

Office of Superintendent,
Great Trigonometrical Survey.
DEHRA DHOON, 25th August, 1862.

FROM

Major J. T. WALKER, *Engineers*,
Officiating Superintendent G. T. Survey,

TO

THE SECRETARY TO GOVERNMENT OF INDIA,
Military Department,
Fort William.

SIR,

I have the honor to narrate the progress made in the course of the operations of the Trigonometrical Survey, since its late Superintendent, Sir Andrew Waugh, submitted his last Tabular Progress Report, with his No. 13,115, dated 31st January 1861, to your office.

2. Government having objected to the form of the Tabular Progress Reports hitherto submitted, I proceed to adopt a form of Report, somewhat similar to the late Surveyor General's triennial narratives of the progress made in this Department, which I trust will meet with approval.

3. The operations in Kashmir under the superintendence of Captain Montgomerie have made good progress, notwithstanding the increasing difficulties which have had to be encountered as the work progressed, and entered higher and more inhospitable ground. In the year 1861, the triangulation was extended over an area of more than 12000 Square Miles, including some very elevated and difficult country in Zaskar, Rukshu, the Upper Indus, and in Khagan and Nubra. At several points it was carried up to the Chinese Boundary, and stations were visited in the neighbourhood of the Parang and Baralacha passes, where a junction of secondary points was formed with the North West Himalaya Series, the basis of the Degree sheets recently published in Calcutta by the Surveyor General. The stations in Ladak on the Upper Indus were very high, generally over 17,000 feet. Mr. Johnson took observations at one station more than 20,600 feet high, the greatest altitude yet attained as a station of observation. Several remarkable peaks Trans Indus, probably forming the watershed between the Chitral and Swat Vallies, were fixed from the stations West of Khagan.

4. The Topography embraces an area of about 14,500 square miles executed on the scale of 4 miles to the inch, leaving but a very small portion of little Thibet unfinished, and completing the greater portion of Nubra, Ladak, Rupsbu, (or Rukshu) and Yanskar. Several of the Salt Lakes on the Table land of Rukshu have been surveyed. Some exceedingly difficult ground was sketched, by Captain Austen, in little Thibet, varying in altitude from 7,000 to 28,900 feet above the Sea. The glaciers he has discovered and surveyed are probably the largest in the world out of the Arctic regions. The Baltoro Glacier, in the Braldo branch of the Shigar Valley, being no less than 36 miles long. The Bialoganso is nearly as long, and forms, with the glacier on the Nuggair side, a continuous mass of ice nearly 64 miles in length. To delineate them properly a great amount of roughing and exertion, and not a little danger, had to be undergone by Captain Austen, as it was necessary for him to encamp on them for days, and to ascend to great heights on either side.

5. The carrying out of these interesting operations has involved vast labor and exposure. The country was found to be barren and desolate in the extreme, and the weather very unfavourable, in consequence of the extraordinary heavy rains, for which the year will probably be long remembered. Contrary to their wont, the clouds crossed over the South of the Himalayas to the Northern side, bringing heavy falls of snow in August, and generally hindering the work. Supplies and firewood had to be carried great distances, argols of Yak dung being often the only fuel available. Under these circumstances, the outturn of work is most creditable to the Officer in charge and his Assistants. Captain Montgomerie testifies to the zeal and cheerfulness with which all under his orders have executed the difficult tasks assigned to them. He also acknowledges the cordial assistance which the members of the Survey have invariably received from the Maha Rajah of Kashmir and his higher officials.

Captain Montgomerie reports, that "Lieut. Thuillier extended the Triangulation across Khagan, and fixed a number of points Trans Indus, thus making a good foundation for further extension, completing a good season's work, and altogether making very good progress."

"Mr. Johnson pushed on his work with his usual energy and success over very difficult ground, involving the ascent of some very elevated peaks. Notwithstanding the natural difficulties of the country and the bad weather, he crossed Rukshu, and completed a good season's work, and made very satisfactory progress."

"Mr. Beverley triangulated a very elevated piece of country and finally fixed the position of Hante the most important point on the Upper Indus, in the South East of Ladak,—altogether progress very satisfactory and out-turn of work good."

"Mr. Clarke made good progress in Zaskar, and completed a satisfactory season's work."

"Mr. Neville continued his Triangulation in Nubra, and made very fair progress, having to visit several very high stations."

**KASHMIR
SERIES.**

Executive Officer:

Captain T. G. MONTGOMERIE,
Bengal Engineers.

TRIANGULATION.

Assistants:

Lt H. R. THUILLIER,
Engineers, 1st Assistant.

W. H. JOHNSON, ESQ.,
Civil 2nd Assistant.

W. G. BEVERLEY, ESQ.,
Civil 2nd Assistant.

Sub-Assistants.

Mr. S. H. CLARK.

Mr. C. J. NEUVILLE.

Mr. J. Low.

TOPOGRAPHY.

Capt. H. H. G. AUSTEN,
Bengal Staff Corps,
Topographical Assistant.

Captain A. B. MELVILLE,
Bengal Staff Corps,
Topographical Assistant.

Lieut. H. DEBRET,
Late 57th N. I.,
Proby. Topl. Assistant.

Mr. E. C. RYALL.

Mr. W. TODD.

Mr. H. J. BOLST.

(6.) The Kashmir party being employed in mountains which are only accessible during the Summer months, its Field Season is the period of recess of the Trigonometrical parties employed in ordinary districts. The usual Survey year commences in October, by which month the computations and maps of the preceding field Season are generally brought up, and the party is ready to take the field again. The Kashmir Survey year is exceptional and commences in March. The Officers in charge of the various parties submit their respective annual Reports on the termination of the Field operations, which are the real test of the advance made during the year. Thus the Superintendent of the Department cannot prepare Progress Reports for strictly synchronous periods. Sir Andrew Waugh's last report embraced the Summer of 1860, and the preceding Winter.—The present narrative embraces the Summer of 1861, and the Winters of 1860-61 and 1861-62, and consequently gives the progress which has been made in two successive field seasons of ordinary Triangulation, and one season of the Kashmir operations.

(7.) The COAST SERIES,* between Calcutta and Madras was placed under the Superintendence of Captain Basevi, Bengal Engineers, in the autumn of 1860, the exigencies of the Department having required his transfer from the Trans-Indus Frontier all the way to the Madras Coast.—His operations commenced in the vicinity of Vizagapatam, and were proceeding towards Rajahmundry, when on approaching the hill of Kapa in the Rampa estate, he found that his signallers had been driven away from the hill with threats of violence, and that the inhabitants of the District were assembling to prevent him from ascending. The estate is Rent free, and the people are a lawless set, though under the control of the Godaveri Magistracy. Captain Basevi, having obtained an extra Military Guard and a body of Police, made his way to the summit of the hill without molestation, and took the necessary observations. One day, the people set fire to the grass on the hill, which was about 8 feet high, and a Rajah brought intelligence that they were collecting to attack the Surveyors; but the fire was extinguished, and the attack was not attempted. Captain Basevi's chief apprehensions were for the signallers whom he had to leave behind at the station, but a guard was left with them, and they were unmolested. The only serious inconvenience occasioned was in having to construct the station on a block of laterite several feet below the hill, for the summit was covered with dense jungle which there was no means of clearing away without the assistance of the villagers, all of whom had absconded.

(8.) Fortunately, such interruptions are of rare occurrence, only happening in the unusually lawless districts around Hyderabad. The operations proceeded without further opposition or hindrance, excepting from the physical difficulties of the ground passed over.—The district between the Godavéry and Krishna Rivers was crossed, with considerable trouble, owing to the absence of high hills, and the undulating nature of the ground which was all the more difficult because covered with dense jungle. Thus the selection of stations in such a manner as to form an unbroken chain of quadrilaterals and polygons, became a very tedious and laborious undertaking, involving the repeated rejection of positions which at first promised the requisite visibility in all directions, but were afterwards found to be deficient in some essential relation. Nevertheless, in the two field seasons

COAST SERIES

Executive Officer,
CAPT. J. P. BASEVI.

Assistant.

R. CLARKSON, ESQUIRE,
Civil Assistant.

Sub Assistants.

MR. G. HOWARD,) Topog.
1st Class	
) Surv.
MR. J. ELLISON,	
1st Class,) 1860.
MR. F. RYALL,	
2nd Class.)

"Mr. Low assisted Captain Montgomerie, in computing and current duties of the Season. He was subsequently employed on Topographical work, in which he made very fair progress."

"Captain Austen completed his sketch in first rate style, made very good progress in all directions, and turned out a first rate season's work."

"Lieutenant Melville, commencing in the north of Zanskar (of Zaskar) surveyed a large portion of it, including all the large glaciers, to the West, as well as those, at the head of the Butnai river. Some of these glaciers were 15 to 7 miles in length. Total progress very good, and with the Trigonometrical points now available, he will be able to complete the sketch of Zanskar during the ensuing season. Whilst surveying, Lieutenant Melville made very successful and characteristic Photographs of Glaciers, and of the Country generally. His progress in Photography has been very rapid, and highly creditable. Captain Montgomerie has no doubt but that Lieut. Melville will become a proficient in the art."

"Lieutenant De Drett was trained in the use of the Plane Table, and assisted Captain Montgomerie in the computations and current duties of the Series, and will no doubt be able to turn out a piece of independent work during the ensuing season."

"Mr. Ryall sketched a large portion of the Shallow, and Shayak or Nubra valleys, the ground varying in height from 27,000 feet to 8000 feet, including some very large glaciers, one of them 24 miles in length. Notwithstanding the very great difficulties of the ground, Mr. Ryall made very good progress and turned out a first rate season's work, and executed it in good style."

"Mr. Todd sketched a very rugged and difficult piece of the Upper Indus and also a portion of Rukshu, right down to the Parang Pass, altogether a very elevated and desolate piece of country, which Mr. Todd sketched very characteristically, and notwithstanding the difficulties of such a country, he made very good progress and turned out a first rate season's work."

"Mr. Dolst sketched a portion of the Indus Valley, and of Rukshu—progress fair, and execution characteristic and neat."

* On the Coast Series, the principal operations consist of 52 Triangles, arranged so as to comprise one double and five single polygons, and one quadrilateral. 21 Triangles were measured during the first Season, with a 2 foot Theodolite by Darrow, giving a mean trianguler error of 0".65, and an equal number measured the next season, with a similar instrument by Troughton and Simms, gave a mean error of 0".37—Azimuthal observations on Circumpolar Stars were taken at 3 stations.

The selection of stations devolved almost entirely on Mr. Clarkson, excepting when he was so delayed by the difficulties of the ground that Captain Basevi had to suspend the triangulations and proceed to his assistance. After crossing the Krishna River, Mr. Clarkson's advance was very rapid, and he succeeded in selecting Stations as far South as Nellore, 140 miles beyond the terminal side of the triangulation.

Mr. Howard was employed in conducting a secondary series immediately along the Sea Coast. He worked on fast and well as he had hills and clear ground, but on approaching Coconada, his progress was much retarded by having to clear every ray through very valuable ground, abounding in mangoe trees and palmyra trees. His triangles extend over a distance of about 100 miles, defining the Coast Line well, and fixing the positions of the lighthouses at Coconada and Coringa,—points of Nautical importance.

Mr. Ellison was employed in building Platforms at the Principal Stations, and he subsequently carried a Secondary Series of Triangles to fix the position of Rajahmundry and Dowleishwaram. In December 1861 he was transferred to the Assam Series.

Mr. F. Ryall was employed as recorder, and afterwards in building Stations and in Secondary Triangulation, in which his progress was very satisfactory.

the principal triangulation was carried a distance of upwards of 180 miles. It has now reached a point in the Guntoor district near the meridian of Madras, whence it will merge into the meridional arc which is intended to connect Jubbulpore and Madras, and to be extended Southwards into Ceylon.

9. After completing his triangles thus far, Captain Basevi returned to Vizagapatam, to select a site for the Base line of verification, which it is proposed to measure in this neighbourhood. He succeeded in obtaining a suitable site, but not until his field operations had been so long protracted that it was the middle of June before he could break up his Camp and return to quarters. In the event of Captain Smyth's expedition into Central India taking place, Captain Basevi has been nominated to accompany it in the capacity of Astronomer and Topographer.

10. The INDUS SERIES, running parallel to the Western Frontier of British India, was completed by the close of the Field season 1859-60, when the late Surveyor General decided on carrying an oblique series along the South East Bank of the Sutlej, from Mittankote to Ferozapore, to tie up the Punjab Meridional series, and form a basis for future triangulation into the deserts of Sind and Rajpootana. Certain small portions of the Indus triangulation which had been executed with a two foot theodolite gave unusually large re-entering errors. Lieutenants Herschel, and Thuillier, both of the Bengal Engineers, and 1st Assistants of the G. T. Survey, were consequently sent to revise them with the Great Theodolite, while Mr. Armstrong was selecting Stations and building Towers on the line of the Sutlej. 21 principal triangles were ably and rapidly revised, after which Lieut. Thuillier proceeded to join the Kashmir party, while *Lieut. Herschel took in hand the Sutlej Triangulation. This consists of a Series of single triangles, of which one flank rests on the sand hills fringing the Bahawalpore desert, and the other in the lowlands which are periodically inundated by the Sutlej. Thus the greater portion of the rays traverse moist jungles of tamarisk and long grass, alternating with ridges of sand, forming a combination which is peculiarly troublesome in disturbing the atmosphere, and causing lateral refractions to perplex and weary the observer and impair his measures. The Principal operations consist of 38 triangles, extending over a distance of 132 miles from a side of the Indus series below Mittankote to the vicinity of Pak Puttan. Being entirely in the plains they cover an area of only 1960 miles.

11. Lieutenant Herschel reports that "all the principal towns and villages along the line of the Series have been fixed where practicable. They are necessarily few in number, as the country is more and more thinly populated from Ahmedpur eastwards as far as the British boundary. From Bahawalpore to Fazilka, the towns become fewer and of less importance, reaching a climax of insignificance in Bahawalgurh, the capital of nearly half the whole state, which is nothing but a hamlet without a single pukka house in it, and deriving its importance apparently

* Lieutenant Herschel took astronomical observations for the direct determination of azimuth at 9 stations at an average distance of 72 miles apart. His mean triangular error is 0'.53. In 85 angles his mean probability of error is 0.25 between extremes of 0.10 and 0.38. He has given the following interesting table as a test of the accuracy of his work.

(A.) *Maximum difference between observations.*

B Number of measures in a set.	0"	1"	2"	3"	4"	5"	6"	7"	8"	TOTAL.
	to 1"	to 2"	to 3"	to 4"	to 5"	to 6"	to 7"	to 8"	to 9"	
2	1	0	0	0	0	0	0	0	0	1
3	229	251	93	0	0	0	0	0	0	567
4	3	13	65	22	1	0	0	0	0	104
5	0	5	4	29	13	1	0	0	0	52
6	0	0	0	5	11	5	3	0	0	24
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1	0	1
9	0	0	0	0	1	0	0	0	0	1
TOTAL	227	269	126	56	26	6	3	1	0	730

Total 0' to 3' = 656. Total greater than 3' = 92

In this Table the unit is a set of measures of an angle on a single Zero, the arguments being A the maximum difference between the respective measures forming a set, and B the number of measures.

SUTLEJ SERIES.

Executive officer,
Lt J. HERSCHEL, *Engineers.*
1st Assistant.

Assistant.
W. ARMSTRONG Esq.,
Civil Assistant.

Sub-Assistant.
Mr. G. J. RYALL,
Senior Sub-Assistant.

Mr. W. F. THORNTON, *Season*
1860-61.
2nd Class.

Mr. J. T. BURT,
3rd Class.

from nothing but the prestige of an old ruined fort, and the residence in it of the temporary holder of the largest (but by no means the richest) Kardari in the states. The country is singularly poor in Mosques, temples, tombs, or indeed prominent buildings of any kind."

12. The RAHOON MERIDIONAL SERIES,* under the charge of H. Keelan, Esq., 1st Assistant G. T. Survey, has advanced a distance of 176 miles, by 83 Principal Triangles, arranged in quadrilaterals and hexagons, covering an Area of 4130 Square miles. It has laid down portions of Jeypoor, Ulwar, Deoli, Boondi, and numerous other places of importance. In one more field season, it should reach the Longitudinal Series between Calcutta and Kurachi, where it will terminate. The published Charts of the Kotah and Boondi territories indicate a succession of hills over which it was supposed that the triangulation might have been carried and completed last season. But the ground was found to be the very reverse of what had been expected, and to require the construction of Towers, thereby protracting the operations into another Season.

13. The GOORHAGURH MERIDIONAL SERIES, under the charge of Geo. Shelverton Esq., Civil 2nd Assistant G. T. Survey, traverses a meridian close to that of Umritsur, and was brought to a termination last Season by joining the Arumlia Series, which had some years previously been carried, by Captain Rivers of the Bombay Engineers, up an adjacent meridian, as far as Ajmeer, from the Great Longitudinal triangulation. From Sirsa to Ajmeer it crosses a desert tract, of which Mr. Shelverton reports that "the main difficulties encountered were scarcity of water, of building material, of laborers and of provisions—the country traversed had suffered for three years from extreme drought; large villages originally containing upwards of 500 families had been deserted by all except first class Farmers who were too proud to work. Wholesome water was scarcely procurable, and water even for building purposes had frequently to be conveyed from distances of 4 and 5 miles. The large reservoirs of water upon which the inhabitants depended for their supply during the greater part of the year had invariably been exhausted, and the expensive kucha wells of the country barely sufficed for local wants. It was therefore under very adverse

Lieutenant Herschel has introduced an improvement in the referring marks at present used in the Survey. Instead of having two apertures one for a lamp, the other for a heliotrope, he made both lamp and heliotrope illuminate the same piece of ground glass, the aperture of which was limited by a circular diaphragm of diameter suitable to the distance. Thus one object is intersected instead of two, and there is no flickering or unsteadiness of signal from wind or imperfect direction of heliotrope; there is no dazzle from too bright a sun, nor total disappearance in its absence, for the mere reflection of the sky suffices to illuminate the glass in tolerably clear weather. One mile is considered the best distance for such a mark.

Mr. Armstrong was employed in both seasons in selecting stations. He has formed a junction with the southern extremity of the Jogi Tila Series, and laid out his triangles so as to merge into the Goorhagurh Series to the East of Ferozpoor. He was subsequently employed in carrying a Series of triangles with a 14 inch Theodolite from the vicinity of Pak Puttan towards Moolta, via Hurrappa, Cheechawutni, Talamba, and Mukdoompur, near which last place the triangulation has at present closed.

Mr. Geo. Hyall was chiefly employed in constructing the numerous tower stations which it was necessary to erect in the lowlands of the Sutlej. He also assisted Mr. Armstrong in selecting sites. He carried secondary series of triangles to fix the position of Shoojababad, Mysce, Futtohpoor, and Karor, and finally made a reconnaissance from Bahawalpur into the Desert, for a distance of about 65 miles, as far as Anoopurh, on the Jogi Tila Meridian, to ascertain the feasibility of continuing that Series in a Southerly direction, which had long been doubted, but is now proved to be quite practicable, as the desert was found to have numerous sand hills suitable for Trigonometrical stations.

Mr. W. Trotter acted throughout the field season of 1860-61 as Lt. Herschel's immediate Assistant in the Office and Observatory, giving every satisfaction. He subsequently resigned his appointment in the Survey having obtained an Ensign's Commission in H. M.'s 34th Regiment. He was succeeded by Mr. J. T. Burt who has worked well. The greater portion of the party returned to Head Quarters by the 19th May, followed on the 31st by Mr. Armstrong.

*Mr. Keelan employed Colonel Waugh's 2 feet Theodolite No. 1 in his triangulation. The average error of his 33 triangles is 0.36. The mean probability of angular error is 0.30, between extremes of 0.12, and 0.65. Azimuth observations were taken at 3 stations. The Secondary triangulation covers an area of 7040 Square Miles.

In the Season 1860 61, Mr. N. A. Bellety assisted Mr. Keelan in selecting sites, on which he afterwards built the requisite Stations. He carried a Series of 37 secondary triangles over a distance of 170 miles, to lay down the position of Ulwar and other towns. During the following recess, he was disabled by a severe accident from immediately resuming field operations, and has ever since been temporarily attached to the Computing Office in consequence.

In 1860-61, Mr. M. C. Hickie carried a Secondary Series of 33 triangles over a distance of 130 miles to fix Sambher, Jeypoor and other towns.

In 1861-62, Mr. C. J. Carty, who was attached to the levelling operations, volunteered to take Mr. Bellety's place for a time, and while his camp was marching to Serouje, proceeded by dak to the Ar-bu'li range, to select stations northwards from the side of the Longitudinal Series, with which the Rahoos was to form a junction. He labored very energetically under most trying circumstances, never pausing though daily ill with fever.

In 1861-62, Mr. H. Keelan Junior carried a creditable Secondary Series of 25 triangles over a distance of 120 miles, and determined the positions of the cantonments of Deoli, and the city and Fortress of Boondi, and numerous other positions.

Mr. C. Braithwaite acted as Observatory Assistant with much intelligence and promise.

† Mr. Shelverton employed Colonel Waugh's 2 feet Theodolite No. 2 in his triangulation. The average error of his 69 triangles is 0.54. The mean probability of angular error is 0.45 between extremes of 0.18 and 0.87. Azimuth observations were taken at only one station. The Secondary triangulation covers an area of 10,954 Square Miles. Owing to the paucity of good natural or artificial objects, 152 Secondary Station marks were built for future reference.

Mr. A. W. Donnelly is very favourably reported of by Mr. Shelverton, for the amount of work he has accomplished in selecting stations, building towers and platforms, and executing Secondary triangulation embracing 29 triangles, and a Series of 160 miles in length, starting from and terminating on the Principal Series to fix Deekaneer and Nagour.

Mr. M. C. Hickie executed a network of triangles 88 miles long by 16 broad on the east flank of the Series, and is reported to have laid out his ground judiciously.

Mr. F. Bell is reported to have worked well in the preliminary operations, and afterwards in executing a series of Secondary triangles over a distance of 104 miles, through the desert, on the parallel of 29° 30' to the meridian of 73° and thence South to Bikanere, to join Mr. Donnelly's Series.

Mr. G. W. E. Atkinson was of much use as Observatory Assistant.

RAHOON MERIDIONAL SERIES.

Executive officer:
H. KEELAN Esq.
1st Assistant.

Assistants:
N. A. BELLETY, Esq. } Season
Civil 2d Asst. } 1860-61.

C. J. CARTY } on temporary duty
Civil 2d Asst. } Season
1860-61.

Sub-Assistants:

Mr. M. C. HICKIE, } Season
1st Class, } 1860-61.

Mr. KEELAN, } Season
Junior, } 1861-62.
2d Class.

Mr. H. W. C. WILKINSON, } Season
2d Class. } 1861-62.

Mr. C. BRAITHWAITE,
2d Class.

GOORHAGURH MERIDIONAL SERIES.

Executive Officer:
Geo. SHELVERTON Esq.
Civil 2d Assistant.

Sub Assistant:
Mr. A. W. DONNELLY,
Senior Sub-Assistant.

Mr. M. C. HICKIE,
1st Class.

Mr. F. BELL,
2d Class.

Mr. G. W. E. ATKINSON,
2nd Class.

circumstances that the Goochgarh Meridional Series was conducted during the Field Season of 1860-61.

14. During the following season the deserts of Bikaneer, Shekhawati and Marwar were extensively traversed, and a very large area of both principal and secondary triangulation was executed, reflecting much credit on Mr. Shelverton and his Assistants, who skillfully and energetically availed themselves of the facilities offered by mounds and hills, commanding extensive prospects, to fix a large number of positions of importance. In the two seasons the triangulation was carried a direct distance of 342 Miles by 50 consecutive triangles, covering an area of 4,454 Square Miles.

ASSAM PARTY.

Executive Officer :

C. LANE ESQ.,
Chief Civil Assistant.

Assistant.

W. C. ROSSENRODE ESQ.,
Civil Assistant,
Offg. in charge, season
1861-62.

Sub-Assistant:

MR. H. BEVERLEY,
Senior Sub-Assistant.

MR. J. ELLISON, } Season
1st Class. } 1861-62

MR. A. DESOUZA, } Season
1st Class. } 1860-61..

MR. SHUTTER,
2nd Class.

15. The ASSAM PARTY,* in charge of C. Lane Esquire, Chief Civil Assistant, was employed in 1860-61, in triangulating along the Eastern Frontier, from the South of Gowhattay to Cherra Poonjee. Recent prohibitions regarding the impressment of Coolies occasioned much embarrassment, notwithstanding that the majority of the Cossyabs are porters by trade; delay was thus caused in taking the field, and often afterwards. Mr. Lane reports that it frequently proved of assistance, as a turning point to the arguments employed to persuade these loyal people to act as porters, to tell them they were required "on Her Majesty's Service," interpreted "Maha Rance ka kam." The operations were further impeded by clouds and mists, and latterly by storms of such severity that on one occasion the whole of the Bunder Bazar, on the bank of the Scorma, was utterly destroyed and no vestige left. Final observations were taken for 19 principal triangles arranged in a double Series, extending over a direct distance of 62 Miles, and covering an area of 1207 Square Miles. Eight important Snowy Peaks of the Bhotan Himalayas were fixed.

16. During 1861-62, Mr. Lane was absent on leave on medical certificate, when his place was ably filled by Mr. W. C. Rossenrode, who extended the triangulation a direct distance of 89 miles Eastwards through Cachar towards Munnipoor, and 25 Miles Southwards towards Independent Tipperah, in all 114 miles, by 30 triangles arranged in a double series covering an area of 2024 Square Miles. Some of the stations were situated in the Jynteapore District, but the observations at them were fortunately completed before the present rebellion broke out. Reciprocal observations had still to be taken to them from other stations around, necessitating the employment of Hindoostani clashes to work the signals on them; the men, though robbed and threatened, maintained their posts during the rebellion, and only came away when signalled to do so at the termination of the observations.

* The area of Secondary Triangulation executed during both seasons is 10,250 Square Miles, fixing the positions of Silchar, Sylhet, Jynteapoor and numerous other places of importance. One azimuth only was determined by astronomical observation.

Mr. W. C. Rossenrode was employed in 1860-61 in selecting sites for stations, and in secondary triangulation, making good progress.

Mr. H. Beverley was employed in secondary triangulation, building stations, clearing rays, and opening-out paths for the large Theodolite employed in the principal operations. He was subsequently deputed to select stations within the British Territory, to be used in case the attempt to cross Independent Tipperah might prove unsuccessful.

Mr. A. DeSouza was directed by Mr. Lane to make a Topographical survey of the Cossia plateau, of which he accomplished about a thousand square miles, on the scale of 4 miles to the inch. Subsequently he fell ill with inflammation of the knee joint, and as there was no one to take his place, the topography could not be extended further. He was ordered to Sea for change of air, and is now assisting in the astronomical observations for the determination of the longitude of the Andaman Islands.

Mr. Lane having also obtained sick leave it became necessary to call up Mr. Ellison from Vizagapatnam to join the party.

Mr. Shuter was employed as an observatory assistant and in desultory secondary triangulation; he is reported to have been diligent and assiduous.

Mr. Rossenrode reports as follows of the tribes who inhabit Independent Tipperah: "The Court of the Rajah at Agratolla is composed entirely of Bengalees. A Bramin of Bengal has the sole management, and conducts the affairs of the state. Being a Bramin, he is also the spiritual adviser of the Rajah, who pays him the greatest reverence and respect, and remains standing during any interview which may take place between them. The Praboo, as this Bramin is called, is not very popular from having cut down the expenses of the Rajah, reduced his retinue, discharged many of his retainers, and sold the superfluous elephants and horses. He has done much good since the country has been under his management. A younger brother of the Rajah, Barchand Thakoor, resides at Lavatolla. He has received the rudiments of an English education, and has been taught Chemistry, Medicine and Photography, and amuses himself taking likenesses. He takes no part in business, and seems to have no influence whatever."

"The court being composed of Bengalees, none of these men were willing, or would volunteer their services when an agent was required, to accompany Mr. Ellison, and their reluctance to do so may be attributable to the difficulties they would have to encounter in an unexplored, uninhabited portion of the country through which Mr. Ellison pointed out to them on the map that the work would have to be conducted.

"On enquiry, Mr. Ellison learned that the country was uninhabited owing to the inroads of the Kachak Kookies, an Independent tribe, who leave their hills and fastnesses in the interior, and make frequent forays, plundering and murdering the Tippera Rajah's people. The great dread of this savage and inhuman tribe causes such a panic throughout this portion of the country, that all the inhabitants deserted their villages and settled on the Frontier, or in the Cachar, Sylhet and Comilla districts, and no persuasion will induce them to accompany a small detachment such as Mr. Ellison's was. With a large armed force able to repel any attack, these very people formerly subjects of the Rajah of Tippera, are ready to render every assistance, and to guide the forces, in order that the Kachak Kookies may be severely punished, nay exterminated from the country.

"There are several tribes in Independent Tipperah. The Kookies, Nagas and Tipperas inhabit the hills and jungles. They select a locality for their Village, clear it and the surrounding hills and valleys, and cultivate the rich virgin soil for two, three or at the utmost, four years, and then remove to some other equally favorable locality. They chiefly cultivate cotton, a fourth of which is given to the Rajah annually; a portion is spun and manufactured into coarse cloth for household use, and some pieces of cloth of better texture, as well as the surplus cotton, are taken to the nearest bazar, or market, and exchanged for goats, pigs, fowls or ornaments. They also cultivate rice, yams, and a grain termed chena, (which grows only on these hills,) for their own consumption. The Kookies and Nagas have no caste, they eat dogs, and cats; in fact every animal and every bird is eaten. The Kookies of Assam, Cachar, Manipur, and Tippera have different dialects, and the same may be said of the lan-

17. I have already reported (1) that on learning that the Bengal Government had ordered a Survey of Independent Tipperah to be made, I arranged with Mr. Buckland the Commissioner of Chittagong, for our Triangulation to be carried across Tipperah, on the direct line from Cherra Poonjee to Chittagong, instead of taking an extensive circuit westwards, as was originally contemplated, in order to keep within British Territory, and away from a frontier believed to be insecure. Mr. Ellison was deputed to enter Tipperah to reconnoitre the country, and select sites for the stations. He was considerably delayed by having to wait for the Rajah's Agents, but he made some progress, and is reported by Mr. Buckland to have "behaved with much tact and patience, although he had to encounter the usual obstructiveness of the Rajah and his people." Mr. Ellison has supplied some interesting information regarding the Hill tribes inhabiting Independent Tipperah, which I have extracted from Mr. Rossenrode's report and given in the foot notes.

18. The BOMBAY PARTY,* under the superintendence of Lieutenant now Captain C. T. Haig Bombay Engineers, 1st Assistant, was engaged in 1860-61 in completing the triangulation necessary to connect the Guzerat longitudinal series, on the parallel of 23°, with the Singi meridional series, which had been brought up from Bombay as far as Surat, by Captain Rivers, some years previously. The connexion was satisfactorily accomplished, notwithstanding that the section of the party employed in selecting stations, got entangled in some malarious Jungles, where both Europeans and Natives were attacked with Jungle fever, and had to retire to Broach until the sickly season was over. In 1861-62 the Guzerat Longitudinal series was extended eastwards to the Khanpisura series on the meridian of 75°, and a series of triangles on the meridian of Oodeypore was carried between it and the Karachi Longitudinal, thus completing the Triangulation of the northern portion of the Bombay Presidency. The principal operations involve 126 miles of triangles arranged in a double series, and about 190 miles arranged singly, the total number of triangles being 42, covering an area of 7450 square miles.

19. The LEVELLING OPERATIONS, † under Captain Branfill, of the late 5th Bengal European Cavalry, 2nd Assistant, have made good progress, having in the two field Seasons been carried from a point near Mitunkote, on the Indus line of Levels, to the Dehra Dhoon Base Line, via Bahawalpoor, Ferozepoor, Looliana, Umballa, and Saharanpoor, and thence on to the Seronge Base line in Central India, via Meerut, Allyghur and Gwalior, over a distance of 999 miles. In the course of these operations, Stone Bench Marks were fixed at distances of 12 to 15 miles, and the most substantial milestones met with by the road side were also determined, for future reference by Canal or other Engineers engaged in levelling operations. A satisfactory connexion has been made with the Ganges, and the Eastern Jumna Canal levels, and those of the Allahabad and Agra Railway, which are now capable of being reduced to the mean Sea level as a common datum.

usage of the Nagas of the above named places. The Tipperas, in dress, appearance, and habits, resemble the inhabitants of Assam. They have their own language and are a low caste of Hindoos; from a constant intercourse with the people of the plains they are more civilized, and understand Bengali. The Tipperas are candid, straight-forward, cheerful, and of all the hill tribes met with on this side are most trustworthy and intelligent. The Kookies and Nagas are a sullen, morose, treacherous set, and cannot be confided or depended upon. They do not mix with their neighbours and consequently retain their barbarism. The Kachar Kookies are an independent tribe, and nothing is known of them except that they make frequent incursions, rob, plunder, and murder the inhabitants."

* Astronomical observations for azimuth were taken at two stations.

Of the Meridional Series, south of Oodeypoor, Captain Haig reports as follows:—"The country through which this series runs is inhabited by the wildest set of savages that I have as yet ever had to do with. The thieves (who form a portion of the inhabitants of every Village) for the sake of the clothes a man has on his back, assault him; if he attempts to escape, they bring him down with a shower of arrows, utterly regardless of his life. On this account, communication by messengers was attended with great risk, and consequently Messrs. DaCosta and McGill were each unacquainted with the other's progress until they actually met, otherwise I had intended them to be in frequent communication. It is partly due to this that the Series has a bend in the centre, and partly because the Raja of Saloomber, a very refractory chief, would not permit a Station to be built on his hill, although directed to do so by the Political Agent."

Mr. DaCosta was employed in carrying a Secondary Series of triangles along the west Coast of the Gulf of Bombay, from the mouth of the Sabarmuthee River to Gogo, over a flat tract of country, which for a great portion of the year is entirely under water. Also in selecting principal stations for the Mungalore and Oodilpoor Series, over a meridional distance of upwards of 180 miles. He laid out a Secondary Series down the East coast of the Gulf of Cambay as far as Surat, and carried other triangles to fix the position of Baroda. His services are very favorably reported by Captain Haig.

Mr. G. McGill was employed in selecting and building stations in a malarious tract of country which had often previously been attempted, but never before with success, sickness and other difficulties having invariably driven back the Surveyors.

Mr. Anding rendered valuable assistance in the observatory, and in desultory duties.

† Mr. Carty worked with Captain Branfill during the Season 1860-61; the next Season he carried an independent line of levels from Seronge to Allyghur, assisted by Ramchund, an intelligent and hard working native of Lahore who was once in the service of the unfortunate Aloolube Schlagintweit. The first year, Ramchund executed 175 miles of branch levels to fix positions of importance.

In 1861-62, Mr. C. Wood assisted Captain Branfill, by whom he is favorably reported of.

During the course of the levelling operations, it has often been noticed that though the independent results obtained at each station by the respective observers differ at all by almost imperceptibly minute quantities, the differences have a tendency to go one way, and have occasionally accumulated to large amounts. On this curious and perplexing subject, Captain Branfill reports as follows:

"I think we can all subscribe to the following facts—The state of the weather and the season of the year have a very considerable effect on our results, as shown by the difference between observers. We have found that the apparent law of our differences is least developed some time in the middle of the cold season. In a run of bad weather (i. e. bad for the work) the apparent law of our difference is for the most part marked when the atmosphere is clearest, and when we have supposed our observations to be freed from error; and conversely

(1) My No. 21 dated 31st 1862
March to your address.

BOMBAY PARTY

Executive Officer:

Captain C. T. HAIG,
Bombay Engineer,
1st Assistant.

Assistant.

J. DA COSTA, Esq.,
Civil 2d Assistant.

G. MCGILL, Esq.,
Civil 2d do., junior grade.

Sub-Assistant:

Mr. ANDING,
2nd Class.

LEVELLING OPERATIONS.

Executive Officer:

Captain B. R. BRANFILL,
Late Bengal 5th Cavalry,
2nd Assistant.

Assistants:

C. J. CARTY Esq.,
Civil 2nd Assistant.

Mr. C. WOOD, } Season
2d Class. } 1861-62

Native Leveller,
RAMCHUND.

**COMPUTING
OFFICE.**

J. B. N. HENNESSEY Esq.,
1st Assistant.
BABOO MAHDANATH
SIKDAR.

20. The COMPUTING OFFICE in Calcutta, under the Superintendence of Baboo Radannath, Chief computer, was engaged in completing the triplicate manuscript volumes of the General reports of the Parishath, Hurlong and Chendwar Meridional Series, and in furnishing elements for the various Topographical and Revenue Survey Parties requiring them. In March last, Baboo Radannath retired on a pension, after 30 years' service, during which he had repeatedly earned the approbation of the successive Surveyors General under whom he had served. On his resignation it was deemed advisable to remove the computing office from Calcutta to the Head quarters of the Trigonometrical Survey at Dehra Dhoon, to bring it into more direct connexion with the Superintendent of the Department, and also with the field parties whose computations it has revised and collated.

21. The distant location of the computing office had entailed the formation of a small office at Head Quarters under the superintendence of J. B. N. Hennessey Esq., 1st Assistant G. T. Survey, composed of Native Surveyors, and newly joined Sub-Assistants, who thus had an opportunity of being rigorously trained in the theoretical portion of their new duties. This little office has lately completed the triplicate manuscript copies of the General report of the North Eastern Longitudinal Triangulation between Dehra Dhoon and Purneah, in two thick imperial volumes; it has also been employed in revising the computations of the mountain triangulation of the North West Himalaya Series, computing 3 volumes of the report of the Levelling operations, and preparing the triplicate general report of the Trans Indus Frontier Survey; also in supplying elements, examining candidates, instructing new assistants, and other current work. On the transfer of the Calcutta Office to Dehra, all but one of the old computers took their discharge, but fresh men have been entertained, and I have every reason to expect increased efficiency from the new computers, under the direction of Mr. Hennessey.

22. The Drawing Office, under superintendence of W. H. Scott Esq., Civil Assistant G. T. Survey, has been chiefly employed in compiling Maps of Kashmir, and Ladak, from the plane table sheets sent in by Captain Montgomerie. The first of these large maps has already been transmitted to the Home Government, the second is well advanced. Ten original preliminary charts of the Triangulation in different parts of India have been forwarded for the use of the Surveyor General's Office, and duplicates have been prepared for the Geographer to the Secretary of the State for India. Triplicate charts have also been constructed for the manuscript volumes of the General Report.

23. Between the completion of a Survey, in this country, and its publication, a long interval invariably elapses, during which even the Supreme and Local Governments are without access to valuable information, acquired, but unimpartible because of the costliness of manuscript maps and the time occupied in their construction. I have therefore been induced to attempt to employ photography for making rapid copies of our maps and charts, as a temporary substitute for the final engravings. This process has of late year been extensively adopted in the Ordnance Survey of Great Britain for reducing maps, as a substitute for the pentagraph. Two complete sets of photographic apparatus were sent out to this country by the Secretary of State for India, for similar employment, and it is with one of these that I am endeavoring to have our maps copied. The operation is by no means easy, for the apparatus has had to be specially adapted to make full scale copies, and not reductions merely, for which it was originally intended, and the maps require to be drawn with special reference to future copying or reducing by photography. An ordinary finished map cannot be reduced without a large portion of the names becoming too microscopic to be easily legible. In the first Kashmir Map the rivers were colored in blue, and the broken land and low hills in red, the higher ranges being in Indian ink. Consequently a photograph of it would show no rivers, and would invert the depth of shading of the high and low hills, bringing the latter into excessive prominence.*

24. Captain Melville, who has already been mentioned in connexion with the Topographical Survey of Kashmir, has attained considerable skill as a photographer, and succeeded in making an excellent reduction to half scale of the second Kashmir Map, before any names were printed on it. The reduction will have the names inserted by hand, and will then be ready for being copied to full scale, and afterwards printed, for as extensive circulation as the limited means at my disposal will permit. I have every reason to hope that with Captain Melville's assistance, I may be able to supply a want, which has often been seriously felt.

25. In concluding this report of the operations of the Trigonometrical Survey, I am happy to be able to express my opinion that the progress made on all sides, both in the field, and during

ly in a run of good weather, when the air is hazy from smoke or dust, or greatly agitated by wind, and in short, when we have found most difficulty in reading the staves, our results have most coincided with each other. Our differences do not appear to vary with the distances of the staves. On the contrary the differences are perhaps even more marked as the day grows older, and the distances of the staves from the instrument are reduced. The general direction in azimuth of the line of our work has some connection with the cumulative differences, and we have noticed that the tendency to differ is more marked when proceeding towards a certain point of the compass, than when proceeding from that point towards its opposite."

* A Map of Asia between the parallels of 20° and 60° on the scale of 100 geographical miles to the inch, has been recently compiled under my superintendence, partly in this office, and partly in the Surveyor General's of which I had temporary charge from 10th January to 24th March last. It gives the most recent information available from our own and other sources of the countries between St Petersburg and Peking, Tobolsk and Calcutta. The boundaries of the territories respectively under British and Russian protection are shown, and the caravan routes from India to all parts of Asia. The Map is now available in the office of the Surveyor General, Calcutta.

Mr. James Peyton has rendered valuable assistance in the drawing office, having executed the hill shading of the whole of the Kashmir Maps, and of a Map of Jhelum and Rawul Pindce, from the Topographical Surveys of Captain Robinson.

the recess, by the Survey parties, and by the offices at Head quarters, has been most satisfactory, and I would respectfully solicit the favorable notice of Government for the Officers, already cited, in charge of the respective parties and offices.

I have the honor to be,

Sir,

Your most obedient servant,

MAJOR, ENGINEERS,

Offg. Superintendent,

Great Trigonometrical Survey of India.

Mr. Harry Duhan, Extra Assistant, in charge of Corresponding branch of this office, accompanied me to the Presidency, and carried out the arrangements for the transfer of the computing office from Calcutta to Dehra, and has invariably been of much assistance.

Mr. Robert Scott has been employed in the Corresponding office and as general store keeper, and has been most assiduous in the execution of his multifarious duties.
