the highest lay a few small patches of snow, thence to their bases was one succession of shades of yellows, purples, reds and browns, the invariable coloring of Tibet—not a scrap of green. My intention was to proceed along the northern shore as far as it was possible, and to eventually turn north, and work round into Chang Chùngmo. But it being necessary first to see something of the south side also, I left the supplies and sepoys at the spot where we had first struck the lake, and taking one small tent I marched on, skirting the southern shore towards a low point that runs down to, and overlooks the whole of the western end, and forms the termination of the longest spur from the lofty snow-bound range, which forms the southern watershed of this basin.

Late in the afternoon we reached a very small patch of cultivation, with some two or three wretched huts, called Spang Mik, and the next morning, by 9 A. M., reached the foot of the low point, named by the Survey Pankong (*b*) Hill Station. For so high an elevation, a considerable amount of green grass, Tibitan furze, and cultivation occurs on the west side of the hill, having a few houses scattered about it, forming the village of "Mun," the largest in the Pangong district. I ascended from it to the station by a short easy pull of some 1,000 feet above the lake, obtaining a most commanding view, up and down it, across to the spurs of north bank and high up among the snowy peaks to the south, where small glaciers just show their noses above the masses of the old moraines, which extend down to the ancient level of the lake. Little streams flow down these steep inclines like silver threads from the ends of these glaciers, to finally lose themselves in the silt and sands that skirt the edge of the lake, for only the most considerable of these streams find an exit in its waters. Such is the one that flows through the little oasis of Mun, it owes its size to the streams from three glaciers uniting some distance above the village. The silt brought down by these, has formed a miniature delta, or arm of shallow water running out into the lake. In the course of a conversation with the coolies and men of Mun, I learnt that some three or four marches further on, the lake narrowed to a mere stream which was fordable, and that it was not necessary to follow the northern shore, where ran besides the worst road. I changed my route, sent back for the supplies and camp at Spang Mik, and late in the evening they all had arrived. Other advantages accrued by following the south shore, viz., that I saw more of my ground without having to ascend to very high peaks, there was plenty of water and wood as far of the Chushal river, and the villages extended further. On the other hand, the northern shore is very bare, and water is only obtainable by digging holes close to the edge of the lake, into these water percolates, but only slightly less saline. On the 22nd July, my march lay over the sandy, stoney plain, skirting the shore of the Pangong, crossing two or three ravines where sections are well displayed of former and higher levels of its waters in sands, interstratified with a angular rubble like that distributed over the present surface. At about eight miles from Mun, the straggling village of Mèruk is passed on the right hand, and the last on the lake Karkpèt is three miles further. The level ground between the shores and the foot of the mountains increases much in breadth as one proceeds east, and the stream from Chushal gives from a distance no signs of its proximity, and I was rather surprised on coming suddenly upon a fine body of water, flowing with a quiet current through a narrow belt of green grass some 10 feet below the surface of the plain. Finding plenty of wood and a nice green sheltered spot under the bank, I pitched camp by the side of it.

The extent of level ground here is considerable, quite ten square miles, dotted over in the vicinity of the stream with a few low bushes, and over the rest grows a scanty coarse grass in tufts. Towards the shore of the lake rise two very conspicuous isolated low rocky knobs, a mile apart, and between these is the confluence of the Chushal stream and the Pangong Tso. The next morning I walked across and ascended the most eastern eminence, having the strange sounding name of Tuggù Nuggù. This had formerly been a fortified post, the level space at the top was enclosed by a low stone wall, while a detached out-work had been built on the low spur that ran out on the east side; none of my coolies, who were all from this district of Pangong, could give any account of it, as to when or by whom it had been built, it must be comparatively an ancient work, still considering how soon events are forgotten by such men, its age may be only 150 to 200 years. It was a lowering morning, and before I had finished my survey work from this position, it came on to rain hard, which we sat out on the top, the shower passed off up the lake and it had a fine effect on the view in that direction; with the lines of falling rain over the expanse of water, and the misty mountains bounding its sides. The state of the plain which, when dry, is covered with a hard incrustation of lime and a salt, that crackles under the feet,

had now by the wet been turned into a sticky loam, that adhered to the boats in huge lumps, and remained like a cement upon every thing it came in contact with. One and a half miles beyond Tuggù Nuggù low spurs abutt upon the lake in cliffs of 150 to 200 feet high, and the way leads along the narrow shore at their foot, with very deep water washing the bank. Passing one large bay we rounded a low narrow point of beach only to find the existence of another bay, called Phùrsook, this forms the boundary between the Kashmir Rajah's territory and the Chinese district of Rudokh. Phùrsook formed a circular sheltered little lake in itself, a narrow strait only connects it with the water out-side. It was evidently of great depth in places where the hills came down in cliffs upon it, a narrow beach ran along the foot of these formed of talus cemented by lime. The bay formed a perfect harbour, in which a line of battle-ship might have floated, and sailed in and out of. Were this lake in a less elevated region, or on a line of trade, how useful would the water communication prove up and down the extent of its two long portions. The first or lower lake is 40 miles in length; the second 33, giving a total of 73 miles, exclusive of the upper long portion beyond Tso Nyak, which is quite 18 miles.

I shall not detail each days march, winding in and out of the bays of this long length of water, but will attempt to give a general description of it, connected with which are several points both curious and interesting.

The first that must strike any one of observation is the evidence of this lake having been formerly fresh for its entire length. Myriads of dead fresh-water shells now strew the shore, these thrown up by the waves in a long white ridge, lie so thick in some of the bays, they can be taken up in handsfull. They are principally of Lymnæa and Phanorbis, but though I searched diligently, I never found a large bivalve, only one very tiny *Pisidium*, that I found inside one of the specimens of Lymnæa; nor did I ever find a living specimen, which I had hoped to do in the upper lakes where the water was very slightly brackish. When these shells existed, the former lake must have had quite a different aspect from its present one, and in it must have grown for the sustenance of these molluscs beds of water plants, while its banks would have been fringed probably with grass and rushes. In the lower lake there is not a vestige of any sort or kind of plant, the beautifully blue clear water washes a bank of sand and pebbles, the latter perfectly free even of algæ. This is not the case beyond Ote, where the water is much less salt, there the stones under water are extremely slippery and covered with vegetable growth. At this part also, patches of a coarse water weed are also seen here and there along the shore, but not growing luxuriantly, and evidently making a struggle for existence. The waters of the western end are far more salt than those of that near Ote, noticeable even to the taste, but it is not until the stream that connects the two portions is fairly entered that it is by any means drinkable; thence for the whole distance eastward, we used the lake water, save when we had the luck to find a spring of really fresh. By looking out carefully we discovered springs in three places flowing out from under the bank, and in one spot these springs were bubbling up for some distance out into the lake, rendering the water quite fresh around, it was quite a pleasure to see the poor yâks who carried our baggage take their fill of it, when for three days they had drank nothing but salt water. A curious feature of the Pangong is the almost entire absence of streams whose waters find an exit in it, considering the great area that some of them drain; for, with the exception of the few glacial rills and the Chushal stream on its south shore, and the stream at the extreme west end, from the Marse Mik La, there are none. The northern shore is particularly dry, not a single rill joins it for its entire distance, until arriving at "Pal," on the upper lake; and the same may be said of the southern shore, from the Chushal river to Ote, and for many miles beyond. Many of the ravines have their sources at a considerable distance, but near the lake have broad dry beds from 2 to 3, and up to 500 yards in breadth of rubble and sands. I may instance the very large lateral ravine at Ote, the longest branch of which runs back into the snowy mountains of Chang Chùngmo, for a distance of 40 miles, draining altogether an area of nearly 400 square miles. The silt which in former times has been carried down from the above area has formed the plain of Ote, the broad barrier to what would otherwise be a continuous long reach of water. This was no doubt the old configuration of the lake, for a rise of some 12 feet would cover the greater part of the Ote plain even now. In nearly all the higher ravines, water is plentiful, and glaciers of the second order are seen, but the streams are all sopped up in the broad bed of the main valley which acts like a perfect sponge; the stream breaks out occasionally here and there only to hide itself a few hundred yards down. The last water seen being above the fort of "Lanakh-khur," but it nowhere is seen to flow into the lake, being lost in the sands of the plain.

Another point in the history of this lake, on which may be based a good deal of theory as to its older aspect, is the former size and extent of its waters. On every side unmistakable traces that the level was much above the present one, are seen in the lines of old beaches and in the beds of sand, containing the fossil remains of fresh-water shells,* interstratified with beds of angular dèbris, which I mentioned before, are to be seen in the little dry ravines that cut through the plain, over which the road from Man to the Chushal stream runs. This is a rough section of these beds, in which No. 1 represents the present plain of surface dèbris, the scattered talus of rocks brought down from the mountains of the south bank, when the small glaciers, at present only two to

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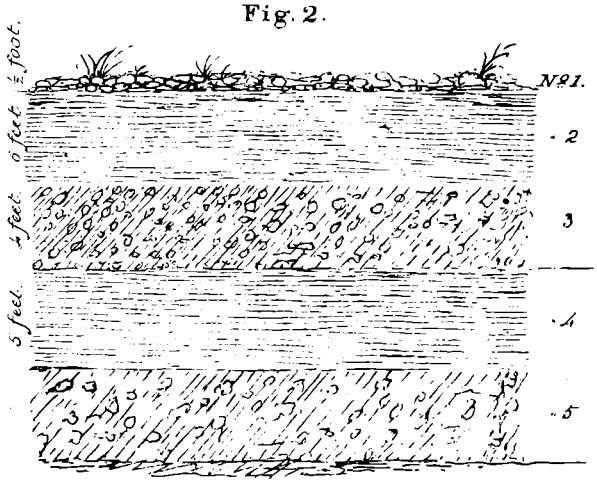
* These fresh-water shells are the same as those now found on the edge of the lake, while the stems of plants are plainly discerned; where these last are seen, the sandy clay is generally tinged with an iron color.

four miles long, extended nearly down to the lake, as proved by their old moraines still to be seen. Winter snow and the water action of time have spread their materials far out, nearly down to the waters edge. No. 2 are fine sands and arenaceous clay, such as would be now in the process of formation near the dèbouchement of the Chushal stream, perhaps a little coarser, which a moister climate would entail. It contains shells and stems of plants. No. 3 is a bed of angular débris, the same in every respect to the upper bed, No. 1, but much thicker. No. 4 again are sands, like No. 2, containing the same shells. No. 5, débris as beds 1 and 3.

Fig. 2.



This section proves great changes, and also, I think, that the lake existed prior too, certainly during the latter part of the great glacial period in the Himalayas. Whether the scooping out of the depression in which its waters lie, is due to glacial action in the first instance, when this high region was (as is most probable) deeply overlaid by ice and snow, is a hazardous question, and one rather problematical. From the alternation of the beds of débris and finer deposits, we can infer that there have been changes from milder and moister seasons than at present exist, back to colder and drier; during the first beds, like No. 3, would have been deposited by the increased transporting power that would have carried the materials further out into the lake; while, at the same time, the level of the waters would naturally have been much higher. Its waters must then have generally held much silt and mud in suspension to form the shell beds of above section. At the present day, no deposit of any kind is taking place, save perhaps near the dèbouchements of the Chushal, and the extreme western tributaries. A closer inspection with some leveling would, I think, somewhat clear up the mystery attached to the huge masses of alluvial deposits seen in the valleys of all the great rivers of the western Himalayas, from the Chang Chúngmo and Leh, to Skardo, in the valley of Kurgyl and valley of Dras, and on both the Jhelum and Chandra-bagha (Chenab) rivers. Give a greater rain-fall to the Pangong district, and a lower snow line (now above 20,000 feet), the ravines would be seen with fine running streams in them, and allowing time would cut through the barrier at the Surtokh La;* and eventually down through the whole length of the alluvial deposits in this lake basin, the large valley and its tributaries then drained would resemble most closely on either side the sand, shingle, and conglomerate deposits now seen at Tanksè and on the above-named rivers. These deposits at Ote would be somewhat higher, and would cover a greater area from the junction of the great tributary there. The height of the waters of the Pangong have much diminished, and are diminishing at the present day: the first travellers who visited it, now some years ago, would I think find a marked difference on its shores. The coolies of the district assured me that formerly, say 30 years ago, it was not practicable to proceed along the southern shore, following close to the edge of the lake from Phùrsook to Ote, which at present is quite easy—even yâks can be taken—only in one or two spots was there any difficulty, where the cliffs approached close down to the waters edge, a rise of 15 feet would bring the water close to them, and even 10 feet would render such places quite impracticable for animals and nearly so for man. From other information I could collect the fall must now be from 1 to and 1½ feet per annum. The difficult spots mentioned above only have been practicable for yâks for the last four years (1863), before that time the track lay over a rough ridge a short distance back from the shore. The men of the district also said that it is only for the last 20 years or so that the waters have fallen at this rapid rate. The rock that lies out in the lake at its western end, distant 1¼ mile from the shore, is about 5 feet high. It has only been noticed for the past four years, so this would again give a fall of about one foot a year. Again the numerous lines of the beach marks, and at some points as many as five and six can be counted, denote falls of level of about a foot. These all lying close to the waters edge are very recent, as evidenced by being so well defined. But as a proof that the waters of the Pangong lake in former times have fallen below its present level, I may state that on a long point of land in the little bay of Phùrsook in deep very clear water, I looked down upon a terrace 10 feet below the surface which terminated in a cliff, where the stratification of the sand and clays

* The rock bounding the north side of this pass is a hard crystalline limestone, nearly on edge, up to the plane surface of which the ridge of detritus extends. The depth to which the rocks *in situ* have been eroded prior to the talus that has since been precipitated against them, is in all probability sufficient to drain the whole extent of the Pangong and valley towards Tanksè, if these present accumulations were removed.

could be well seen, the bottom was not visible beyond this, and it was too far out to sound the depth. This would be the section.

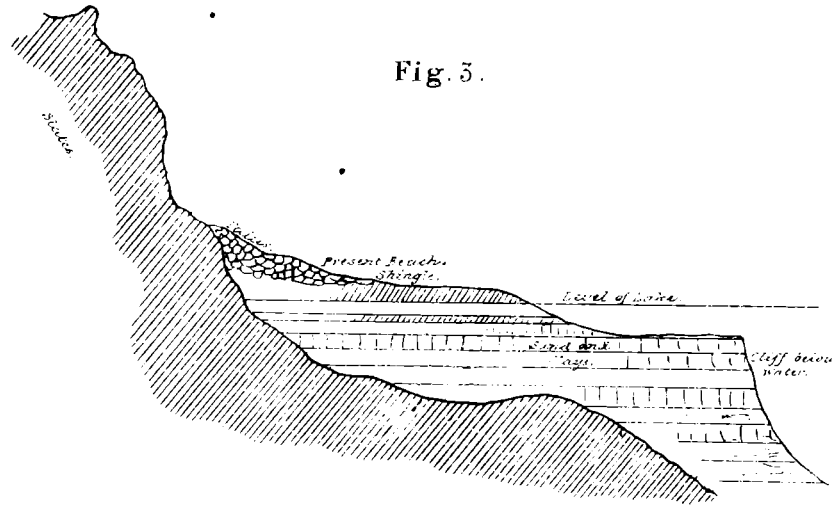


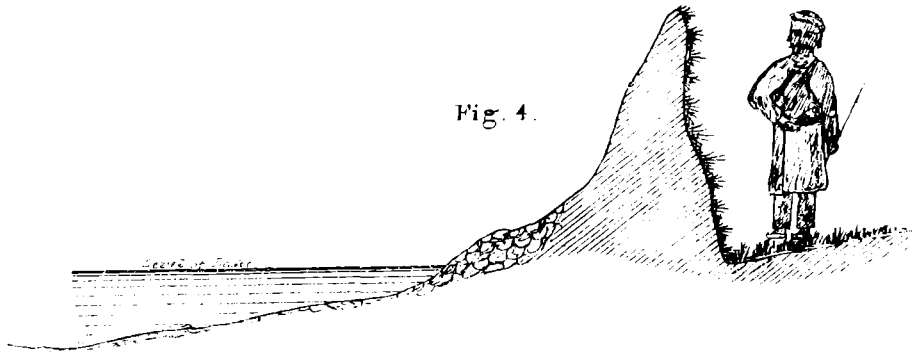
Fig. 5.

The only deduction to make from such comparatively recent changes is, that of the level of its waters has been alternating with moist and dry periods of time, the slow process of which may be even now going on almost imperceptible to man. The water of the Pangong depending as it does mainly on the winter snow, (query, may not the snow fall in this part of the Himalayas be much less now than formerly,) and the country passing through a period of diminishing falls. Slow as such changes may be, they are by no means improbable or impossible. The western end of the Pangong Tso lies as near as possible in latitude 34° and longitude 78° 30′, thence its direction is due south-east to latitude 33° 40′, it then takes a bend easterly and follows that latitude as far as Noh, in longitude 79° 50′. The mountains to the north-west of the first long reach are of no great apparent elevation, in July there was very little snow to be seen, and only on the very highest portion, or the main range, which nevertheless is from 18,000 to 19,500 feet high ; the highest peaks being 20,000; but the level of the lake being 13,931 feet above the sea, detracts considerably from their great altitude. The terminal knobs of the spurs from the above range lie close on the edge of the lake, rising to the height of 600 to 1,500 feet, generally terminating precipitously, and the lake I should imagine is excessively deep at such places. It would be a most interesting scientific enquiry to sound with some portable kind of boat the depth of this lake. To the south-west a high range runs parallel to the lake, some of the peaks on which attain an altitude of 21,500 feet; this range terminates in a peak above and to the east-south-east of Tanksè, which is 20,003. The above fine line of mountains, covered as they are with perpetual snow, and their ravines terminating above in small glaciers, form a fine boundary to this valley on the south. The southern watershed follows the lake very closely as far as Ote. It there extends further south, and between that place and Pal, several very large lateral ravines descend into it, all with the usual broad, dry, gravelly beds, the largest of these are the Algrong, Tengun, Kiam-Surpo Loombas, or valleys. On the northern shore, beyond the very large valley of Chang Burmah, which finds its exit at the Ote plain, there is another, the Dal-Loomba, that drains the considerable tract of 150 square miles; the silt carried down from this has narrowed the lake very much, forming a low point jutting out into it, and has contracted the waters to a quarter of a mile in breadth. Altogether the mean breadth of the second lake, " Tso Nyak," or " middle lake" is much less than the first or true " Pangong."

Wherever a tributary ravine joins the shore, there is grass, scanty as a rule, and of a very coarse kind. At Ote it is much richer, especially in the vicinity of the stream that unites the two lakes. On both banks of the second lake, wood is found in plenty, growing luxuriantly in places, at Algrong and Numkum it formed a scrubby jungle; but on the northern shore, at Silùng, it was met with no more, and the only fuel was a stunted plant which throws out a good deal of woody root, and is found all over this country; and I never found a scarcity of it even up to 18,000 feet in the Chang Chùngmo, save where the ravines were very rocky. Descending from the small ridge between Paljùng and Pal, the extensive plain near the latter comes in view, bounded by low spurs on every side save the east, where a conspicuous peak rears its head, a small stream winds its way through the eastern side of the " maidan," and joins the lake being the only one on the northern shore that does so. Three and a half miles beyond Pal the second lake ends, and a small stream is found flowing into it through half a mile of

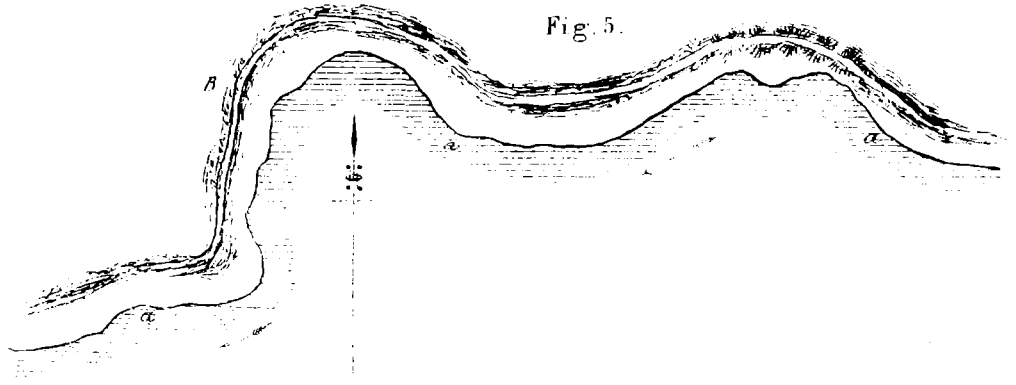
sandy flat ground, beyond which is another lake, called Tso Rum, having a length of about four miles, after crossing again some flat ground, Lake Tso Nyak, (the second,) is reached connected as before described with Tso Rum below. Near the northern shore of this last is situated the small village of Noh, a short distance up a tributary from the north. This place I much wished to visit, but as will be shown further on, I could not manage to accomplish it. On the northern shore of Tso Nyak, the effects of a very peculiar natural force may be seen; at intervals a ridge of sand and earth runs parallel to the line of beach, at first I attributed this to the action of waves, but observing the large proportions of these banks in some situations, and at last seeing the ridge quite 6 feet high; and, moreover, that the bank had been fairly turned up, as if with a gigantic plough, I was fairly puzzled to account for such an appearance, and on questioning the guides, then learnt that during winter, when the lake is frozen over hard, the water naturally accumulates under the ice and flowing westward can find no exit. When the pressure becomes too great it tears up the frozen earth on the shore and liberated flows over the surface of the ice. I give a slight sketch of a section through one of these banks, showing the old surface grass still growing on the perpendicular face of the upheaved ground, which of course is on the inland side. On measuring this I found it an inch or two over 6 feet.

Fig. 4.



I noticed also that the banks were higher and better developed on the western curves of the bays; one reason for this may be seen by a glance at the accompanying diagram.

Fig. 5.



Where *a*, *a*, *a*, represent the shore of the lake, the waters of which have a tendency to flow west, in direction of the arrows. These waters (?) suddenly increased by springs in bed of lake, and subjected to the upper pressure of a frozen surface meet with another residing force in the curve of the bay at B. That line where the ice united to the frozen ground, meets the dry soil into which water does not percolate, and is consequently comparatively dry, would be the line of least resistance; and upon that line the disruption would take place and the pent up waters find an exit. Where the bank is sandy or clayey and covered with grass, it would be turned up in the manner as shown in Fig. 4. In spots where the shore is gravelly, the water seems to drive in the sand and stones before it from the bottom of the lake out upon the shore, and this being a continuous annual action it has in some bays formed a bank quite 3 feet high; whether this phenomenon has been observed before on other lakes I do not know, it could not take place even here, did not this lake Pangong receive a large amount of water from the east, with a determination to flow towards its old natural exit near Lùkoong. During summer evaporation no doubt carries off a great amount of the surplus water that drains into it, but in the winter this must cease, and with its upper casing of ice the water to free itself thus tears and roots up the bank in the curious manner above detailed. During the whole time I spent on the shores of the Pangong, the only animal I saw was the Kyang, or wild ass of Tibet, a few couple of these were grazing on the grassy maidans of the northern shore. Of the birds, geese were plentiful in the stream between the first and second lakes, and I saw many young broods. The Brahmini goose, teal, a red headed diver with white body, and a very black plumaged duck, made up the water birds. There was a great scarcity of the smaller birds, a sandpiper and wagtail were occasionally seen

on the shore. The large fish eagle was plentiful at Ote, attracted there by the fish which are seen for the first time in the slightly brackish water flowing out of the upper lake; this lake is full of them, they much resemble the tench in shape and color, only somewhat longer in the body and are covered with slime like those fish. I had fortunately brought a rod, and all its et cæteras, and had near Num Kum, in deep water under ther ocks, a very good afternoon sport, catching some five and twenty; they ran about a pound in weight, the largest I caught being about 4 lbs. They would rise at a fly when the surface was much rippled, and seeing them rising at gnats, I managed to catch two with a small midge fly, the first artificial I fancy ever thrown on these waters; but their extreme clearness is much against fly fishing. The most paying bait after all was dough, this they took readily enough, and I might have caught double the number in another hour, but had to move on to camp. These fish formed a welcome addition to our food as long as we remained on the lake, I supplied my old Bhut Moonshie, and some of the guard with hooks and lines, they became fierce fishermen, and brought in good bags. It is a fine sight to see the lake during a storm, when a good strong wind is blowing down a long extent of its surface, and dashing the waves, which rise to a considerable height, against the hard rocky shore: I had the fortune to see its surface in this state one morning, and sitting down watched the waves rolling in, it was a minature sea; and Pangong waves brought up thoughts of beaches in old England. Though the country is so barren, the lake has its beauties, in the varied tints of surrounding hills and mountains, and the rich deep blue of its waters, becoming quite of an emerald green color as they shallow near the shore. During the summer months the lake is quite deserted, and we did not fall in with a soul the whole distance up to Pal, or we might not have got so far. At that time of the year the flocks of shawl wool goats, sheep and yâks, are grazed in the higher valleys on the young rich grass that springs up in some places after the snow has left the ground. During winter they are brought down to the level "maidans" near the lake, and Ote I was told becomes dotted with black "Champa"* encampments. Snow they said never lies long at Ote, though the lake freezes all over very thick, and the degree of cold must be very considerable—what a glorious expanse for skating the lake must then present. The Champas or Changpas, who spend the winter on the lake at Ote, come from both Noh and Rudok, the said plain is a disputed piece of ground, the men of the Pangong district claim it, though judging by the site of an old fort standing on a low rock on the north-western side of the plain, I should say it undoubtedly belongs to the Lhassan authorities, by whom it was built years ago: proximity of Leh and greater power of the Thanadar there, places it in the Kashmir Rajah's territory. Walls of stone and earth are built up as a protection for the tents against the wind, and to render them still snugger, I observed that the interior floor had been dug down to a depth of 3 feet, which must make them warmer abodes. I found the summer winds of this country cold enough, what the winter are like I can well imagine, the amount of comfort in a tent on the edge of a frozen sheet of water stretching for miles must be a very minus quantity. During the whole period of my sojourn there in August 1863, the weather, with a few solitary fine days, was miserably cold, nothing but cloud, sleet, and rain. I may have seen it under disadvantageous circumstances, and I trust at times it does enjoy a little warmth and brightness.

On the 1st of August we reached Paljung, and in the afternoon of that day came in sight of the first natives we had seen, viz., three men driving some yâks in our direction, they saw us at the same time, and turned and bolted; we followed, but failed to overtake them, it being about two miles to the point they had rounded, they had disappeared up some lateral ravine out of sight, our approach was therefore known to the Rudok men. It rained in torrents during the night, camp was pitched at Paljung, where a long broad nulla bed came down to the lake, and a low long promontory ran from the hills on the north out into it. Our road next day on towards Pal lay over this, it being a very long round to follow the shore under the cliffs. From the low pass the broad dull green plain of Pal was seen, and on its eastern side we discovered the black tents of a small Tartar camp. As our approach was now certainly known to these people, we bent our steps towards them. Three men came out to meet us, and turned out very mild individuals, one being a Lhama or priest, their dogs, of the large Tibitan breed, were much more noisy and furious at the intrusion of strangers, and were not to be reconciled until long after the tents were up. These Champahs informed me that one of their number was about to ride into Noh at once to give the news of our arrival, and have it thence sent on to Rudok, I at once sat my Bhut Moonshi down to write a letter to the Governor of the place, requesting that he would raise no difficulty to my paying the place a visit, and see its monasteries, &c.

The next two days I remained at Pal, for the hills were buried in dense cloud and a good deal of rain fell, so that I was unable to proceed with any survey work in an eastern direction; on the third day, the Zimskang of Rudok rode in with some twenty followers, and pitched his tents on the other bank of the little stream, and came over at once to see me. He was a native of Lhassa, a short stout jovial fellow, and brought a letter from the Governor of Rudok, and a white scarf together with a present of two damuns (bricks) of tea, and some sheep and goats for my men. The letter was then read by the Moonshie, and was to the effect that it was not in his power to give me leave to visit Rudok, as he had strict orders from his superiors in Lhassa to prevent foreigners crossing the frontier, and that it would eventually be known if he permitted it. He added that he could not use force to prevent my further progress, but he trusted I would not lose him his appointment by

* "Champa," the nomadic tribes of this country.

so doing, and that I would accept the presents as a sign of friendship. Having received orders not to bring on any collision with the Chinese officials, I had to give up the idea of seeing Rudok, but I held out for one more march towards the place and gained my point, but not before showing some anger at their absurd wishes. The Zimskang again came over after my dinner about 9 o'clock at night, to beg I would not proceed any further; but I said they must abide by their first agreement. The afternoon of that day I was enabled to ascend the limestone mountain east of camp and fix my true position, the range around Rudok and the eastern end of lake were also again visible, and I was enabled to get intersections with other rays. The 5th broke fortunately clear and bright, so I started early along the shore of the lake in direction of Noh, my friend the Zimskang, stuck to me like a leech the whole day with a few of his men, and a curious dressed rabble they were, with their enormous flat mushroom shaped hats, and all mounted on little scraggy but sturdy ponies, they were all very jolly and amiable, I made no secret of my work and showed and explained the map of the lake to him, which he thoroughly understood. I have found the people of Tibet far in advance of those of Hindustan as regards drawings, and what they are intended to represent. At a small hill called Tobo Nokpo, whence I had promised to return the previous day, I fulfilled my agreement evidently to the great pleasure of the Zimskang, who was now more pleasant than ever and thanked me with many salams. On the 6th August my tents were struck to leave Pal, and the Rudok men did the same, I was invited over to their tents previous to starting to partake of a parting cup of salted tea churned with butter, which is always kept simmering on the fire, it is by no means a bad beverage when made with good fresh butter. I gave him a few presents and we parted.

At the eastern end of the Pangong the hills somewhat decrease in altitude, the highest lying to the north of Noh. Looking in a direction due east from the higher points I ascended, the country appeared flat but undulating, and I observed in the far distance two or three pieces of water, these may turn out to be connected with Pangong Tso, probably bounded by steep sides which were not discernable at twenty miles, they may extend for some distance; the breadth of this high region was considerable, and extended up to a snowy range that rose suddenly on the south. The more level surface was not bounded by any mountains, and was seen stretching to the horizon.

The morning we left Pal was raw, cold and cloudy; the road lay north-westerly for some distance over the dead level plain, that showed distinctly it had once been covered by water, for dead fresh-water shells are seen for some way, we then rose from it over a long very gradual slope of some three miles which at last contracted into a ravine, bounded with very low and easy scarped hills. Portion of this ravine was well wooded with the same kind of shrub as grew along the shores of the Pangong. The little camp of Champas continued their march with us, and had we been one day later coming into Pal we should have missed them altogether, and gone straight into Noh without meeting a soul. Nearly all their worldly goods were carried on sheep, only a few articles on the ponies which they rode. The women drove the former, and in fact did more in the packing, unpacking, and pitching of the tents, than their lords and masters; after which they were sent out on the hill side to collect the roots of a low shrub having a scent like lavander. One of the girls was very nice looking, and wore a peculiar head dress which is not seen on the Ladakh side. The usual narrow fillet of cloth worn by the Ladaki women was treble the usual width, and covered with torquoise and silver ornaments; near the attachment at the forehead was a bar of silver set with small torquoise, pendant from which so as to lay on the forehead were a number of silver coins attached by short strings of coral beads, the effect was very good. I had the young lady brought over to my tent, where she sat for her portrait, and was delighted at the drawing made of her. The encamping ground was called Tobo Ruberu, and was a level piece of green grass, with several good streams of water flowing across it, for curious enough the higher ravines of the country have plenty of water, but they are all absorbed a few miles down in the sand and gravel of the broad water ways. The valley was here high, broad, and nearly level, the mountains were of no great elevation above it, not more than 3000 feet; the lower slopes falling gradually from them into the valley, which was patched with furze of stunted growth, and plenty of good grass. The morning of the 7th broke clear, sunny and bright, with a fresh breeze, we started early and gradually ascended the valley to the pass in our front, called the Dingo La (16,270 feet), on the top the ground was nearly level, expanding into wide open ground to the north; on the left rose a hill about 1,000 feet, which I determined to ascend to obtain a view over the hills and country around. Walking a short distance up this, a small tarn was seen in the centre of the level ground north of the pass, which had once evidently extended over the greater part of its area. Scattered plants of rhubarb are here seen but very tough and acid. The rocks were all of limestone formation, with a strike nearly east and west. I found no fossils, but it resembled in appearance the palæozoic rocks of Dras, &c. I obtained from the peak a fine view, but could see no more of the eastern end of the Pangong near Noh, on account of a dense haze in that direction. I was much disappointed and could only fix a peak or two looming up through the mist. My own camp and the Tartars had gone on, and I quickly followed them down the valley. This was very characteristic of these regions, spreading out into a broad gravelly plain, on the left side of which was a sharply defined scarp showing its general level had been uniform, this plain forms the head of one of the branches of the Dal Loomba. We parted with our Champa friends at a place called Chuchan, where they encamped to graze their goats and sheep for a few days, while we proceeded on along the side of the hills of the right bank rising gradually to a low pass called Sa Lam, and descending on the other side to another broad tributary of the Dal

Loomba, which at this spot branched into three broad arms that penetrated into the mountains on the north for some eight miles. The longest of these valleys had a direction north-west, and up this our road to the Chang Chùngmo ran, no water was here to be found, and it was not until we had proceeded another two miles that water was found in the bed of the ravine. Where we halted fuel grew in plenty—the yellow flowered Tibitan furze, differing slightly from the European in not being quite so thorny. The valley was still broad, but the hill sides descended into it with steeper slope, it was here called Drukker. When on the Sa Lam a horseman was seen riding down the valley from the north, who joined us, he had come from an encampment up the valley, and said he was sent to escort us on to the pass ahead; our movements were therefore well known, though we should not have supposed a human being to have been within miles, but the Champas were evidently on the watch, and espied us the moment we topped the pass of Sa Lam. Between camp and the Demjor La, the valley bore the same character save that the broad gravelly bed was covered with a luxuriant growth of furze, this swarmed with hares, which got up in all directions, and I had some good shooting. The Demjor La was reached about 10 o'clock, I found it by boiling point thermometer to be 17,465. The rise was gentle the whole way, and fell in like manner into the valley on the north. As I came up to the usual pile of stones on the crest, two fine *Ovis ammon* came round a spur to the right, at about 200 yards distance. I managed to get a little nearer but missed them. A fine mass of hill rose to the south appearing easy and near, I sent the camp on to the stream below and commenced its ascent, this was a good deal steeper and further than I had anticipated, proving to be 20,240 feet high, the labor was rewarded, for from the summit I obtained a splendid view, and did a large amount of work; massive snow beds still covered the top, and the wind was bitterly cold. The mountains to the south of the Pangong were well seen, with the great snowy range near the Indus beyond Rudok; and I still longed to go on in that direction. Of the mountains to the south and west, there was a fine view, of a country bleak, naked, stony, and inhospitable, only in a tributary of the great Chang Burma Loomba, whence was a way to Ote, was anything green; a little grass and furze there skirted the stream. Work being finished we were soon down again upon the level ground of the valley, and on a piece of very wet ground I was surprised to flush a snipe. It was a bitter cold evening, but the camp was in as sheltered a spot as we could find, and there was some good grass here for the yâks. Our Champa guide took leave of us on the Dimjor La, so that we proceeded on the next day alone. The valley below camp took the usual configuration and ran towards the north-west with a bed about one-fourth of a mile broad, at about three miles we reached the confluence of a large valley from the north; and up this I determined to proceed, and thence ascend to Kiepsang trigonometrical station. Several Kiangs were here seen, and up the valley numerous Tibitan antelope. After marching up the gravelly wide bed for five miles, whose main tributary turned to the east, and ended in an extensive elevated plain on the surface of which lay some large snow beds, we were rather at a loss to find water. I took the eastern branch, while the yâks and servants proceeded up the western (the Nertsè Loomba), towards a patch of green grass where I thought water would be found, and this proved to be the case. From this the staff on the top of Keipsang was visible, and a very delightful little pull up it looked. I followed the eastern branch to a low pass which overlooked a narrow gorge that terminated a short way down on another high level plain. There was no track of any kind to be seen here, and my guides told me that the country on beyond was grazed over by a nomad tribe, called Kirghis, who did not own allegiance to the Rudok authorities, that they were great thieves and robbers, and occasionally came into Tanksè to exchange their wool for grain, of which they had none. These are the people who wander over the plains, thence to Ilchi and into a *terra incognita* on the east. It was not until late that I got back to camp, going to bed with the prospect of a stiff ascent next day. I was up and off very early, taking some breakfast with me; at this hour it was very cold, and the water of the little stream was frozen hard, and the backs of the yâks were quite white with frost. I took the line of a ravine which led up to the ridge east of the Kiepsang staff, the ascent was most fatiguing, over the loose angular débris that filled the steep bed of this ravine, whose waters were frozen into water-falls of ice. In this ravine we put up from under a rock a hare so benumbed with cold, it could not run, and it was knocked over with a stick by one of my coolies, to his great delight. On reaching the ridge, there was still a long pull up to the pole, but the view recompensed all the labor to legs and lungs; the ascent was 3,200 feet, the peak being 20,035, while the camp below was about 16,800. Bleak wastes of hill and wide dry drainage courses met the eye to the north-east, backed by some high mountains, whose loftier peaks were covered with snow, and threw down some small glaciers. To the south the great tributary of the Pangong, the Mipal valley could be followed for many miles, high rugged angular mountains bounding it on every side. It was very, very cold, and I could scarcely do my work or hold the pencil, the clouds were gathering up fast, and before I left the peak it had begun to sleet, I got under the lea of the ridge for breakfast and made a brew of tea in the boiling point thermometer pot, of which I gave a tot all round to the Bùuts, and then descended on the western side into the valley below; by skirting the hill sides, down into the ravines and over spurs, we reached by evening the Kiùng Gang La, 17,259 feet, on the boundary of the Kashmir and Rudok territory. At this pass are stationed throughout the summer months a guard of a few Rudok men, these we now met, and who got a dose of chaff from my Tanksè coolies, for thus being taken in rear, but they were very good humoured, and said that they were now off for their homes, and left that day with their ponies, black tent, tea churn, &c. We saw a good many antelope during the day. Near the pass was a great thickness of the conglomerates, sandstones, and course shales, seen in the Indus valley, which formation it is most curious to find, having so wide an extension in this direction and opens out a wide field for geological speculation. The south-west wind was bitterly cold all the afternoon, and in the tents, though they were in a some-

what sheltered ravine, it was very cold all night. The next morning we proceeded down the ravine to the north, which was grassy for some way. The coolies who had gone on with the breakfast things came upon seven wild yâks, who went off down the valley and were not seen again; they are, I believe, very wary, great numbers are to be seen here later in the season, when they are driven out of their higher haunts by snow into these lower grazing grounds, which were covered with their traces. They occupy this part of the country from about the end of October until March, the larger number roaming away into the high plains on the north, though some remain throughout the year in the neighbourhood of the Pangong, but I do not think are met with south of it. About half way down, the ravine narrows very considerably, and a mass of rock quite detached rises in the centre of the valley, a narrow gorge to the west being the direct road to Kyam; by this the coolies proceeded while I took the east side crossing a low connecting ridge. Numbers of hares were seen, and I bagged a couple for the pot. I fell in with, near this, a Mr. Turnor, a traveller from England, and when I told him the beat I was going, he said he would accompany me. He had been searching for the pass by which M. Schlagenweit had gone towards Ilchi, but by the natives with him (for he could not speak Hindustani) had been taken off in this direction quite a contrary point of the compass. We marched on together, reaching at last the main stream of the Chang Chùngmo, called Kyamgo Traggar, this was broad, and a great thickness of alluvial deposits were exposed on its sides. It was an alluvial plain in its transition state before the river had cut its way down to the solid rocks, its former levels were beautifully shewn in a series of steps and terraces, of which as many as five could be counted.

At the point where we descended from the alluvial terrace into the bed of the Kyamgo Traggar, there was a small rill of water, but this disappeared about half a mile on, where the valley narrowed considerably and the hills rose on either hand in high cliffs of limestone, forming a regular gorge, through this the wind blew with great violence from the eastward, and dark angry clouds hid the mountain tops, it was evidently setting in for a stormy afternoon. We pushed on, struggling against the strong gusts of wind, and the gorge widening as we proceeded, at last brought us to a broad valley spread over with detrital matter, the mountains still towered in cliffs to the south, but rose very gradually from about 1½ miles to the north, towards the high ridge of Sam kang and Cham-kang. It now began to snow hard, and we got under the lea of a low cliff, and sat there until our coolies came up, when we pitched the tents with great difficulty, for the tent pegs would not hold in the gravelly bed of the stream, but by means of large boulder stones this was accomplished; it was a miserable evening, snow falling until sun-set, and lying on the top of the tents and in dry high spots. When the clouds broke at that hour, beautiful appeared the surrounding mountains with their white covering, the fleecy clouds, drifting up against the sides added greatly to their height, the whole suffused with a lovely rose hue and the sun shining upon the wet surface of the many tinted rocks, brought out their colors brighter than ever. Fires were soon blazing away and we got our dinners as if nothing uncomfortable had happened. One must give the Indian cooks immense credit for the manner in which they work under the discomfort and difficulties that must from time to time happen on the march.

The valley ahead of us appeared to end at about six miles distance, and thus it had been sketched in on the rough reconnoissance I had, so the next morning it was determined to leave the camp where it stood, and go on ourselves to the main ridge of the valley, and return by evening. After breakfasting we walked up the soft gravelly bed of the river, for about four miles, it then narrowed considerably, and took a bend to the east-south-east, and at three miles further on divided into two large branches, that having a nearly due east course we followed. From the mountain spurs, having approached so close to the broad bed of the Kyam go Traggar, the absence of water, and it having also taken a bend we had been led to imagine its course here ended, but this we were both of us much surprised to find was not the case, for we now beheld ahead of us an enormous broad gravel covered valley, stretching away to the foot of mountains at least 18 miles further to the eastward. It was quite impossible to reach the main ridge that day, so I sent a coolie back to bring on the tents. This open valley had the most peculiar aspect of any I had yet seen, but partook in its dry gravelly bed a good deal the nature of those valleys I have seen between Pal and the Kiùng Gang La, its elevation was about 16,400 feet, and its breadth in widest part about two miles, the ridge of hills bounding it to the north lay about four to five miles off, but were only 3,000 feet above it, and the spurs came with a very gradual fall towards the valley. On the south a very low ridge of about 500 feet in places not more than 300, separated this valley plain from another broad one of a like character, the ravines of which ran up into the hills in wide beds, from 2 to 300 yards in breadth. Several broad lateral drainage plains also formed a junction with the one we were in from the northern line of hills that ran parallel with it. Directly ahead a low broad pass was visible, the mountains rising to the south of it in snowy peaks 21,000 feet high, but from the great altitude we stood at, and their distance 15 miles off, they gave no idea of so great an altitude. Plenty of the woody rooted wild lavander, or rather a stunted plant with the like scent, grew around, but grass was very scanty, only in two or three spots was there found barely sufficient for the yâks; a few large patches of snow still lay on the plain, these (for the hill sides were now quite bare of it) were the remains of deep drifts formed by the winter winds. Water was also very scarce, and we could obtain none that day until we reached the spot chosen for camp in the evening. The distances on this plain seemed interminable, the ends of low projecting spurs appeared in the clear atmosphere quite close at hand, and had not the position of the pass ahead been fixed tolerably correct on my

plane table, we should in all probability have made our plans to reach it that evening; and my fellow traveller would not believe that it lay so far to the east as it did. The "mirage" on the flat gravelly plain had at times the appearance of beautiful blue still lakes; antelope were very numerous, and running across the plain in vicinity of this appearance, looked double their natural size. We found the sun very hot in the middle of the day, but while waiting for our tents in the afternoon, found a blazing fire very comfortable; and the night with the usual great alternation of temperature was very cold. We were on our way up the valley early on the 13th August, but did not reach the foot of the low hill until the afternoon. Antelope still very plentiful, and the males magnificent creatures, with beautiful long thin horns. The summit of the pass (17,960 feet) was quite 1,500 feet above the level of the valley at camp, but the ascent very gradual. The snowy mountains on the south could now be well seen, their valleys filled with ice, and from the pass in easterly direction lay another valley which also widened out into another of the same type as that we had marched up; the hills seemed to fall on both sides, and the country generally to take a more open plateau like character. I could not spare time to proceed any further, I had much work to finish in the rear, and some high points to ascend, which the early snow-falls would shut up for the season. I much longed to explore, but could not do so. Mr. Turnor went on beyond for two days, and gave me afterwards a sketch of the ground. It appeared that some ten miles further, the open valley turned sharp south, and disclosed a long piece of water like the Pangong, but the mountains shut out the end of it, nor did he even get so far as the edge to tell me whether it was fresh or salt; so that this may be, for all we know, another rival to the great Pangong Tso. Turnor saw six or seven miles of its waters, which he described as having a breadth nearly equal to that of the above lake. I retraced my steps therefore down the valley finishing the sketch of it. Some fine agates and cornelian are to be found in a small ravine, at the spot where the long southern spur from Chamkang H. S. abutts on the Kyamgo Traggar. I made a short ascent here in order to look over into the country to the south-east. This presented the appearance of large broad level valleys, that might almost come under the designation of plains, the undulating ridges that divided them being of so little elevation. On the 15th August, I had returned to the junction of the road from Pal with that running down the valley towards the direction of Leh, and encamped close to the hot springs of Kyam. These rise at foot of the hills on the left bank, the alluvial plateau on the edge of which they are situaded extends for about half a mile to the river and ends in a low cliff. The water rises in several spots, covering a distance of about 150 yards long. The spring on the extreme west side is the largest, and temperature the highest: this I give below. The ground about is wet and swampy, and consequently beautifully green with grass and weeds; an incrustation of lime had formed about the springs, but very sparingly.

	Degrees.
Western spring, ...	103·5
Centre, ...	102·0
Eastern, ...	98·0

From the north-west a large tributary here joined the Chang Chùngmo river, adding so much to the depth of its waters, that it was a matter of difficulty crossing at the two fords below Kyam. The valley now lessened much in breadth, but the alluvial deposits were still well developed, and were cut into a series of steps by the gradual falling of the lake or the diminished waters of the river on a drier climate commencing. At Pamzal the valley was still narrower, but these accummulations had disappeared. Here the Chang Chùngmo is left and the road leads up the Rimdi Loomba to the Marsè Mik La, (18,452) and thence descends towards the Pangong basin, with a gradual fall down a broad valley passing Phobrang, Yùrgo, Tùblang to Lùkùng. At Chuggra, about three miles short of Phobrang, I turned to the north-west to the Kepting Kiptung La, 17,642. In the Gedmure Loomba was a green expanse of grass, with a rather severe ascent to a grazing spot called Boomzi, from this a high broad plateau extended to the pass; the line of water-shed being so broad that it was difficult to assign its exact position. This high wide valley parted north and south in first direction to the Ororotze La, 18,050 feet, only used by shepherds when taking flocks to graze in the lower courses of the Chang Chùngmo river.

The scenery here was grand and very striking from its novel nature. On the broad high plateau are three small lakes, from which flows away a stream bordered with bright green grass, running parallel to slopes of talus backed by mountains over 20,000, culminating in peak Shayok (No. 2) 21,000 feet, these mountains rise very abruptly and send down a row of glaciers, that end in moraines upon the plain of the Koh Loomba. The sides of this mountain mass are rugged in the extreme and topped with perpetual snow. Shayok (No. 2) throws down a mass of ice covered with moraine débris which abutts upon the river itself. From the foot of this glacier I hardly ever saw a grander sight than the steep falls of rock and ice of 3,500 feet in a horizontal distance to the highest point of only three miles. This portion of the Pangong mountains is well worth the visit of a traveller. At the time of my visit the increasing cold had driven the shepherds with their flocks and herds from the higher grounds, and we found some families at Montol, from which place there is a path over the mountains to Mùglib. I followed the Koh Loomba valley down towards the lake, where it ends in a narrow gorge opening out into a considerable broad expanse of open ground, on which are scattered some small hamlets containing only three or four families each, viz., Phobrang, Yùrgo, Tùblang, and last of all, where the stream dèbouches into the plain of the Pangong itself, is Lookoong. Coming down the defile upon Yùrgo is a very peculiar and striking peak overhanging the road. Its high rounded point is called by the natives "Chomo Kong Go," or the "Woman's Head," it having some resemblance to the shock head of a Tibitan belle.

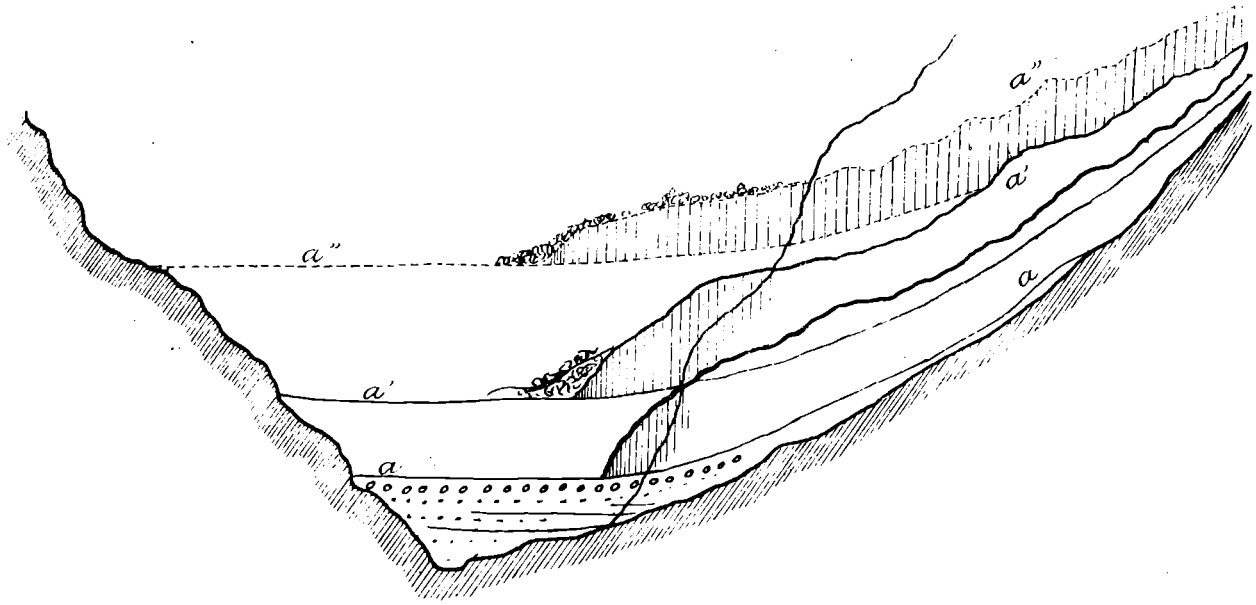
Lookoong is situated about two miles from the spot where the waters of the Koh Loomba join the lake, this distance is covered with sand, white and glaring to the eyes, and the sides of the ravine are cut down about 12 feet, forming a cliff of that height on either side. I did not see any fish here, the body of water in the stream, though much reduced from the quantity that rises at its sources, is still very considerable, though not equal to that of the Chushal stream. I had now finished the whole of my work, and went on that day as far as Mùglib, thence to Tangsè, where I paid up my coolies, and for yâks, &c. The men had behaved very well, never had I any occasion to be put out with them. From Tanksè I returned to the Indus valley over the mountains by way of the Kay La, 18,256 feet. The Kay Loomba river is fringed with grass and bushes for a considerable distance up, and at a height of 16,300 feet flows out of a lake about 400 to 500 yards long, of very deep clear water. It owes its origin to a large landslip from the left side of the ravine, by which cause a very considerable portion of the hill side has moved forward and been disrupted. The rock is granitoid, the same as the Chang La, and forms the main axis of this mountain chain between the Indus and Shayok. From the lake to the pass, the scenery was wild as wild could be; near its source the ravine turned south and was nearly level for some distance, finally ending amid a mass of scattered rocks, débris and snow; large beds of which still filled the ravines and lay in patches on the summit of the ridge. The wind blew with great violence from the west-south-west on reaching the pass, with that cutting, piercing, unsparing, manner, it does at these elevations; behind the shelter of some rocks I boiled the thermometers, and then descended into the valley below. All my followers now on the return journey, walked their best, and by the evening we were well into the cultivation of the valley above Chimray. The next day I reached Leh, and was glad to meet some brother Surveyors, also on their return from their respective surveys.

In the foregoing pages, reference has often been made to the great accumulations of boulders, gravels, more or less angular, clays and sands, near Tanksè and in the Chang Chùngmo, it is necessary to add a few words in conclusion regarding the cause I assign to their formation. This is I think clearly glacial. Proofs are not wanting that in ages past the valleys of the Himalaya contained glaciers of enormous length and thickness, the only prototypes of which are to be seen in those now filling the valleys of the Karakoram, far north in Baltistan. About half way between the villages of Kungun and Gond, lying on the Sind river, a tributary of the Jhelum, Kashmir, and at the village of Gond itself, marks of glacial action are unmistakable in the deep grooves or striæ marks cut in the hard metamorphic slates, at a height of about 150 to 200 feet above the present level of the river. This point is 20 miles in a direct line from the head of the valley, where at present some very small glaciers exist. How much further this glacier extended towards the plain of the Kashmir valley, it is impossible to say, but at the dèbouchement 10 miles below, thick beds of débris are to be seen; the Sind river is still of very considerable size, and glacial accumulations are very soon swept away, as may be seen in now existing large glaciers below their terminal cliffs.

Taking 5,500 feet as the lowest limit of its extension, every valley in the vicinity of a range equal in mean altitude to the mountains north of Kashmir, must have once been the bed of these moving rivers of ice. The indications of glacier extension are also seen on the north of the Zogi La, between the present glacier of Muchoi and Pundras, at 10 miles from the pass; it is my belief that the Dras plain was once buried in ice, and that this region presented much the same appearance that the neighbourhood of the Mustakh does now. The imagination can hardly conceive the enormous magnitude that glaciers like those in the Karakoram must have once attained,* and that they extended into the Scardo valley on the Indus; 70 to 80 miles is by no means improbable. Smaller ones from the ridge to the south we know did, for near Kepchùn, a fine mass of moraine protrudes into the plain nearly a quarter of a mile, having very large angular blocks on its surface. Moreover, this moraine must have been formed after the valley around Skardo had assumed somewhat its present configuration, for this basin has at some period been filled up with beds of lacustrine deposit, gravels, and conglomerates, to a height that overtops the present isolated rock rising above the town, the coarser beds being the highest in the series; but it is quite natural to suppose that on a milder climate succeeding, these larger alluvial deposits would be the first to be removed by the extinction of glaciers further down the valley, while the cold was yet intense enough to preserve those around and above Skardo. Though the vast accumulations of detritus in the Skardo basin were I conceive due to the glaciers from the high ranges both to the north and south of the Indus near Basho, which glaciers must have extended close down to and dammed up the river, it does not follow as some might be led to suppose, that the whole mass of such a mighty barrier should be formed of ice. It was the débris of moraines that would have composed this, from its continued accumulation in so narrow a gorge as the Indus there presents. These exuviæ there piled up, would have raised the bed of the gorge, and the bed of the lateral valley as well, also elevating the active cause, viz., the glacier itself, and in course of time the whole valley level would have been brought up to the height of the great deposits around Skardo. The section in next page, will I hope explain my meaning, in which a, a', a'', represent the successive levels of the gorge and corresponding lateral glaciers.

* The existing glacier of Baltoro is 36 miles long in direct horizontal distance.

Innumerable other instances can be seen of ice action throughout the Kashmir territory; I will instance near the Fotu La, on road to Leh, a spot now far removed from such causes in action. Even in the valley of the Jhelum, below Bara Mùla, the effects of a glacial period can be seen. That glaciers filling lateral ravines have extended across the main valleys at some periods of their existence is most probable; and in nearly every case where gravel deposits are seen, some side ravine below, having its sources high up can be pointed out, whose glacier has formed a temporary stoppage to the main river into which it ran, and such effects are still in progress in the highest ranges of the mighty Himalayas. When glaciers extended down to 5,000 feet, what must have been the appearance of the upper Shayok Indus and Chang Chùngmo, where 12 to 13,000 is the lowest level of the country, contemplation of such a scene in the mind's eye, renders the formation of lakes and the accumulations of detrital matter a natural sequence very easy to imagine. Further, when such powerful forces



of ice and water were in action, their results would have extended far down the main drainage lines, and are to be sought for at the dèbouchements of such rivers as the Indus, the Sutlej, Ganges, &c.; and I believe that the more recent accumulations of immense boulder beds composed of rocks from the inner ranges, such as may be seen in the Noon Nuddee, Deyrah Dhoon, and other places along the base of the Himalayas, may owe their existence to a glacial period in those mountains.

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