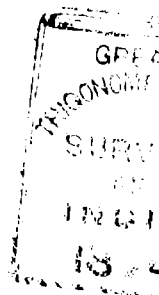


ABSTRACT
OF THE
REPORTS OF THE SURVEYS
AND OF OTHER
GEOGRAPHICAL OPERATIONS
IN
INDIA
FOR
1871-72.



PRINTED BY ORDER OF
HER MAJESTY'S SECRETARY OF STATE FOR INDIA IN COUNCIL.

LONDON:
SOLD BY W. H. ALLEN AND CO., 13, WATERLOO PLACE;
EDWARD STANFORD, 6, CHARING CROSS;
HENRY S. KING AND CO., 65, CORNHILL;
N. TRÜBNER AND CO., 57 & 59, LUDGATE HILL.

1873.

P R E F A C E.

The Annual Abstract of the Survey and other Geographical Operations in India during the year 1871-72, is arranged on the plan of the "Memoir on the Indian Surveys," and of the Abstracts for 1869-70 and 1870-71, which give a history of these operations up to March 1871. The intention of these Annual Abstracts is to indicate the more important and interesting operations of the year, previous to an examination of the detailed Reports, with their valuable appendices. It is hoped that the Abstracts continue to be useful for purposes of reference, and with this object foot notes are given, referring the reader to passages in the Memoir or in the Abstracts of 1869-70 and 1870-71 in which the previous history of each operation is described and the previous services of each officer that is mentioned are given.

Colonel Walker's memorandum on the completion of the portion of the Indian Atlas to be engraved in England; and the important statements prepared by Colonel Thuillier and Colonel Walker on the work of the surveys, for the use of the East India Finance Committee of the House of Commons, will be found in an Appendix.

ANALYTICAL TABLE OF CONTENTS.

I.—INDIAN MARINE SURVEYS, 1871-72.	PAGE
Subject still under consideration - - - - -	9
Mr. Chapman's Survey of Bahrein - - - - -	9
Provision of a steam cutter for the Bahrein survey - - - - -	10
Marine Surveys required - - - - -	10
Port of Colachul opened, but not surveyed - - - - -	10
II.—THE GREAT TRIGONOMETRICAL SURVEY OF INDIA, 1871-72.	
Brahmaputra Series - - - - -	11
Bidar Longitudinal Series - - - - -	11
Biláspur Meridional Series - - - - -	11
Bangalor Meridional Series - - - - -	11
Mangalur Longitudinal Series - - - - -	12
Highest Peak in Southern India - - - - -	12
Triangulation in the Asam Valley - - - - -	12
Gujrát Survey - - - - -	12
Katiwár Survey - - - - -	12
Garhwal Survey - - - - -	12
Latitude Observations - - - - -	13
Pendulum Observations - - - - -	13
Tidal Observations - - - - -	13
Levelling Operations - - - - -	13
Computing Office - - - - -	13
Publications - - - - -	14
Colonel Walker's return to India - - - - -	14
III.—THE TOPOGRAPHICAL SURVEYS OF INDIA AND WORK IN THE OFFICE OF THE SURVEYOR-GENERAL, 1871-72.	
Character of the work - - - - -	14
No. 1 Party. Gwalior and Tonk - - - - -	14
No. 2 Party. Kandesh and Nimar - - - - -	15
No. 3 Party. Bustar state and Jaipur - - - - -	15
No. 4 Party. Rewah and Biláspur - - - - -	15
No. 5 Party. Bhopal and Málwa - - - - -	15
No. 6 Party. Rájputána - - - - -	15
No. 7 Party. Lushai Expedition - - - - -	15
Drawing and compiling - - - - -	16
Work published - - - - -	17
Engraving of the Atlas - - - - -	17
Lithographic Branch - - - - -	17
Photographic Branch - - - - -	17

IV.—THE REVENUE SURVEYS OF INDIA, 1871-72.	PAGE
Amount of work - - - - -	17
✓ Cadastral Surveys in the North-West Provinces - - - - -	17
Mattra and Murádabad Surveys - - - - -	18
Agra and Hamirpur Surveys - - - - -	19
Revenue Surveys in Bengal - - - - -	19
Hazáribágh Survey - - - - -	19
Death of Mr. O'Donel - - - - -	20
Work completed - - - - -	20
Progress of the Madras Revenue Survey - - - - -	20
Failure of the experiment in Bombay - - - - -	20
Conference of Surveyors - - - - -	21
New arrangement for Bombay Surveys - - - - -	21
V.—THE SUPPLY OF INSTRUMENTS.	
Inferior quality of Old Instruments - - - - -	21
Improvements effected - - - - -	22
Method of Inspection - - - - -	23
Instruments inspected in 1872 - - - - -	23
Cost of Inspection - - - - -	24
VI.—THE GEOLOGICAL SURVEY OF INDIA, 1872.	
Mr. Medlicott in the Sátपुरa range - - - - -	24
Mr. Willson in Bandalkhand and Rewah - - - - -	24
Coal Fields of Kota mapped by Mr. Mallet - - - - -	24
Mr. Ball examining Coal-bearing Rocks in Sirguja - - - - -	24
Deputation of Mr. Bauerman to report on Iron - - - - -	24
Mr. Hacket in Jabalpur and Rewah - - - - -	24
Mr. Fedden tracing out rocks under Deccan trap - - - - -	24
Mr. Wynne and Dr. Waagen in the Salt Range - - - - -	24
Report on fossils of Kach (Cutch) - - - - -	25
Mr. King in the Godávári valley - - - - -	25
Mr. Foote in the Deccan - - - - -	25
Mr. Theobald in Burma - - - - -	25
Dr. Stoliczka's work on Kach - - - - -	25
Mr. Blanford's researches in Persia - - - - -	25
Publications in the Records for 1872 - - - - -	27
Volumes of Memoirs - - - - -	27
Palæontologia Indica - - - - -	28
Progress of Geological Maps - - - - -	28
Mr. Calvert on the Mineralogy of the Himalayas - - - - -	28
VII.—THE ARCHÆOLOGICAL SURVEY OF INDIA.	
General Cunningham's Scheme of Work - - - - -	29
Employment of Mr. Beglar and Mr. Carlcyle - - - - -	29
Reprint of the Reports from 1862 to 1865 - - - - -	29
Researches in the Gangetic valley - - - - -	29
„ „ Agra and Delhi - - - - -	29
Work of Mr. Burgess in the Bombay Presidency - - - - -	30

	PAGE
State of Frescos in the Ajanta Caves - - - - -	30
Report of Mr. Griffiths on Ajanta Frescos - - - - -	30
VIII.—METEOROLOGICAL OBSERVATIONS, 1871-72.	
Questions of the Organization of a Meteorological Department still under consideration - - - - -	30
Work in Bengal - - - - -	30
Observations in the North-West and Central Provinces made comparable with those of Bengal - - - - -	31
North-west Provinces - - - - -	31
Punjab and Oudh - - - - -	31
Mysor - - - - -	31
Berárs - - - - -	31
IX.—THE MADRAS OBSERVATORY, 1871-72.	
Unpublished arrears - - - - -	31
Observation of μ Argus - - - - -	32
Longitudes by Electric Telegraph - - - - -	32
Eclipse of the Sun - - - - -	32
The Comet of Biela - - - - -	32
X.—GEOGRAPHICAL EXPLORATION AND NEW PUBLICATIONS.	
Major Montgomerie's explorers - - - - -	33
Journey of No. 9 round Mount Everest - - - - -	33
Sir Frederick Goldsmid's Frontier Commission - - - - -	34
Work of Majors St. John and Lovett - - - - -	34
New Map of Persia - - - - -	34
Progress made in Geographical Knowledge of Persia - - - - -	35
Longitudes by Electric Telegraph - - - - -	35
Major Lovett's work in Baluchistan - - - - -	36
Major St. John and Mr. Blanford's work - - - - -	36
Map of Western Asia, by Captain Felix Jones - - - - -	37
Manuals of Districts in the Madras Presidency - - - - -	38
„ Madura - - - - -	38
„ Vizagapatam - - - - -	38
„ Bellary - - - - -	38
Reprint of the Memoir on Curg - - - - -	39
Results of Mr. Forsyth's Mission to Yarkand in 1870 - - - - -	39
Mr. T. T. Cooper's account of his journey through Assam and Mishin - - - - -	40
Colonel MacGregor's Gazetteers of Afghanistan and Persia - - - - -	41
Gazetteers of Kokan and Turkish Arabia - - - - -	41
XI.—GEOGRAPHICAL DEPARTMENT OF THE INDIA OFFICE, 1872.	
Death and Services of Mr. Walker, late Geographer - - - - -	41
Progress of the Catalogue - - - - -	42
Copies of Dutch Maps and Charts - - - - -	43
Discovery of old Geographical Memoirs - - - - -	44
Presentations and preparation of Maps - - - - -	44

APPENDICES.

- A.—Memorandum by Colonel Walker, dated September 1872, on the arrangements for the final completion of the portion of the Indian Atlas to be in England ; with a Note on the subsequent progress - - - 47
- B. & C.—Statements prepared by Colonel Walker and Colonel Thuillier for the East India Finance Committee of the House of Commons - 55 & 66
-

A B S T R A C T
OF THE
R E P O R T S O F T H E S U R V E Y S
AND OF OTHER
G E O G R A P H I C A L O P E R A T I O N S I N I N D I A
FOR
1871-72.

I.—INDIAN MARINE SURVEYS, 1871-72.

The Secretary of State has not yet been furnished with the opinions and suggestions of the Government of India as to the best means of placing the Marine Surveys on an efficient footing, which were called for in a despatch in the Geographical department, dated March 30th (No. 7), 1871.¹ It is, therefore, presumed that the subject is still under consideration.²

Meanwhile Mr. Morris Chapman and Mr. Thompson, in the schooner "Constance," have proceeded with the survey of the Bahrein reefs.³ Mr. Chapman arrived at Bahrein on the 23d of October 1871. His initial data of latitude and azimuth were determined by numerous astronomical observations; the latitude of origin being 450 feet N. 10° W. of the highest part of the old Portuguese Fort. The base line was measured four times with iron chains, carefully compared with a steel standard; its azimuth being determined by means of numerous sets of observations to α Polaris at its greatest elongation with a 12" Troughton and Simms' theodolite. Careful tidal observations were taken at Bahrein; and in March, when the fair weather set in, soundings were commenced, the edges of the reefs at low water springs being put in by plane table. In May nearly all the crew were attacked with fever, and Mr. Chapman returned, with the "Constance" to Bombay, where he completed a fair chart of Bahrein harbour and its adjacent reefs. The remaining work com-

¹ See "Abstract" for 1869-70, p. 11, and for 1870-71, p. 9.

² See Note, p. 11.

³ See "Abstract" for 1870-71, p. 12.

prises much of the sea face of the reefs, and a steam launch is very urgently needed. The tides run so strong that, without a good breeze, the Lascars cannot pull against them for any length of time; but with a steam launch, fitted with a condenser, the surveyor could remain outside and work, instead of having constantly to run into port for water. A steam cutter, 26 feet in length, for this surveying service, has accordingly been ordered in England, and was to have been ready to be sent out on about the 30th of June 1873.

The great ocean and coasting trade of India renders the provision of accurate charts on adequate scales of the coasts and anchorages, a very important part of the duty of the Government. But, since the abolition of the Indian Navy, nothing has been done, except a survey of the mouths of rivers in Orissa and at Chittagong, and this work in the Persian Gulf, and no proper arrangement has been made for the execution of much-needed marine surveys. New surveys are urgently required of the coasts between Calicut and Bepur, from Santopilly to Point Palmyra, from Nizámpatam to Cocanada, and of various shoals on the Coromandel coast.¹ A survey is much needed of the new port of Kolachul in Travancor, near Cape Comorin, which has never been properly surveyed by the authority of Government, but was practically discovered by the coffee planters in the adjacent hills. They found that large ships could sail between some outlying rocks, and ride at anchor to leeward of them in still water. The first ship called there in March 1871, and since that date two other ships have loaded at the port of Kolachul. A survey is also urgently needed of Palk Strait and the Gulf of Manar; and there should be a periodical examination of the river mouths of Mangalor and Cochin, and of the mud banks off Narakal and Alepy. Mr. Robertson has pointed out the need for surveys of the mouths of the Narbada and Tapti, and several others are much wanted. The adoption of effective measures for securing the due execution and continued revision of Marine Surveys and Charts on a systematic imperial plan, is a question which yearly becomes more urgent. In a despatch, dated March 30th, 1871, the subject of Marine Surveys was brought to the notice of the Government of India by the Secretary of State as one of very great importance, and as deserving of early and serious attention. But the

¹ See "Abstract" for 1870-71, p. 9.

despatch, as has been already mentioned, has not yet been answered, and the subject is believed still to be under the consideration of the Government of India.¹

II.—GREAT TRIGONOMETRICAL SURVEY OF INDIA, 1871–72.

During the season of 1871–72 the Great Trigonometrical Survey has been proceeded with on five series, and the completed work is represented by 10,310 square miles of principal, and 13,530 of secondary triangulation. The work on the Brahmaputra Series, under Mr. Beverley, was confined to approximate operations, as much of the strength of the party as possible being devoted to the Asam triangulation.

The Bidar Longitudinal Series,² under the charge of Mr. Rossenrode,³ who took the field in December, 1871. The country was hilly and intricate, marching and arranging for supplies was a matter of very great difficulty, and pack bullocks were the only available means for carriage. Tigers and other wild animals were numerous and very troublesome; and after February the smoke from the jungle fires rendered the progress of observing very slow. Towards the end of April the Bidar Series was completed, and a junction was effected with the Coast Series. The Biláspur Meridional Series⁴ was extended 42 miles in the district of Chattisgarh; but it was difficult to find stations owing to the total absence of all permanent buildings in the wild forest-covered country. Some ruined temples were seen, in the depths of dense forest, on sites where, in some remote period, a large town existed, but they did not rise above the trees. The Bidar Series party, having completed that portion of their work, will now take up the southern portion of the Biláspur Series.

Lieutenant Rogers⁵ carried on the northern section of the Bangalor Meridional Series⁶ without intermission, until a junction was effected with Sir Andrew Waugh's southern section of the Great

¹ Since this was in type, the Government of India have requested that a conference may be held at Calcutta in the ensuing cold season between the Naval Officer who may be selected by the Secretary of State to investigate the Marine affairs of India, the local Maritime Administrations, the several Chambers of Commerce, the Marine Authorities, the Surveyor-General, and Commander Taylor, late I.N.

² See "Memoir," p. 115; "Abstract" for 1869–70, p. 11; and "Abstract" for 1870–71, p. 18.

³ See "Memoir," p. 114, and "Abstract" for 1870–71, p. 17.

⁴ See "Abstract" for 1869–70, p. 12, and "Abstract" for 1870–71, p. 18.

⁵ See "Memoir," p. 113, "Abstract" for 1869–70, p. 12.

⁶ See "Abstract" for 1870–71, p. 18.

Arc, extending north to Dehra Dun, on the 1st of March. Lieutenant Rogers also fixed the positions of Haidarabad and Sikandrabad.

The operations of the Mangalur Longitudinal Series, on the parallel of 13° , were pushed on with great energy by Major Branfill.¹ The series was carried over the western Ghats, a difficult range, partly covered with dense jungle. From the computations of the previous season's work it was found that the Aneimudi Peak, in the Animalle Range, has an altitude of 8,837 feet above the sea, nearly 200 feet higher than the Dodabeta Peak, on the Nilgiris, which has hitherto been supposed to be the highest mountain south of the Himalayas.

The triangulation of the Asam valley² has been continued to the eastward by Mr. W. G. Beverley³. It was necessary, owing to the unsettled state of the hill country, to carry the triangulation along the valley which, when not covered with forest, is clothed with gigantic tropical reeds and grass. The reeds were so thick that, in clearing a way, they had to be cut one by one, as if they were small trees. The series has now reached the Sibsagar district.

The Topographical Survey operations of the Great Trigonometrical Survey have been carried on in Gujrat, Katiwar, and Kamaun. Major Haig⁴ was at the head of the Gujrat Party,⁵ which commenced operations near Surat, and an accurate map will be prepared of the city. Very good progress was made, and 1,036 square miles were triangulated. In Katiwar,⁶ under Captain Trotter,⁷ very important work was done, for the old maps of this country are excessively inaccurate, and, as regards the lines of drainage, positively misleading. The agent of the Bombay, Baroda, and Central India Railway, on examining the new maps, was induced to lay out an entirely different line for detailed survey from what he intended when he had the old maps only to judge from. In Garhwal the field work began with an extension of the triangulation of the Mana and Niti valleys that drain into the Alaknanda branch of the Ganges.⁸ This was a very difficult piece of work, as the stations were above

¹ See "Memoir" p. 112, "Abstract" for 1869-70, p. 12.

² See "Abstract" for 1870-71, p. 17.

³ See "Abstract" for 1871-72, p. 17.

⁴ See "Memoir," p. 118.

⁵ See "Abstract" for 1869-70, p. 13, and "Abstract" for 1870-71, p. 18.

⁶ See "Memoir," p. 118, "Abstract" for 1869-70, p. 13, and "Abstract" for 1870-71, p. 19.

⁷ See "Abstract" for 1869-70, p. 13, and for 1870-71, p. 19.

⁸ See "Memoir," p. 116, "Abstract" for 1869-70, p. 12, and for 1870-71, p. 20.

the limits of forest, and some of them 17,000 feet above the sea. From three stations near the Niti Pass, eight lofty peaks of the Trans-Himalayan range were fixed. One of them is the celebrated Kailas Parbat, or Gangri, which was formerly measured by Major-General Strachey.¹ The present operations show that his results were newly correct, the height now established of 22,028 feet, being just 28 feet in excess of General Strachey's measurement. The field work of the season comprised the triangulation of the country east of Naini Tal, up to the Nepal frontier, on the Sardah river.

Latitude observations were carried on by two parties under Captains Campbell and Herschel,² on the 75th and 78th meridians.³ The Pendulum Party, on the death of Captain Basevi, was placed temporarily under the charge of Mr. Hennessey, who took pains to collect and arrange every record of Captain Basevi's valuable operations,⁴ in order that none of his hard-earned results might be lost to posterity. Subsequently, Captain Heaviside took charge of the Pendulum Party, in order to take the observations which are required to complete Captain Basevi's work. He will afterwards proceed by Aden and Egypt to England, and complete the Series at Greenwich.

Tidal operations⁵ have been satisfactorily completed at Tutikorin, and Major Branfill will select a site at Mangalur for another set of tidal observations. In Katiwár Captain Trotter very carefully examined the coast line between Diu and Verawal, with the object of selecting stations for tidal observations. Lieutenant Baird⁶ has been entrusted with the superintendence of the tidal observations, and, it is hoped, that he will be enabled to carry out a complete survey of the coast in the first instance, so that sites may be selected and ready when the new instruments arrive from England.

The levelling operations⁷ for 1871-72 were conducted by Captain Carter, who carried the main line to the Great Trigonometrical Survey, Towers of Sonákhoda⁸ and Ramganj, which mark the ends of one of the initial bases.

In the computing office Mr. Hennessey has continued the calculation of the Sironj-Chach Quadrilateral; and the whole mass of this

¹ See "Memoir," p. 251.

² See "Memoir," p. 120, "Abstract" for 1869-70, p. 13, and for 1870-71, p. 20.

³ See "Memoir," p. 119, "Abstract" for 1869-70, p. 13, and for 1870-71, p. 20.

⁴ See "Memoir," p. 120, "Abstract" for 1869-70, p. 13, and for 1870-71, p. 22.

⁵ See "Memoir," p. 225, "Abstract" for 1870-71, p. 49.

⁶ See "Memoir" for 1870-71, p. 50.

⁷ See "Memoir," p. 119; "Abstract" for 1869-70, p. 13, and for 1870-71, p. 23.

⁸ See "Memoir," p. 91.

⁹ See "Memoir," p. 122.

extensive work, which forms the basis of the geodesy of northern India, has now been reduced by the most accurate of modern processes. Progress has also been made with the new volumes of the "Account of the Great Trigonometrical Survey." The drawing office was chiefly occupied with the preliminary charts of triangulation, and the charts of levels; but a map of the country round Delhi was compiled for the use of the camp of exercise, and experiments were made as to the most convenient form for issuing such maps for use with troops in the field. Copies were printed on waterproof india-rubber cloth, on white cloth, and on several kinds of paper; and it was found that the white cloth promised to be most useful in the climate of India. A second edition of Colonel Walker's map of Turkestan has now been prepared, and will shortly be published.

Colonel Walker returned to India in October 1872, and Major Montgomerie is now in England on furlough.

III.—THE TOPOGRAPHICAL SURVEYS OF INDIA, AND WORK IN THE OFFICE OF THE SURVEYOR GENERAL, 1871-72.

Seven Topographical Survey Parties were at work during 1871-72, under the direction of the Surveyor General, and they have made systematic progress in filling up the blank country in the respective divisions, so as to provide for each sheet of the Indian Atlas in due order. As the Surveys progress, the ground to be taken up becomes more insalubrious and difficult of access. The ground now occupied by each party is very wild, much of it altogether uninhabited, and in many parts very malarious. The vast tracts still remaining have never come under the operations of any Survey, but every corner will now be penetrated and defined. A marked impression is thus steadily being made, in laying down the features of the country and completing the first Survey of all India. An area of from 16,000 to 18,000 square miles on an average is annually mapped by this department.

No. 1 Party,¹ under Lieut. Holdich,² was at work in Gwalior and Tonk; an unusually difficult country. From the head of the Kunu valley to the Párbati river, the country is one continuous level of uninterrupted jungle. Scarcity of water and constantly recurring famines has reduced the population, and the cities are now hamlets standing in the midst of ruins.

¹ See "Abstract" for 1870-71, p. 24.

² See "Abstract" for 1870-71, p. 24.

The 2d Party,¹ under Mr. Girdlestone,² was surveying the north-east corner of Khandesh, and Holkar's territory of Nimar, together with small portions of the native states of Barwáni, Dhar, and Sindia.

Colonel Saxton,³ with No. 3 party,⁴ was in the Bustar State of the Central Provinces, and Jaipur, Panchpenta, and Madgul of the Vizagapatam Agency; a very wild mountainous country, from 500 to 5,000 feet above the sea.

No. 4 Party,⁵ under Major Depree,⁶ was in the Rewah State and the Biláspur district. Their ground included the high plateau from which rises, at Amarkantak, the Narbada river, and the Johila, a tributary of the Son. The highest part of this plateau is 3,860 feet above the sea. The valleys are bare of forest and covered with tall coarse grass, and the inhabitants are wild Gonds, who live in wretched mud huts. The Party also extended its operations to the plateau of Sohágpur in Rewah where the Son rises, and to part of Chatisgarh.

Captain Riddell,⁷ with No. 5 Party was in Bhopal and Málwa, on the Narbada and its tributaries the Sindor, Tendoní, and Banna. A small portion of the valley of the Betwa is also within the ground surveyed in 1871-72.

The triangulation of No. 6 Party,⁸ under Captain Strahan, extended along the eastern flank of the Arabulla range in Rájputána, the highest point of which next to mount Abu is 4,330 feet above the sea. The range forms a long precipitous ridge rising abruptly from a plateau, and constituting the watershed of this part of India. The western portion of the country triangulated is in the plains of Marwar.

The 7th Party conducted the Survey operations with the expeditionary force in the Lushai and North Chittagong hills. Major Macdonald with Captain Tanner, Mr. Clifford Barrett, and Mr. Gordon Cooke, accompanied the southern column from Chittagong. This party succeeded in establishing a series of 27 secondary triangles emanating from a base of the Eastern Frontier Series of the

¹ See "Abstract" for 1870-71, p. 25.

² See "Abstract" for 1870-71, pp. 10 and 26.

³ See "Memoir," p. 128; "Abstract" for 1869-70, p. 18, and for 1870-71, p. 25.

⁴ See "Abstract" for 1870-71, p. 25.

⁵ See "Abstract" for 1870-71, p. 25.

⁶ See "Memoir," p. 128, and "Abstract" for 1870-71, p. 25.

⁷ See "Abstract" for 1870-71, p. 25. ⁸ See "Abstract" for 1870-71, p. 25.

Great Trigonometrical Survey, and 76 minor triangles. It established 40 well-defined points, and its work covers an area of 2,300 square miles of country, never before laid down, or even attempted to be painted. The mountain ranges and water system were sketched in from the Kurnafuli river to the valley of the Koladin in the extreme east. Unfortunately, although the two columns of the Lushai expedition approached each other very closely, a junction was not actually formed. It is hoped that improved relations with the hill tribes will hereafter enable the department to fill up this and other gaps which still disfigure the map of India. The northern column, starting from Cachar, was accompanied by Captain Badgley in charge of the surveying party, assisted by Lieut. Woodthorpe, Mr. E. V. Leach, Mr. Ogle, Mr. Robert, and Mr. McCay. The triangulation of this party emanates from a side of the Cachar Secondary Series of the Great Trigonometrical Survey, and extends for 25 miles, in a S.E. direction into the Lushai country. Thence a route survey of 191 miles formed, with the triangulation, a connected basis for the delineation of 4,800 miles of entirely new topography. The party was within 40 miles of Major Macdonald's party which accompanied the southern column. The officers of both parties have given very interesting descriptions of this new country, and of the manners and customs of the wild tribes which inhabit it. Lieut. Woodthorpe published a narrative of the proceedings of the left column of the Lushai expedition.¹ His opening chapters contain a summary of the events which led to the expedition, and some particulars respecting the physical and intellectual characteristics of the Lushais, their villages, customs, and wasteful method of cultivation by jungle clearances. The rest of the work consists of a narrative of the march, with various incidents and adventures, and accounts of the skirmishes with the hill men. The book is illustrated by two sketches and a map, showing only the route of the left column, and not covering sufficient ground to give a notion of the general plan of the campaign. Captain Tanner also wrote an account of the work of the right column, containing graphic descriptions of scenery, and interesting ethnological details. A new general map of the entire frontier, showing all these recent additions, is in course of preparation.

The drawing and compiling branch of the Surveyor General's

¹ "The Lushai Expedition, 1871-1872," by R. G. Woodthorpe, Lieutenant Royal Engineers. (Hurst and Blackett, 1873.)

office, under Mr. James, supplies the engraving, lithographic, and photozincographic offices with materials, and also complies with all official requisitions for special maps and tracings. During the year under review, nine new quarter sheets of the Indian Atlas were completed, and several are under compilation. A most useful standard map of India, on a scale of 64 miles to the inch, is also being prepared, and will be engraved on copper, on four sheets. A new standard map of Bengal in outline, on a scale of 16 miles to the inch, as a sister map to those of the Punjab and north-west provinces, has been completed; and the general map of the eastern frontier is commenced.

The engraving of the remaining quarter plates of the Indian Atlas is progressing very satisfactorily.¹ Up to the end of 1872 18 quarter plates had been engraved and published in India, and as many are in various stages of progress. Sixteen native apprentices are receiving instruction in the art of engraving on copper, and three new engravers have been added to the European staff. The process of steel facing the copper plates to preserve them from deterioration has been adopted, and the necessary apparatus has been received from England. In the lithographic branch 702 sheets of maps have been placed on stone, and 177,986 copies printed off. Among them may be mentioned the Revenue Survey sheets of the provinces of Sind and Oudh. Captain Waterhouse,² under whose energetic superintendence the photozincographic branch¹ of the office has attained its present high standard of usefulness, has spared no efforts to meet the demands for the immediate reproduction and issue of survey maps. As many as 1,428 were published, the number of copies being 117,320. He has also produced a beautiful specimen Map, by the photocollotype process, of a reduced Atlas sheet, and another of an old Dutch map of Bengal.

IV.—REVENUE SURVEYS.

There were 16 Revenue Survey Parties employed during 1871–72, under the orders of the Surveyor General, seven in the upper and nine in the lower circle; and the total area surveyed was 18,144 square miles.

The year 1871–72 inaugurated the system of cadastral field Surveys

¹ See "Abstract" for 1870–71, p. 26.

² See "Memoir," p. 185, 131, and 137; and "Abstract" for 1870–71, p. 26. (8967.)

|| on accurate principles.¹ They were commenced in the districts of Mattra and Murádabad, in the North-West Provinces.² The size of the fields averages 1·02 acres; in Madras they average 2·7 acres, and in Bombay they vary from 20 to 40 acres for dry crops, to from 4 to 8 acres for rice cultivation. The small size of the fields of course increases the amount of measurements to be made, recorded, and plotted, and consequently the cost of the Surveys. During this, the first year, the cost was 5 annas per acre, but it will be considerably

¹ In a letter from the Secretary to the Government of the North-West Provinces to the Secretary to the Government of India (No. 2272 A., Dec. 23, 1872) attention is invited to a passage at page 28 of the "Abstract of the Reports of the Surveys, &c." (for 1870-71), which is said to contain erroneous statements "not in accordance with facts."

The remarks in question are :—

1. That the first Revenue Survey of the North-West Provinces was executed by professional surveyors.
2. That this vital principle has since been set aside.
3. That the return to the old and more accurate system is quite in accordance with the views of Mr. Thomason.

There is nothing in the Secretary's letter which contradicts the two first of these remarks, the correctness of which can scarcely be disputed. The first Survey was undoubtedly executed by professional surveyors, although it is true that, owing to the extraordinary haste with which the work was pushed forward (3,000 square miles each season), the topography was omitted, and the resulting maps were all but useless for any purpose but the settlement. They were used for the Atlas of India, but the sheets which were constructed from such materials are incorrect and require revision.

The second remark, that the vital principle of making the Surveys by professional agency has been set aside, is strictly accurate, although a correct system has recently been adopted in Mattra and Murádabad.

The third remark is based on several passages in Mr. Thomason's directions for settlement officers. In paragraph 30 he says, "The scientific survey is of great value as a check upon the Ameens," although he adds that the giving of topographical information is a secondary consideration. He also refers to the Scientific Survey at paragraphs 25 and 27, and to the principle laid down by him of "simultaneous procedure between the professional survey and khusreh." These passages prove that an accurate system was in accordance with the views of Mr. Thomason, and a reference to paragraph 30 of Mr. Thomason's directions, as well as to paragraph 29, will show that the remark at page 28 of the "Abstract" for 1870-71 is quite in accordance with facts. Mr. Thomason's views are also referred to by Colonel Thuillier, in a letter dated Feb. 12th, 1870, No. 229, paragraph 9.

Mr. Thomason did not put so high a value upon a correct Survey, and upon the importance of combining settlement work with the preparation of Maps for general administrative purposes as is done at the present day. Thirty years ago such Maps were not so urgently needed in every department of the government. But he considered the scientific Survey to be of great value as a check; and its operations are, therefore, quite in accordance with his views.

² See "Abstract" for 1870-71, p. 29.

reduced during 1872-73, for many causes inseparable from starting work of an entirely new character, contributed to increase the rates in 1871-72. The work is most intricate, and Colonel Gastrell, the Superintendent of the Revenue Surveys (upper circle), reports that great credit is due to Colonel Anderson and Major Vanrenen, who have conducted the operations in the Mattra and Murádabad districts, for the completeness of the work in every respect, and for the extent of the areas that have been completed. A facsimile of one sheet of a village in Mattra, by Colonel Anderson, illustrating the style and minuteness of the cadastral operations now being carried on in the North-West Provinces, is forwarded with the report. More permanent Survey marks are needed, to make this cadastral Survey complete and efficient in every respect. There are masonry marks erected at triple junctions of villages, which are used as theodolite stations, and plotted down on the village maps. But these alone are not sufficient to enable additions to be made to maps hereafter, without unnecessary labour and expense, and it is proposed to have the nearest survey station, right or left of the triple junction, permanently marked, so as to give a good and reliable base line, from which any new measurements can at once be laid off. The cadastral Surveys are on a scale of 16 inches to the mile; and Colonel Thuillier anticipates the very best results from these operations, both financially and professionally, as regards systematic and accurate measurement, with permanent recordings of the maps of "fields" and ascertainment of true areas. "Eventually," he continues, "I believe they will prove not only invaluable as a correct permanent record of the landed tenures for all purposes of Revenue assessment, but an immense saving of expense will be effected in the end, by doing away with the constant necessity for partial remeasurements for irrigation, canals, railways, roads, and other purposes, which are now perpetually being made in an irregular, unsatisfactory, and expensive manner, for emergent engineering objects." Besides Mattra and Murádabad, Revenue Surveys on accurate principles, on the scale of 16 inches to the mile, have also been commenced in Agra and Hamirpur. The other Revenue Surveys of the upper circle were at work in Bareli, Kurnal, Dera Ghazi Khan, and Bháwalpur.

In the lower circle (Bengal) 4,760 square miles were surveyed in Naugong, Dorang, and Sibságar in Asam, and in Hugli, including a Topographical Survey of 1,099 square miles in Hazáribágh and a portion of Lohardugga in Bengal. The Hazáribágh Survey

was made by Captain Sconce,¹ who is reported to have combined triangulation with a close and searching delineation of the topography of the country, and by his system, energy, and skill to have made a splendid topographical survey of Hazáribágh. The department has to deplore the loss of Mr. O'Donel,² which occurred in the height of the field season, on April 22d, 1872. Colonel Vanrenen, in recording his death, says that he entered the service in 1836, and by sheer hard work, industry, and perseverance, he worked his way up to the highest grade of the executive branch. In the Central Provinces the Revenue Survey Parties were at work in the districts of Chindwara, Ráipur, and Bhandára.

The combined area completed by the Topographical and Revenue Surveys was 36,054 square miles, at an average cost of 3*l.* 10*s.* 1*d.* per square mile. The annual cost of the Great Trigonometrical Survey is 70,000*l.*, of the Topographical 70,000*l.*, and of the Revenue 100,000*l.*, making the total cost of the Surveys 240,000*l.*

The Madras Revenue Survey,³ under the superintendence of Colonel Priestley, made steady progress. Up to 1872 the Survey of eight districts was completed, and eight were in progress. The finished area amounts to 32,122 square miles, besides 7,862 in the districts still under Survey. The excess of assessable area brought to light by the Survey ranges from 2 to 23 per cent., and in the completed districts the Survey gives 24,000 square miles, which have hitherto only been counted as 21,500 for assessment purposes. The average assessment is 3*s.* 9*d.* per acre, and the addition of these 2,500 square miles to the taxable area represents an annual gain to the State of 300,000*l.* The value of a Revenue Survey on accurate principles can scarcely be disputed in the face of such facts as these. The average size of fields is about two acres, and the approximate number measured and potted in the eight completed districts is 7,000,000. The number of village maps that has been drawn is 15,546, and the average error per mile, shown by the test of comparing the work with that of the Great Trigonometrical Survey, is 7·61 feet.

During 1871-72 the experiment of the combined Revenue Survey and settlement measurements in the Bombay Presidency⁴ was tried in the Násik district; and after being fully reported upon, it was decided by the Government of India not to have been sufficiently

¹ See "Abstract" for 1869-70, p. 16.

² See "Abstract" for 1869-70, p. 16.

³ See "Abstract" for 1870-71, p. 32; also "Memoir," pp. 106 and 133.

⁴ See "Abstract" for 1870-71, p. 34.

successful to warrant its continuance on the same principles for another season. The operations of the party from Bengal comprised a survey of each village including all the topographical details required for geographical maps on a scale of 8 inches to 1 mile, that being the scale in general use in the Bombay Presidency. The Bombay Parties were to measure and class the fields within the village areas.

The work of the two Parties could not be made to agree, and it was found that this double system of measurements was impracticable. A conference was, therefore, held between Colonel Francis, the Survey and Settlement Commissioner of Bombay, the Surveyor General of India, and the Superintendents of the Revenue Survey Department of India, on the 24th of February 1873, on the subject of combined Revenue and Topographical Survey in the Násik, Púna, Sholápur, and Ahmadnagar districts. It was arranged that a General Topographical Survey, on a scale of 2 inches to the mile, should be executed by the Department of the Surveyor General, entirely independently of the Bombay Revenue Survey of fields. By this arrangement the whole of the Bombay districts will be laid down on one uniform scale of professional Topographical Survey, whilst the Revenue Survey of fields will proceed intact and be totally free from all clashing.

V.—SUPPLY OF INSTRUMENTS.

The 11th section of the Memoir on the Indian Surveys contains an account of the Lambeth Observatory, created and superintended by Colonel Strange, of the system under which it is managed, and of the work it performs.¹

Colonel Strange was appointed to examine and test all instruments ordered for India in 1863. On October 15th, 1866, Colonel Strange submitted a report, and on March 3d, 1873, he sent in another interesting report, based on the results of 10 years' experience of the working of his system.

When Colonel Strange was first appointed there was no one kind of instrument supplied to India which was not faulty, either in respect of form, principle, workmanship, or material, and frequently in all these respects. Parallel rulers were not parallel, protractors indicated angles enormously in error, scales and level staves were incorrectly graduated, spirit levels were imperfect, barometers had

¹ See "Memoir," p. 138.

enormous errors, and the more elaborate instruments, such as theodolites and levels, stood in need of thorough reform in every detail.

The great improvement effected by Colonel Strange has been attained by three measures, the abolition of patterns, the abolition of tenders, and a system of thorough inspection.

The pattern system is an encouragement to the trade to stand still, and the result is the perpetuation of forms which have long been condemned and superseded by the advance of knowledge. But there is no finality in science. In no branch of human knowledge is there more rapid and extensive change. At the same time, a system of supply without patterns entails invention and skilful superintendence, and could not be adopted unless the services of such an officer as Colonel Strange were available, who to unsurpassed knowledge of the use and construction of scientific instruments, adds a practical acquaintance with Indian surveying, acquired by many years of arduous service in the field. In December 1867, Mr. Thomas Cushing, an accomplished mechanic, trained under the eye of Mr. Thomas Cooke of York, was appointed as Colonel Strange's assistant. Under the colonel's instructions he has now become qualified to inspect, adjust, and observe with every description of scientific instrument and apparatus furnished to the Indian services.

The system of employing makers of repute has been substituted by Colonel Strange for that of tenders, but he gives orders to more than one for each class of instrument. This plan stimulates effort, and affords the means of checking any augmentation of prices. Makers are called upon to give estimates, not tenders, for each class of instruments.

The instruments are subjected to rigorous inspection, and to actual trial before payment is made. This has raised their price, but at the same time it has greatly increased their accuracy. In 1865 there were 4,148 instruments inspected, which cost 10,609*l*. In 1872 the number inspected was 18,000, and the cost 20,845*l*. The number of different kinds of instruments ordered through Colonel Strange is about 150; several have to be individually carefully examined and tested, and some require to be taken to pieces. The following is the average annual number of the most important kinds:—

Theodolites - - -	145	Microscopes - - -	17
Levelling Instruments -	152	Pentagraphs - - -	19
Thermometers - - -	739	Salinometers - - -	34
Barometers - - -	25	Hydrometers - - -	17
Aneroids - - -	20	Telescopes - - -	48
Insts. Mathl. cases -	406	Levelling Staves - -	212
Chronometers - - -	45	Prismatic Compasses -	103

Colonel Strange remarks that the only just mode of viewing the cost of inspection, which he calculates at 3·57 per cent. of the cost of the instruments,¹ is by looking on it as a per-centage of the cost of the departments using the instruments; and on this point he offers the following calculation :—

“ My office is not kept up for its own sake, but for the sake of maintaining the efficiency of certain departments, such as the Public Works, the Surveys, and, to a certain extent, the Medical and Educational Departments. It is as an integral part of these departments that the cost of instruments, including their inspection, is rendered necessary and is to be justified.

“ Viewing it in this way, I take the expenditure of late years on Public Works in India as between seven and eight millions (8,000,000*l.*) per annum.

“ The number of instruments which would be supplied if no inspection existed would probably be the same as that supplied at present with inspection; but one effect of efficient superintendence must be, and has been, to raise the price of instruments. I held out no other expectation on being appointed, as I conceived one of the main objects in appointing me was to put a stop to the supply of low-priced bad instruments by inferior makers. It is difficult to arrive exactly at the amount of this increase, which has affected different kinds of instruments very unequally, but I am quite sure that if I take it at 10 per cent. on the whole I shall be considerably over-estimating it.

“ Taking the average cost of instruments for the last five years, as before, at 16,343*l.*, then 10 per cent. of this will be 1,634*l.* We have then—

“ Increased cost of instruments consequent on inspection	- 1,634 <i>l.</i>
“ Colonel Strange’s salary - - - -	- 350 <i>l.</i>
“ Mr. Cushing’s „ - - - -	- 170 <i>l.</i>
“ Observatory Attendant - - - -	- 64 <i>l.</i>
Total	- 2,218 <i>l.</i>

“ Comparing this with 8,000,000*l.* we find that the superintending,

¹ Average yearly cost of instruments for the last five years, 16,343*l.* The cost of inspection is 584*l.*, being 350*l.* for the salary of Colonel Strange, 170*l.* for that of Mr. Cushing, and 64*l.* for the Observatory attendant, being 3·57 per cent. on the cost of the instruments. A commission agent would charge 5 per cent. for merely buying such instruments, without even pretending to submit them to any efficient examination.

“ improving, and inspecting of the instrument supply adds at present
 “ 6·6*d.*, or say sixpence halfpenny per 100*l.*, or about $\frac{1}{36}$ th of 1 per
 “ cent. to the cost of the departments to whose efficiency such
 “ superintendence, improvement, and inspection contributes. I
 “ need make no remarks on this result.”

VI.—THE GEOLOGICAL SURVEY OF INDIA, 1872.

During 1872 Mr. Medlicott was engaged in the examination of the Sâtpura coal fields and adjoining country.¹ The most important practical results of his work are the possibility of coal being found to extend under the more recent deposits of the Narbada valley, and the probability of workable coal being traced more to the south in the Dudhi valley. Mr. Medlicott recommended that boring trials should be made, but the undertaking was attempted to be carried out without proper tools or efficient supervision. Mr. Willson was engaged in extending the geological lines and boundaries from the north of Damoh into Bandalkhand and the adjoining territory of Rewah.²

The coal fields of Kota, on the southern borders of the Mirzapur district, have been mapped by Mr. Mallet, who noticed 14 outcrops of coal, most of them very thin and worthless, but two or three have a workable thickness of fair coal. During the later part of the year Mr. Mallet took up the examination of the Hazáribágh district. Mr. Ball was engaged in the examination of the coal bearing rocks in Sirgúja, and afterwards he was deputed to accompany Mr. Bauerman in his visit to the more important iron yielding districts, with a view to giving a definite opinion on the feasibility of establishing ironworks in India. Mr. Hacket³ has carried his lines and divisions from Jabalpur into Rewah; while Mr. Fedden, during the early part of the year, extended his examination of the rock in the Nizam's territory adjoining Chanda, tracing out the existence of a group of rocks under the great Deccan trap, related to the Upper Jurassic rocks of Kach, and the Rájmahal beds of Bengal.

Mr. Wynne and Dr. Waagen⁴ have completed the mapping of the whole of the Salt Range, in the Punjab, and have obtained a remark-

¹ See “ Abstract ” for 1870–71, p. 38.

² See “ Abstract ” for 1870–71, p. 38.

³ See “ Abstract ” for 1870–71, p. 38.

⁴ See “ Abstract ” for 1870–71, p. 40.

ably interesting and extensive series of fossils. Afterwards Mr. Wynne was at work in the country north of the Salt Range; while Mr. Waagen returned to Calcutta and took up the detailed examination of the *cephalopoda* from Kach, a group which will form one of the most important contributions to the *cephalopoda* fauna of the Upper Jurassic formations ever published.

Mr. King took up the examination of the country near the Godávári, in continuation of Mr. Blanford's Survey of the previous year. He discovered the most southerly coal deposit that has hitherto been found in India, and has come upon some fossiliferous beds between Rájmahendri and the sea, the organic remains of which will prove of high interest. As the jungles become drier and more accessible, Mr. King will extend his researches northwards.

Mr. Foote¹ has been carrying out the boundary lines between the Deccan trap rocks and the underlying beds, and between those intermediate beds and the gneiss rocks on which they rest, connecting his lines with those previously mapped in by Mr. Wilkinson to the west. In Burma, Mr. Theobald² has been at work in the country between the central range and the eastern boundary of the country on the Sitang river; and in the season of 1871-72 he will have completed the examination of British Burma proper, when a map and general report will be prepared for publication. Dr. Stoliczka³ also completed his work on the province of Kach, and he has defined several well marked sub-divisions of the Jurassic rocks, establishing their close relationship to the acknowledged group in European classifications.

Mr. Blanford had been instructed to devote the working season of 1871-72 to a preliminary examination of the geology of Sind, but on his arrival in Karáchi in November 1871 he was directed, instead of proceeding into Sind, to accompany Major St. John, R.E., in the Survey of the Perso-Baluch frontier. It was proposed that Major St. John's Party should leave Gwadar early in December, and after tracing the frontier between Persia and independent Baluchistan as far as Jalk, should traverse or skirt the desert to the north, and joining Sir F. Goldsmid in Sistan, accompany that officer to Tehran.

Major St. John being detained for a time in Persia by illness, Mr. Blanford devoted the time at his disposal to a brief examination

¹ See "Abstract" for 1870-71, p. 40.

² See "Abstract" for 1870-71, p. 40.

³ See "Abstract" 1870-71, p. 41.

of several places of interest on the Makran coast and the shores of the Persian Gulf, an opportunity of visiting these places in the Government telegraph steamer being afforded to him by Mr. H. Walton, director of the Persian Gulf telegraph. The results, of which a brief account has been published in the Records of the Geological Survey of India, are of some interest and even of practical importance, for his examination of the islands of Hormuz, Kishm, and some neighbouring islets confirms the accounts given by previous travellers of the quantities of rock salt existing in them. The supply appears to be practically inexhaustible. The beds of salt are associated with volcanic rocks and are of much older date than the tertiary formations in the neighbourhood. The principal geological facts ascertained upon the voyage to the Persian Gulf are, the existence of a great series of tertiary beds for which the name of Makran Series has been proposed, several thousand feet in thickness, locally highly fossiliferous, and having a well marked mineral character, which occupy the greater portion of the coast from Somniani, near Káráchi, to the head of the Persian Gulf; the evidence of a rise of land in recent times on the north-east and of depression on the south-west coasts of the Gulf, and a few points connected with the geology of Maskat and of Cape Masandam in Arabia. From the limestone of which the mountains which form the last named promontory consist, a few fossils were obtained, one of which has been ascertained by Dr. Stoliczka to be triassic.

From the Persian Gulf Mr. Blanford returned to Gwadar a few days before Major St. John arrived there, and after a short detention caused by temporary disturbances amongst the tribes in the neighbourhood, they left Gwadar together on the 22d January 1872, and marched *viá* Bahu Kelat, Pishin, the Nihing river, and Kalagán to Jalk. The road, after leaving the later tertiary rocks of the Makran Series near the coast, traversed vertical or nearly vertical beds of unfossiliferous shale and sandstone for the whole distance, and the age of the rocks could only be inferred from the occasional occurrence of small irregular bands and masses of nummulitic limestone. Jalk lies at the edge of an immense desert plain, which, like the other great desert plains of Central Persia, has possibly once been the bed of a lake. Owing to delays caused by the difficulty of obtaining carriage, it was too late when the party reached Jalk to attempt to join Sir F. Goldsmid in Sistan, and they consequently marched to Tehran *viá* Bampur, Bam, Kerman, Shiraz, and Ispahan.

Throughout this long march the principal rocks noticed were of

cretaceous and nummulitic age, volcanic formations being of frequent occurrence, and some of the mountains consisting of granite and metamorphic rocks. An enormous area was found to be concealed beneath alluvial deposits, part of which are probably due to the former existence of lakes, and it was inferred that large inland seas at one time occupied the areas now forming the great desert plains of Central Persia.

Tehran was reached at the end of July, and after devoting a few days to the Elburz mountains, north of the capital, Mr. Blanford left for Europe. The geology of the Elburz mountains differs greatly from that of the ranges south of Tehran, and beds of coal, part of which at least are of oolitic age, occur in them.

Besides his geological notes, Mr. Blanford, with the aid of Major St. John, and of a collector sent by the Indian Museum, succeeded in forming for the Government a large and very valuable collection of the mammals, birds, and reptiles of the country traversed. Very little being known of the zoology of Persia, this collection furnishes a large amount of additional information as to the Persian fauna. Large collections of marine animals also were made on the Persian Gulf.¹

The Records of the Survey were published each quarter during 1872. They contain a paper on a section of the hills near Mari in the Punjab, showing the distinctions of the beds as indicated by their fossils by Dr. Waagen; descriptions of the mineral contents of the gneiss in the district of South Mirzapur by Mr. Mallet; a paper on the sandstones of the Godávári by Mr. Blanford; a more detailed account of the southern portions of this area, showing the occurrence of coal near Kambhampet by Mr. King; two valuable sketches of the geological structure of the shores of the Persian Gulf by Mr. Blanford; an account of a very remarkable case of local jointing in some sandstones near Jabalpur by Mr. Medicott; a notice of petroleum localities in Pegu, and further discussion of the relations of the axial group in western Prom by Mr. Theobald; and two other papers by Mr. Blanford, one a general sketch of the geology of Orissa, and the other on the geology of the Bombay Presidency. These records show the activity of the members of the Survey, and the great progress that is being made, year by year, in the elucidation of the geological structure of India and the adjoining countries.

During 1872 volumes VIII. and IX. of the Memoirs of the

¹ See also page 34.

Geological Survey were issued. In the first a detailed account is given of an immense area, nearly as large as England, in the Madras Presidency, including the districts of Kurnál and Kadapa (Cuddapah), with maps and illustrations. The second includes a notice of the Peninsula of Kach; a description of the geology of the vicinity of Nágpur; a notice of the geology of Sirban hills near Abbotabad in the Punjab, and a short account of the occurrence of ammonites in beds, in the Salt Range, containing other fossils universally admitted hitherto as of carboniferous age. The occurrence of a true ammonite in any of the palæozoic rocks is a fact altogether new, and open of field of investigation of the highest interest. The *Palæontologia Indica* continues to be issued, and the four large volumes of the cretaceous fauna of Southern India, which will complete the monograph of that very important group, are nearly completed. A number containing cephalopode collected in Kach is also ready for issue.

The sheets of the Atlas of India are to be used for showing the geology, and will be the maps composing the final record of the work of the Survey. The four quarter sheets of sheet No. 79, containing the larger portion of the cretaceous area of the Madras Presidency, were prepared some time ago. Two quarter sheets of No. (78, S. E. and N. E.) were printed during 1872, and parts of No. 77 were in the hands of the engravers. The printing in colours, in the lithographic branch of the Surveyor-General's Office, has been very successful, and the issue of the maps will now make steady progress.

A work, bearing on the mineralogy of the Himalayas, has recently been published by Mr. Calvert.¹ His journey into the Kulu valley was undertaken with the object of examining its mineral resources, and he appears to have been well rewarded for his trouble. He has projects for working the silver mines at Manikara, and he has obtained the lease of an antimony mine at Shigoi. He also speaks of finding sapphires worth 250%, and other gems. The present volume contains a pleasant narrative of his journey, with good descriptions of scenery, of the temples and villages, and much useful information respecting the rocks and minerals. It is illustrated by a reduced copy of the Government Survey Map of Kulu, showing the head

¹ "Vazeeri Rupi, the Silver Country of the Vazeers in Kulu: its Beauties, Antiquities, and Silver Mines: Including a Trip over the Lower Himalayah Range and Glaciers." With numerous illustrations. By J. Calvert, F.G.S., Mem. Inst. C.E. (E. & F. N. Spon, 1873.)

waters of the Bias and its tributaries, and the positions of the mines. But the chief attraction of the volume is the numerous illustrations in coloured lithography, consisting of views of mountain and river scenery, temples and villages. Mr. Calvert is an excellent artist, and his charming sketches convey a very excellent idea of the magnificence of the scenery in this part of the Himalayan region.

VII.—THE ARCHÆOLOGICAL SURVEY OF INDIA.

General Cunningham has been actively engaged in organising a systematic archæological examination of India since his return in January 1871. In the conduct of this important Survey, which is of as much interest and value to the science of comparative geography as to that of archæology, he has divided it into five provinces of nearly equal size; the Punjab, the North West Provinces, Bengal, Madras, and Bombay. These provinces are again divided into three sections each, to be explored by one party in a single season. Not more than one-half of the archæological remains of India are now known to us, and inquiries and explorations will lead to fresh discoveries. The regular Archæological Survey was commenced in October 1871, under General Cunningham's personal superintendence. M. Beglar, an excellent photographer, and Mr. Carlleyle, the Curator of the Riddell Museum at Agra, will be the General's assistants.

During the summer of 1871, General Cunningham was superintending the reprint of his Archæological Reports made from 1862 to 1865, for the illustration of which he prepared 99 plates with his own hand. The new edition¹ contains an introduction giving an interesting sketch of the labours of General Cunningham's predecessors in the field of Indian archæological research. It is also illustrated by maps, plans, and architectural drawings, and is altogether in a more convenient and useful form than the original reports. In the winter of 1871-72, he made researches in the Gangetic Valley, and Mr. Beglar and Mr. Carlleyle were at work in Delhi and Agra. The new and valuable information thus collected

¹ "Archæological Survey of India." Four Reports made during the years 1862-63-64-65, by Alexander Cunningham, C.S.I., Major-General, R.E., and Director-General of the Archæological Survey of India (2 vols., Simla, 1871). Maps and illustrations.

will form Vols. III. and IV. of the Proceedings of the Archæological Survey. General Cunningham explored many ancient places in the Punjab in 1872-73, and he proposes to make a Survey of the Central Provinces in 1873-74. The time required to complete an Archæological Survey of the whole of India will extend over 10 or 12 years.

It is proposed to appoint Mr. James Burgess,¹ an eminent antiquary, to the superintendence of the Archæological Survey of the Bombay Presidency. He has already drawn up a memorandum on the architectural and archæological remains in the Bombay Presidency, and in the territory of the Nizam. But the most interesting piece of archæological work in Western India that has been undertaken during the year under review has been the measures for replacing the grievous loss caused by the destruction of the oil colour copies of frescos in the Ajanta Caves, in the fire at the Crystal Palace at Sydenham. The Government of India has sanctioned an expenditure of 500*l.* with this object. Mr. Griffiths, the Decorative Artist in the School of Arts at Bombay, who is an artist of no ordinary merit, was deputed to report upon the state of the frescos. He found the paintings in a most deplorable condition, wantonly defaced and hacked, with water percolating through the rock, and converting them into black unintelligible masses. Yet there are many fragments worthy of being copies, which, in a few years, will be entirely obliterated. Mr. Griffiths formed a high estimate of their value, and says, "These old Buddhist artists were keenly alive to the pleasures derived from, and thoroughly understood the principles of decorative art in its highest and noblest sense."

VIII.—METEOROLOGICAL OBSERVATIONS IN INDIA, 1871.

The question of the organization of a Meteorological Department in India is still under consideration.² The Despatch from the Secretary of State on the subject, dated the 18th of May 1871, and enclosing the Report of the Committee of the Royal Society, not having yet been answered.

In Bengal there has been no change in the number of observatories,

¹ See "Abstract" for 1870-71, p. 42.

² See "Abstract" for 1870-71, p. 43.

nor in the methods of observing and registering, except that the register of rainfalls has been extended to a number of sub-divisional stations. The want of an observatory at Calcutta is pressingly felt, especially as a means of training observers to their work. The difficulties in keeping the work of the observatories up to a proper standard are chiefly attributable to observers never having been regularly trained to their work. Dr. Townsend, who has charge of the meteorological observations in the Central Provinces, and Mr. Elliott, the officiating reporter in the North West Provinces, have, at much pains and labour, brought the registers of their respective provinces up to a standard which renders the major part of them strictly comparable with those of Bengal. The extension of knowledge thus gained has been most important, and has enabled Mr. Blanford to give a more complete sketch of the meteorology and climate of northern India than has hitherto been possible.

Most of the first-class stations in Bengal have now furnished registers for five years. The observers are the electric telegraph station masters, and they are reported to have performed their work conscientiously. At the second-class stations there are native observers under the superintendence of civil medical officers; and at the third-class stations the rainfalls only are recorded. In the North West Provinces there are 14 first-class stations, that of Dehra belonging to the great Trigonometrical Survey. At the Agra Medical College an annual course of instruction is given in the rudiments of meteorological science, and an annual money prize is given, for which 22 students competed. The Punjab and Oudh observations have not yet been made comparable with those of Bengal. In Mysor the only observations that can be relied on as accurate are those recorded in the observatory at Bangalore, which is under the control of the Madras astronomer. In the Berárs there are meteorological stations at Akola, Buldána, and Amráoti, and rain gauges at all the Tahsil stations.

IX.—THE MADRAS OBSERVATORY, 1871–72.

The Madras Observatory has been the centre of astronomical work during the British occupation of India. It was founded in the days of Sir Thomas Munro, and has ever since been directed by a succession of able astronomers, whose series of observations extend from 1787 to 1873. Mr. Pogson, the present astronomer, continues to

observe with valuable results, but for some time his most important work must be the publication of observations already recorded,¹ rather than the further accumulation of results. There are now 20,895 unpublished observations with the new transit circle. This year he records the extraordinary appearance of μ Argus, a star in the constellation of Argo Navis, which is believed to be a permanent furnace world, maintained by burning gases of totally different character to any with which we are acquainted. Mr. Pogson has also obtained a difference of longitude between Madras and Batavia, by exchanging signals along the electric submarine telegraph, with Dr. Oudemans, the Surveyor General of Netherlands India. But the chief work of the staff of the Madras Observatory, during 1871-72, was the observation of the total eclipse of the sun on 12th December 1871. Mr. Pogson's son, the Assistant Astronomer, had previously been sent home to study solar photography. Special instruments were sent out, and a village called Avanashi, on the railway to Coimbatore, was selected as the place for observing. Three fair photographs were obtained during the totality, which verify the existence of a luminous envelope round the sun's disc, to a height of 160,000 miles, and show other interesting features. Mr. Winter, the Telegraph Engineer of the Madras Railway, at the same time made polarisation measurements of the corona. The same eclipse was observed at Utakamand, on the Nilgiris, by Colonel Tennant, assisted by Mr. Hennessey and Captain Herschel, of the Great Trigonometrical Survey, and Captain Waterhouse, an admirable photographer, from the Surveyor General's Office. Six photographs were taken during totality. Colonel Tennant's conclusion is that the corona is solar; it is the atmosphere of the sun mainly shining by reflected light.

In December 1872, Mr. Pogson detected the comet of Biela, at the Madras Observatory, under circumstances of extraordinary interest. This comet was first seen in 1772; but in 1826 Mr. Biela discovered it again, when the orbit was carefully calculated, and the results showed that it revolved round the sun in about $6\frac{3}{4}$ years. In 1832 it returned with the utmost punctuality; and again in 1846, it separated into two, each complete, with a short tail of its own, 150,000 miles apart. The phenomenon produced a profound sensation among astronomers. It, and its companion, were again seen in 1852, but 1,250,000 miles apart.

¹ See "Abstract" for 1870-71, p. 51.

In 1859 it was due, but was too near the sun's position to be found; and, in 1866, it could not be found; it was missing. It was next due, agreeably to its former orbit, in October 1872. On November 30th, Mr. Pogson received a telegram from Professor Klinkerfues, of Gottingen: "Biela touched earth on 27th; search near θ Centauri." Mr. Pogson searched day after day, and on the 3rd he found the comet, securing four comparisons of it with an anonymous star. The lost comet was re-found, but it had no tail. Next morning, December 4th, it was again seen, and with a short tail; it appears actually to touch the earth, and neither the earth nor the comet were conscious of the collision.

X.—GEOGRAPHICAL EXPLORATION, PUBLICATIONS, AND NEW MAPS.

During the year exploring work beyond British India has been executed both beyond the Himalayan peaks, and in Persia. In the former direction Major Montgomerie employed a native explorer, who succeeded in opening out the geography of a very large tract of country, as to which we had previously had but the vaguest conjectural indications.

These explorers are anonymous, and are carefully drilled to observe for latitude and elevation above the sea. The explorer of 1871-72 is known to the world as No. 9. His route led round the great Mount Everest, penetrating on the north to the Sanpu River, and thence south-west over the Dingri-maidan, the most extensive plateau on the south of the Himalyan watershed that is drained by streams flowing direct into India. The route taken by No. 9 corresponds, for some distance, with that of Dr. Hooker to the rest of Darjiling. The new ground commences with Dr. Hooker's most north-westerly point, and includes a large lake which had not previously been indicated on the maps. The positions of many peaks north of those which are visible from the side of India have been determined, as well as that of the celebrated Sakya Monastery. The route traversed by No. 9 is 844 miles long, 550 of which are over entirely new ground, and it elucidates the geography of the basin of the Arun, the largest feeder of the great Kosi River, which drains the whole of Eastern Nepal. The explorer took latitude observations at 11 points, and determined the height of 31 places.

During the years 1870-71 geographical information of great

importance was obtained in Persia and Baluchistan by the Frontier Commission, under Sir Frederick Goldsmid, and by Captain St. John.

Majors St. John and Lovett, R.E., are now engaged in placing on record the results of their geographical labours in Baluchistan and Sistan. On their completion, the first-named officer will compile from these, and other earlier data, a map on the scale of 16 inches to the mile, of the whole of the territories of the Shah. (A similar work has, it is known, been under preparation for some years by the Russian staff, but no copy has reached this country.) A brief sketch of the advances made in our geographical knowledge of Persia during the last nine years will not be out of place here. When officers of engineers were sent to Persia, in 1864, to construct the telegraph from the Turkish frontier to Tehran, and thence to Bushir, it occurred to Colonel Walker that their presence might be utilized not only to extend topographical knowledge of the country, but to fix accurately the difference of longitude of the various cities of importance on the line, by means of the telegraph itself. After some correspondence on the subject with Captain (then Lieutenant) St. John, superintendent of the telegraph in Southern Persia, a detailed proposal was submitted by Colonel Walker to the Secretary of State for India, and met with his approval, subject to the consent of the Persian Government, to be obtained through Her Majesty's Minister at the court of Tehran. The answer of the British Minister was adverse to the proposal, and the matter fell to the ground.

In 1866, however, with the limited means at his disposal, Lieutenant St. John made a survey of the country in the vicinity of the line of telegraph in his own immediate district, based on latitudes fixed by sextant. He also made a section of the country between Tehran and the Persian Gulf by aneroid and hypsometric observations.

Being on leave in England, in 1867, he submitted to the India Office the result of his work, with a request that the necessary instruments might be allowed him to carry out Colonel Walker's scheme as far as possible, showing from his own experience that no difficulties were to be apprehended either from the Persian Government or people in carrying out geographical observations. A second application to Her Majesty's Legation at Tehran, based upon these grounds, met with a more favourable response; and the necessary funds (250*l.*) were placed at Lieutenant St. John's disposal, together with an order on the Survey Department at Calcutta to supply him with the instruments there obtainable.

Captain St. John's absence in Abyssinia prevented his doing anything till the following year (1868), but towards its close he purchased the necessary instruments, and returned to Persia. He then made the necessary arrangements with Captain Pierson, R.E., for fixing the differences of longitude between Tehran and other towns on the line of telegraph; but before they could be carried into effect, Captain Pierson was ordered to England, whence he did not return till the close of 1869. In the next year (1870) Captain St. John's duties detained him at Tehran, and it was not till the winter of 1870-71 that he and Captain Pierson were able to complete their work. During Captain St. John's journey from Tehran to Bushire at that time (Captain Pierson remaining at Tehran) they fixed the difference of longitude of Tehran from Kóm, Kashan, Ispahan, Abádeh, Shiraz, and Bushire itself. By the co-operation of Captain Stiffe, late Indian navy, one of the authors of the latest chart of the Persian Gulf, Captain St. John was enabled to fix, by means of the submarine telegraph, the difference of longitude between Bushire and Karáchi, thus connecting his Persian work with India.

In the summer of 1871, Colonel Walker's presence in England enabled Captain St. John and Pierson to complete the chain of observations between England and India by exchanging time signals between Tehran and London. The result was most gratifying. The accepted longitude of the Madras Observatory, as ascertained by direct astronomical observations, is $80^{\circ} 14' 19''$. As fixed by the telegraph it is $80^{\circ} 14' 43''$, a difference not more than is easily attributable to the personal errors of the observers, who had no chronographs, and used Troughton and Simms' reflecting circles of 6-inch radius, with telescopic power necessarily small. Thus, not only are the longitudes of the principal cities in Persia fixed with very great accuracy, but the starting point of the Indian Surveys is proved to be laid down on the earth's surface within a very small fraction of the truth. This valuable proof was moreover obtained without any expenditure by government beyond the cost of the necessary instruments, having been purely a labour of love on the part of the officers concerned.

To return to the topographical work. In 1870-71 Captain St. John laid down the features of the rest of the country in the vicinity of the telegraph between Tehran and Bushire, all the routes between the last city and Shiraz, the summer road between that town and Ispahan, and with the assistance of Captain Pierson some interesting valleys in the Elburz mountains north of Tehran. The

total area embraced by his work amounted to nearly 50,000 square miles.

In 1870 Colonel, now Sir F. Goldsmid, was ordered to proceed to Persia to carry out a settlement of the Sistán and Balúchistán frontiers. His application for the services of Captains St. John or Pierson to make the necessary surveys was unsuccessful, as they could not be spared from their work at Tehran, and another officer of the telegraph, Captain Beresford Lovett, R.E., was therefore detached with him. Circumstances prevented the expedition proceeding to Sistan, but in Baluchistan much valuable information was obtained. Captain Lovett made a Compass Survey checked by observations for latitude from Gwádar to Bampúr, thence viâ Pishin to Panjgúr, and back to the sea by a different route, altogether nearly 800 miles of road, covering an area of 20,000 square miles. Other routes were surveyed by Major Ross and Quarter-Master Serjeant Bower, R.E. The greater part of the country thus delineated had never before been visited by a European.

Important as were the scientific results thus obtained the objects of the expedition were not fully attained. The actual frontier had only been crossed in two places, and could thus only be laid down by hearsay.

On his return, therefore, Sir F. Goldsmid recommended that Captain St. John should be sent with Commissioners from Persia and Kelat to lay down the features of the country on both sides of the frontier. Accordingly, in January 1872, Captain St. John left Gwadur, accompanied by Mr. W. T. Blanford, of the Geological Survey, and with considerable difficulty succeeded in passing along the greater portion of the frontier line, which lies for the most part in an uninhabited wilderness. On reaching Jalk, which Captain St. John's observations placed 45' further south than the position assigned to it on maps, and which lies at the edge of the great Sistan desert, they turned their steps westward, finding the passage across the desert to the Helmund impracticable. They then traversed the highlands of Central Baluchistan, following nearly the route taken by Sir H. Pottinger in 1809, and arrived at Bampúr early in April. Thence they followed the road traversed by Sir F. Goldsmid the preceding year to Kerman, from which city they travelled to Shiraz. The whole of this route of 1,200 miles from Gwadur to Shiraz was measured by perambulating wheels, the total error in longitude on arriving at Shiraz, the first place whose longitude was accurately known, being a little over one per cent. in

longitude, or three fourths per cent. of the whole distance travelled. The positions of the important towns of Bampur, Bam, and Kerman have thus been laid down with considerable accuracy. The alterations in existing maps are very considerable. Captain St. John places Bampur 19 miles east of the position assigned to it by Captain Lovett, and Kerman 17 miles west of that chronometrically ascertained by Khanikoff. The direction of mountain chains in South-Eastern Persia is also shown by Captain St. John to be identical with those in the west, viz., N.W. and S.E., and not as shown on existing maps, east and west. The altitude of the principal peaks was found to be about 15,000 feet above the sea.

During the journey from Gwadur to Tehran Mr. Blanford made, in addition to a geological section, a large zoological collection, which, added to a number of specimens previously collected by Captain St. John for the Calcutta Museum, furnishes data for a very complete account of the fauna of Persia, as yet almost undescribed. Altogether specimens of 250 birds, eight of which, at least, are new to science, were obtained, besides 50 reptiles and a large number of mammals and fish. The collection is particularly interesting as fixing the geographical limits of many European and Indian forms.

In 1871-72 Sir F. Goldsmid completed his labours by a journey to Sistan. He was met by Captain Lovett at Bam, where that officer had travelled viâ Shiraz and Kerman, visiting the little known district of Khabbis en route. From Bam the party travelled across the Kerman desert to Sistan, whence after a stay of six weeks they journeyed, viâ Birjand, Kain, Bajistan, and Turbat-i-Haidari, to Meshed, and thence to Tehran. The total distance traversed and surveyed by Captain Lovett from Shiraz to Tehran amounted to 2,700 miles, of which half at least had never been previously delineated with any accuracy.

Altogether, the united labours of Captains St. John and Lovett have given us 6,000 miles of route survey, covering nearly 200,000 square miles of country.

Besides the new map of Persia, Captain Felix Jones, of the late Indian Navy, is engaged, under orders from the Secretary of State, on the preparation of a map of Western Asia, including the valleys of the Euphrates and Tigris, from the materials accumulated by the surveyors of the Indian Navy and other observers. A large mass of hitherto neglected material will be utilised, and a most valuable map will be the result. The map will consist of four double-elephant sheets. The first, or N.W. sheet, includes the range of the Taurus

and the watersheds of the Euphrates and Tigris, from Erzeroun to the northern slopes of the Lebanon. The second, or N.E. sheet, will extend from Erzeroun to the frontiers of Russia, Persia, and Turkey around Ararat, and the Turco-Persian frontier, as far as the Fak-i-Gyrra Pass in Persian-Turkistan. The third, or S.W. sheet, will embrace Syria, south of the Lebanon, to the Suez Canal and Mount Sinai, besides a portion of the Euphrates. The fourth sheet takes in Mesopotamia to the Persian Gulf, and the rest of the Turco-Persian frontier. Captain Felix Jones has nearly completed the first, second, and fourth sheets in outline, and has finished the portions covered by the Mesopotamian Surveys, and the Turco-Persian frontier map. The third sheet will contain the new work now in progress under the auspices of the Committee of the Palestine Exploration Fund.

The Madras Government have ordered manuals of the different Collectorates in their Presidency to be compiled and published, under the supervision of the Board of Revenue. The first which appeared was on the Madura country, by Mr. J. H. Nelson, of the Madras Civil Service, published in 1868.¹ It contains an account of the physical geography of the district, its forests, lakes, fauna, flora, mineralogy, climate, and diseases; details respecting the castes into which the population is divided, and a political history, ancient and modern. There are also full details respecting the land tenures, revenue, administration, public work, and educational progress. The manual of the Vizagapatam district,² compiled by Mr. Carmichael, appeared in 1869. It is prepared in the same form, but is less voluminous. The third is on the Bellary District, by Mr. Kelsall. In the first part there is a general description of the country, and chapters on the climate, population, diseases, geology, fauna, and flora. The second part contains the political history, and an account of the revenue and other departments; and the third part gives details of the agriculture, trade, and manufactures, dispensaries, schools, and missions. All three manuals have appendices containing numerous statistical details.³

The Manuals on Madura, Vizagapatam, and Bellary are the only

¹ "The Madura Country." A manual compiled by order of the Madras Government, by J. H. Nelson, M.A., of the Madras Civil Service, and late Fellow of King's College, Cambridge. In five parts. (Madras, 1868.)

² "A Manual of the District of Vizagapatam in the Presidency of Madras," compiled and edited by D. F. Carmichael, M.C.S. (Madras, 1869.)

³ "Manual of the Bellary District," by John Kelsall, M.C.S. (Madras, 1872.)

three that have as yet been published; but in 1870 the memoir of the Curg country, prepared by Lieutenant Connor in 1817, was reprinted at Bangalor, in two small volumes.¹

The embassy of Mr. Forsyth to Yarkand in 1870, accompanied by Dr. Henderson and Mr. Shaw, has borne very rich fruit in a handsome volume, containing a narrative of the journey, and descriptions of its zoological and botanical results.² Dr. Henderson's narrative is both interesting and instructive, and is illustrated by numerous photographs, a map, and a section from Jamu to Yarkand, showing the height of every station and pass. The ornithological portion, illustrated by 32 coloured plates, is by Mr. Hume; the chapter on insects by Mr. Bates; and there are also a list of plants, with coloured illustrations, and a series of meteorological observations.

Altogether, 158 species of birds were observed, but of these only 59 belong to the hills and plains of Yarkand, of which seven are probably new to science. The most interesting of the new species is a noble falcon, which Mr. Hume believes to be the "shanghar" of Eastern works on falconry. The study of the collection points to the conclusion that Central Asia, although visited by numbers of northern and southern Asiatic forms, possesses a distinct resident avi-fauna. More than one tenth of the birds that were seen in Yarkand are unknown both to the northern and southern sections of the continent. The peculiar forms, besides the falcon, are a crested lark, a stone-chat, a wren warbler, and a red-legged partridge. One of the breeding-haunts of the Indian winter visitants has been found in Yarkand. The little warbler performs an annual migration across a lofty desert a hundred miles wide, and over snow-capped ridges 18,000 feet above the sea, in travelling from Yarkand to Southern India and back again. One of the most striking points in the observations of Dr. Henderson is the great altitudes at which many species of birds seem perfectly at their ease. The cuckoo was seen on the branches of a birch-tree 11,000 feet above the sea; the hoopoe was quite at home at 18,000 feet; a

¹ "Memoir of the Codugu Survey, commonly written Koorg," by Lieut. Connor, (Surveyor), Bangalore, 1870, Parts I. and II. See "Memoir of the Indian Surveys," p. 60.

² "Lahore to Yarkand." Incidents of the Route and Natural History of the Countries traversed by the Expedition of 1870; under T. D. Forsyth, Esq., C.B.; by George Henderson, M.D., F.R.G.S., Medical Officer to the Expedition; and Allan O. Hume, Esq., C.B., Secretary to the Government of India for the Department of Agriculture, Revenue, and Commerce." (Lovell Reeve, 1873.)

redstart was hopping unconcerned on the snow at an altitude of 17,800 feet; and the brown-headed gull was seen at 15,000 feet.

The first high snowy range of the Himalayas, we are told by Mr. Hume, defines the area of distribution of a large proportion of species. Many birds occur south of the first snowy range, from the Panjab to Sikkim, which are never found north of that line, except where some large river breaks through the range, and enables them to creep a short distance up the valley. Many, too, are found throughout the midland Himalayas which are never met with south of that range. Mr. Hume believes this sharp definition of range to be due to an equally sharp definition of climate. South of the range is a moist climate and periodical rains, while to the north of it there is an excessively dry climate varied only by occasional showers. South of it there is luxuriant vegetation, to the north a stunted flora.

Among the insects collected was the "painted lady" at the northern foot of the Kuen Lun Mountains, a species of almost universal distribution. Of the other two species of butterflies, Mr. Bates remarks that they are remarkable for the great elevation at which they were found, the highest yet recorded in the flight of butterflies. Both (*Parnassius* and *Mesapia*) are exclusively confined to mountain ranges, and to the northern hemisphere. The *Parnassius* was found, by Dr. Henderson, from 17,000 to 19,690 feet above the sea, and there can be little doubt that the food-plant of its caterpillar grows in the same zone as the perfect insect.

Among cultivated plants, Dr. Henderson noticed cotton, flax, tobacco, plums, apricots, pears, apples, melons, cucumber, gourds, figs, mulberries, hemp, walnuts, poplars, rice, maize, millet, wheat, barley, cabbages, radishes, beans and peas in the neighbourhood of Yarkand. His botanical collection comprised 412 species.

Mr. T. T. Cooper is about to publish a narrative of the journey he made in 1869-70, with the object of finding a practicable route by which Assam tea might be taken to Bathang, the great mart of Eastern Tibet, and thus compete with the Chinese in their large and lucrative tea trade with the Tibetans. In prosecuting this journey he started from Sudiya, and passed through the Mishin country to the borders of Tibet, where he was arrested by order of the Chinese and Tibetan authorities at Roemah, the first frontier post, which eventually compelled him to return to Assam.

This work will be specially interesting with reference to the efforts of the Lieutenant Governor of Bengal to encourage inter-

course with the tribes on the eastern frontier, by means of an annual fair at Sadiya.

Colonel McGregor is working most diligently at the gazetteers of Central Asia for political and military reference, and is ably seconded by other officers in the Quartermaster-General's Department.¹ Parts II.² and IV.³ on Afghanistan and Persia were printed in 1872. They are volumes of 869 and 801 pages respectively, and contain an immense mass of useful geographical and statistical information. Captain Trotter has compiled a gazetteer of Kokan, and another has been completed on Turkish Arabia, but they have not yet reached this country. These gazetteers are not offered as complete accounts of the countries of which they treat, but as compilations of the information contained in such records as the compilers have had access to. They will be much improved and added to hereafter, as more information becomes available.

XI.—GEOGRAPHICAL DEPARTMENT OF THE INDIA OFFICE, 1872.

The death of Mr. John Walker, the geographer to the Secretary of State for India, took place in April 1873. Mr. Walker had been geographer to the East India Company and to the Secretary of State for India for the last 48 years. His father worked for Alexander Dalrymple, and engraved the maps for Parry's and Franklin's voyages, for Vincent's *Næarchus*, for Salt's *Abyssinia*, and for many other works, published in the end of the last and beginning of the present century. The son was thoroughly trained as a cartographer and engraver, and in 1825 he was appointed to compile and engrave the sheets of the *Atlas of India*. The amount of judgment and ability he brought to the great task he undertook is shown by the often disputed but ever approved excellence of his work; and there has always been the highest testimony to the accuracy and excellent style with which Mr. Walker has brought

¹ p. 67.

² (Confidential.) "Central Asia," Part II. A Contribution towards the better knowledge of the topography, ethnology, resources, and history of Afghanistan, compiled (for political and military reference) by Lieut.-Colonel C. M. Macgregor, Assistant Quarter Master General. (Calcutta, 1871.)

³ (Confidential.) "Central Asia," Part IV. A Contribution towards the better knowledge of the topography, ethnology, resources and history of Persia, compiled (for political and military reference) by Lieut.-Colonel C. M. MacGregor, Assistant Quarter Master General. (Calcutta, 1871.)

out the Indian Atlas sheets. He has also produced many general maps of great value, and engraved 87 out of the 200 charts published from surveys executed by officers of the Indian Navy. But the most beautiful specimens of Mr. Walker's work are his production of Colonel Robinson's remarkable survey of Jhilm and Rawal Pindi, on 28 sheets, and his maps showing the results of Major Montgomerie's surveys in Jammu and Kashmir.¹ Mr. Walker was in his 86th year. He had been in failing health for the last two years, and died on the 19th of April 1873. He had just received a complimentary letter, addressed to him by order of the Duke of Argyll, on the value of his long and zealous services.

The catalogue of maps and other geographical documents belonging to the India Office is nearly printed, and will be ready for delivery in the course of the summer. The uses of this collection were fully explained in the abstract for 1870-71;² and the inconvenience and injury to the public service caused by the want of adequate space for its proper arrangement were dwelt upon.³ This inconvenience is more felt every year. The importance of providing the necessary space for the geographical collection is increased by the danger of having both originals and duplicates of reports, and numerical data of surveys, in one office at Calcutta. None of the duplicates have been sent home since 1865; and the Surveyor General is anxious that one complete set should be safely lodged in the Geographical Department of the India Office. Space is still needed for its suitable arrangement, as well as for that of the maps and plans. In the meanwhile every effort is made to render the present state of things as little injurious to the public service as possible.

During the long period that the Dutch held sway on the west coast of India and in Ceylon, many maps, charts, and plans were prepared, and a large number are now preserved in the royal archives of the Hague. Eighty of these Dutch maps have been copied for the Geographical Department of the India Office, and have now been added to this national collection. Some of them are very quaintly ornamented, others are enriched with carefully executed coloured sketches of towns and forts, and several are of considerable value. Among them may be enumerated the following, in order to give an

¹ For a more detailed account of Mr. John Walker's labours, see the "Memoir on the Indian Surveys," p. 281, 282, and 283.

² p. 69.

³ See "Abstract," for 1870-71, p. 56.

idea of the character of the whole set, for which the country is indebted to the courtesy of the Netherlands Government :—

A chart of the Persian Gulf, of the 17th century, with soundings along the Persian shore, and along the Arabian shore from Máskat to Cape Masandim.

A chart with soundings, from Máskat to Cape Masandim, with a plan of Máskat harbour.

A beautifully executed coloured sketch of Gombroon, with the English and Dutch factories. 17th century.

A plan of el Básrah, with coloured sketches. 1677.

A plan of a fort on the island of Kishm, with a long account of it. 17th century.

Entrance to the Gulf of Cambay, and coast near Surat, with soundings. 17th century. This chart is valuable, on account of the rapid changes that take place in the Gulf of Cambay.

Chart of the west coast of India, from Cranganor to Gujráat, with soundings; and the Gulf of Kach, with soundings. 17th century.

A very valuable map of the Malabar backwaters, from Cranganor to Kollam (Quilon), with soundings throughout, on a large scale of more than an inch to a mile. 1697.

A chart, from Goa to Cape Comorin, with soundings; showing the islands and shoals of the Laccadives. Also the “Baxos de Padua,” on which Magellan was wrecked, but which has disappeared from modern maps. Probably by Van Keulen.

Southern part of the Peninsula, with soundings in the Gulf of Manar and Palk Strait.

Coast of Travancor, with an interesting sketch showing the position of the Allápalli mud-bank. The latitude of each end of the bank, and of its outer extremity, are given. 18th century.

A chart from Cape Comorin to Manapad, with soundings off Coil. 1775.

A series of plans and sketches of the Dutch factories and forts at Surat, Broach, Agra, Ahmadabad, Mangalur, Cananor, Cranganor, and Paliport. The coloured drawings of Mangalur and Paliport are beautifully executed. 1678 to 1699.

A series of plans of Cochin, with Vypeen. 1663, 1677, 1680, 1691, 1696, 1765, 1767, and 1782.

The careful and accurate execution of the copying of this valuable series of maps is mainly due to Major Leupe of the Dutch Marines, who is in charge of the Map Department of the archives at the Hague.

A more thorough and exhaustive search has been made for the missing memoirs referred to in the "Memoir on the Indian Surveys," and for other geographical documents; and several have been found. There being no catalogue of these manuscripts a diligent search was the only possible means of discovering them.

Of the seven folio volumes of Colin Mackenzie's Survey of the Mysore, four have been found and restored to the Geographical Department.¹ Two missing volumes of the Travancor Memoir and two of the Dindigul Memoir have also been found.² The other documents that have been added to the collection in the Geographical Department are the original manuscripts of the journal of Dr. Buchanan during his journey to Ava in 1795, and that of Captain Kirkpatrick on Nepal in 1793, a geographical sketch of Assam, in three parts, by Wade, a route from Chunargur to Rájmahendri, by Lieut. James Blunt, in 1795, and notes on the western frontier of India, by Captain Williams, with a descriptive index of his map (1809-10).³

But the most interesting manuscripts that have been found are the Memoirs on Afghanistan by Mr. Richard Strachey, Lieut. Irvine, and Lieut. Macartney. The memoir on a map of Kabul and the adjacent countries by Lieut. Macartney is most valuable. About half of it was published as an appendix to Elphinstone's Cabul. The remainder has never been printed. It contains interesting information relating to Shighnan, Wakhan, and other districts of the upper Oxus, which have recently excited much discussion with reference to the correspondence on the northern boundary of Afghanistan.

During the year 1872 sets of maps were presented to the Royal Botanical Gardens at Kew, to the Privy Council Office for the use of the Judicial Committee, to Sir Philip Wodehouse the Governor of Bombay, to Colonel Yule, C.B., for use in his geographical studies, to the Royal Geographical Society, to the Topographical Department of the War Office, to the British Museum, to the Radclyffe Library at Oxford, and numerous scientific and other bodies. Regular progress has been made in mounting the permanent collection of maps and plans. From 180 to 200 were mounted during the year 1872; making a total of 700 mounted since that work was commenced. It is essential to the

¹ See "Memoir," p. 59.

² "Memoir," p. 61.

³ See "Memoir," p. 67.

preservation of these valuable records that they should all be mounted with as little delay as possible, as deterioration is otherwise inevitable. An assistant to the map mounter has now been sanctioned.

The Haidarabad Circars lithographed since the last report are : Dharur in six sheets, Medack in 12 sheets, and Elgandel in nine sheets. The miscellaneous maps prepared by the Geographical Department include the Turcoman Desert, the Caspian Sea, four maps illustrating the boundaries of Turkestan, copies of the Rain-fall and Temperature Maps of India by Dr. Brandis, a railway map of India for Mr. Juland Danvers' report, and a series of maps to illustrate the moral and material progress of India report.

APPENDIX.

APPENDIX A.

A MEMORANDUM by COLONEL WALKER on the COPPER PLATES of the INDIAN ATLAS which he has placed in the hands of Engravers in London, the Geographical Materials furnished to the Engravers, and the Arrangements he recommends for the final disposal of the Work.—September 1872.

(1.) The plates in question have been entrusted to Mr. Malby, engraver to the Admiralty, and to Mr. Connell, late managing clerk of the office of Mr. John Walker the late geographer to the India Office, as follows :—

No. 1.	S.E. section	-	-	Mr. Connell.
„ 44.	(A). S.E. „	-	-	Mr. Malby.
„ 45.	N.E. „	-	-	Do.
„ 45.	S.E. „	-	-	Do.
„ 46.	Full plate	-	-	Mr. Connell.
„ 50.	„	-	-	Do.
„ 54.	„	-	-	Do.
„ 63	(A). N.W. section	-	-	Mr. Malby.
„ 63	(A). S.W. „	-	-	Do.
„ 64.	N.W. „	-	-	Do.
„ 64.	S.W. „	-	-	Do.
„ 69.	S.E.	-	-	Mr. Connell.
„ 70.	N.E. „	-	-	Do.
„ 70.	S.E. „	-	-	Do.
„ 71.	S.E. „	-	-	Do.
„ 71.	S.W. „	-	-	Do.
„ 89.	Full plate	-	-	Do.
„ 90.	N.E. section	-	-	Do.
„ 90.	N.W. „	-	-	Do.
„ 92.	S.E. „	-	-	Do.
„ 104.	Full plate	-	-	Mr. Malby.
„ 118.	„	-	-	Mr. Connell.
„ 126.	All four sections	-	-	Mr. Malby.
„ 127.	„	-	-	Do.
„ 128.	N.E. section	-	-	Do.

(2.) The geographical materials furnished to the engravers are as follows :—

No. 1. S.E. *New plate.* Lithographed sheets 3 and 5 of the quarter-inch map of the Sindh Revenue Survey; also the lithographed map of the district Nowshera, Hyderabad, Collectorate Sind, published April 1865.

Nos. 44 (A) S.E., 45 N.E. and S.E. *New plates; names and outline completed by Mr. John Walker, but requiring hill etching.*

- Sheet No. 2 (Baltistan or Little Tibet) and sections 11, 12, 16, and 17 of the original (manuscript) map of Kashmir and Ladak.
- No. 46. *Old plate ; extensive additions and corrections for the Himalayan portions, names and outline completed by Mr. John Walker, but requiring hill etching.* Section No. 13 of the original (manuscript) map of Kashmir and Ladak.
- No. 50. *Old plate ; corrections and additions.* Silver prints of photographic reductions of exaggerated sheets 11 to 15 of Rajpootana Survey ; and of 30, 31, 31½, 32, 33, 34, 35, 36, 37, 38, and 39 of Gwalior and Central India Survey ; also photozincographed degree sheets IV. (A) and VI. of Gwalior and Central India Survey, and IV. of Rajpootana Survey.
- No. 54. *Old plate ; corrections and additions.* Photozincographed degree sheets II., III., and IV. of the Topographical Survey of the Central Provinces.
- No. 63 (A) N.W. and S.W., 64 N.W. and S.W. *New plates ; names and outline completed by Mr. John Walker, but requiring hill etching.* Same materials as above for 44, 45, and 46.
- No. 69 S.E., and 70 N.E. *New plates.* Photozincographed half-degree sheet No. IX., and half-degree skeleton sheets X., XI., XII., and XVII. (the two last in one) of the Rewah and Bundelkund Survey.
- No. 70 S.E. *New plate ; nearly finished, by Mr. John Walker.* Corrected first proof of plate with additions inserted in Surveyor-General's Office, Calcutta, 16 January 1871. Completed.
- No. 71 S.E. and S.W. *New plates.* Photozincographed degree sheets IV. and VI. of the Topographical Survey of the Central Provinces. Lithographed revenue survey maps of the districts of Narsinghpore (1862-63), Hoshungabad (1862-67), Seonee (1865-69), and Jubbulpore (1854-62).
- No. 89. *Old plate ; under revision.* Silver prints of photographic reductions of exaggerated sheets 63, 64, 70, and 74, and original sheets 69 and 73 of Chota Nagpore. Photozincographed degree sheet X. of Chota Nagpore, and half-degree skeleton sheets X., XI., XII. and XVII. (two last in one) of Rewah and Bundelkund.
- No. 90. N.E. and N.W. *New plates.* Photozincographed degree sheet No. X. of Chota Nagpore, and half-degree sheets VII., VIII., XII., and XIII. of Rewah and Bundelkund : also silver prints of photographic reductions of exaggerated sheets 64, 65, 70, 71, and 74 of Chota Nagpore.
- No. 92 S.E. *New plate.* Photograph of quarter-inch map of the Ganjam and Orissa Survey, field season 1865-66, and manuscript of field season 1862-63. The quarter-inch maps of 1861-62, '66-67, and '67-68 are also required for this copper plate, and they are believed to have been received in the India Office, but they are not now forthcoming, and the available maps only furnish materials for about one-fourth of the plate.
- No. 104. *Old plate ; under revision.* Silver prints of reductions of original sheets 14 to 19 of the Hazarecbagh Revenue survey ; names of places of little or no importance struck out of the silver prints by Captain Sconce.

No. **118**. *Old plate ; under revision*. Silver print of photograph of map of Western Bhotan, with subdivisions of Daling in District Darjeeling, and adjoining Dooars in Districts Julpigoree and Goalpara. Bhotan, from reconnaissances by Major Godwin Austen and Lieutenants Strahan and Holdich. Photographed copy of East Dooars (1868-69) by John Macdonald, and of West Dooars by J. H. O'Donel.

No. **126** (all four sections), **127** (all four sections), and **128** N.E. *New plates*. Lithographed copies of the Revenue Survey maps of the Districts of Mymensing, Sylhet, Dacca, Furreedpore, Tipperah, Noacolly, Backergunj, Chittagong, and Akyab.

Dry paper prints of **50**, **54**, **89**, and **104** have been sent out to Colonel Thuillier, and meanwhile additions and corrections are being made to the plates to the extent of the materials available for the purpose in this country.

(3.) I constructed skeleton charts for the guidance of the engravers, showing the projections of the lines of latitude and longitude for each of the following new plates :—**69** S.E., **70** N.E., **71** S.E., **71** S.W., **90** N.E., **90** N.W., **92** S.E., **126** (all four sections), **127** (all four sections), and **128** N.E. On those for plates **126**, **127**, and **128** I projected all the Trigonometrical Stations and a number of Revenue Survey Stations, and instructed Mr. Malby, to whom the plates were entrusted, to insert these points on the plates in the first instance, and afterwards to fit the topographical details of the maps in between them.

(4.) I also prepared skeleton charts for plates **133** and **134**, but as the maps which contain the geographical materials for these plates have neither latitudes nor longitudes nor any of the stations of the Great Trigonometrical Survey, it was impossible to fit their details with appropriate accuracy into the Indian Atlas, and this cannot now be done until the meridians and parallels or the positions of the Trigonometrical Stations have been inserted on the maps in the Surveyor-General's Office at Calcutta. For these reasons I have been unable to make arrangements for engraving plates **133** and **134**, but Mr. Malby is quite ready to take them in hand on receiving suitably prepared maps for the purpose, and as they join on to the sheets **126**, **127**, and **128** which he is engraving, it is desirable that he should have them if they cannot be conveniently engraved in the Surveyor-General's Office.

(5.) All necessary instructions regarding the work to be done in each instance have been communicated to Mr. Malby and Mr. Connell, both verbally and by letter. I have particularly requested them not to make any attempts to harmonize and adjust discrepancies which they may meet with in the geographical materials with which they have been furnished, but in such cases to leave blanks on the copper plates to be filled in on the proofs which are sent to the Surveyor-General for examination and correction ; after the return of the proofs the blanks must be filled in on the copper plates. It is not the business of the engraver to harmonize discrepancies but merely to copy his originals exactly, and when discrepancies are met with to leave them to be adjusted by the proper authorities.

(6.) In selecting the plates to be placed in the hands of engravers in this country I have been guided by the Surveyor-General's letter, No. F./188, dated 13 June 1871, to the Secretary to Government of India, Department of

Agriculture, Revenue, and Commerce, and by the Index Chart accompanying that document, and first took up the plates—coloured yellow in the chart—for which materials were stated to have been supplied. I found very little material for **70 N.E.** and **90 N.E.**, but as Colonel Thuillier has repeatedly expressed to me his anxiety to have as much of the engraving done in this country as is possible, I placed the plates in the hands of the engravers, and also the plates of the contiguous sheets **69 S.E.** and **90 N.W.**, for which I found as much material available, though they are not specified in the Index Chart. **54** (full plate) also is not specified, but finding considerable additional materials for it I made it over to Mr. Connell. **105 S.W.** is specified, but no materials whatever were to be met with, and as the lines of latitude and longitude and the margins of this plate had been already engraved under Mr. John Walker's superintendence, I have directed Mr. Connell to make the plate over to this office for transmission to India. **133** and **134** are also specified, but for reasons in para. (4) they could not be taken in hand.

(7.) With the object of rendering all possible assistance to Colonel Thuillier I have gone over the whole of the Atlas Sheets, and made out a list of those which, though not specified in the letter and index chart above referred to, are at present incomplete, and *may be* completed in this country if the geographical materials can be conveniently supplied by Col. Thuillier. Dry paper prints of the plates of these sheets have been sent out to the Surveyor-General's Office, in order that the requisite additions may, if possible, be made to them, after which they would be returned to be placed in the hands of engravers in this country.

The sheets in question are as follows:—

8 N.E. and S.E.		71 N.E. and N.W.
28 full plate.		90 S.E.
51 N.W.		91 N.E. and S.E.
70 N.W. and S.W.		105 S.E. and N.W.

The plates of these sheets should be retained in this office until it is known whether Col. Thuillier would wish to have them completed in England, or sent out to India for completion in his office.

" (8.) Estimates have been received from Messrs. Malby and Connell of the probable cost of the work they have undertaken to perform, and the probable period required for its completion in each instance. These are as follows, the dates given being those of the estimates:—

		£		s.			
1 S.E.	- Mr. Connell	{ 4 May 1872	-	45	0	3 months.	
		{ 12 July "	-	18	0	2 "	
44 (A) S.E.	} Mr. Malby -	14 March "	-	45	0	2 "	
45 N.E.				65	0		
45 S.E.				65	0		
63 (A.) N.W.				60	0	} about 12	
63 (A.) S.W.				60	0		} months.
64 N.W.				40	0		
64 S.W.			35	0			
46 full plate	- Mr. Connell	- 23 March "	-	85	0	9 months.	
50 full plate	- Mr. Connell	- 15 April "	-	120	0	9 to 12 mths.	
54 full plate	- Mr. Connell	- 12 July "	-	90	0	6 to 9 mths.	
69 S.E.	- Mr. Connell	- 23 Sept. "	-	20	0	4 months.	
70 N.E.	- Mr. Connell	- 23 Sept. "	-	40	0	4 "	

			£	s.		
*70 S.E.	- Mr. Connell -	4 May 1872	- 10	15	1 month.	
71 S.E.	- Mr. Connell -	12 July „	- 56	10	5 months.	
71 S.W.	- Mr. Connell -	12 July „	- 66	10	8 „	
89 full plate	- Mr. Connell -	15 April „	- 54	0	5 to 6 months.	
		27 May „	- 12	10		
		12 June „	- 11	0		
90 N.E.	- Mr. Connell -	23 Sept. „	-	50	0	4 months.
90 N.W.	- Mr. Connell -					
92 S.E.	- Mr. Connell -	23 Sept. „	22	0	4 months.	
104 full plate	- Mr. Malby -	1 Oct. „	110	0		
118 full plate	- Mr. Connell -	15 April „	155	0	12 to 14 mths.	
126 all 4 sections	Mr. Malby -	18 July „	330	0	24 months.	
127 all 4 sections	Mr. Malby -	18 July „	270	0	18 months.	
128 N.E.	- Mr. Malby -	18 July „	42	0	5 months.	

These estimates are only given as an approximation, it being understood that if any saving can be effected the Indian Government will have the benefit of such saving, and on the other hand, if the expenses are found to exceed the estimate the charges must be increased. It must be further borne in mind that in each instance the estimate given is that for performing the amount of work specified in my letters of instruction; if the proofs of their work are materially altered or added to when under examination in the Surveyor-General's office, a proportionate increase must be allowed to the engraver's charges.

(9.) I am informed that the work is well advanced towards completion. I have received from Mr. Malby a proof of 64 S.W. which contains a very large amount of elaborate hill etching for the delineation of portions of the Himalayan ranges; I consider it to be very satisfactory, quite as good, if not superior to anything in the previously published sheets of the Atlas. I forwarded it to Col. Thuillier for his inspection, and I give his opinion of it in his own words: "Mr. Malby's proof of No. 64 is excellent, very artistic, and in good relief; he will do the work admirably. It would take us a very long time indeed to do such sheets as these; I shall be very glad to see these long pending sheets turned out of hand."

Mr. Connell has submitted proofs of the following plates for my inspection:—

- 1 S.E. Writing and outline completed, hills not commenced.
- 71 S.W. Outline (very intricate) completed, writing and hills not commenced.
- 71 S.E. Outline and writing completed, hills not commenced.
- 89. Outline and writing completed, hills not commenced.

The hill engravers employed by Mr. Connell have been engaged for some time past in the very heavy hill work required for 46, which is expected to be completed in two months. As Mr. Connell employs the very men who were employed by Mr. John Walker for many years past in engraving the Atlas sheets, I have every reason to believe that the character of the work will not be at all inferior to what it has been hitherto.

(10.) As it will be necessary for me to return to India shortly, before the work can be completed by the engravers, I would suggest that the proofs of the several plates which will be handed in to this office, as each is completed to the extent of the materials given to the engravers, be immediately forwarded

* This plate is now completed.

to Col. Thuillier by Mr. Markham, two or three copies of each proof being sent, as a single copy will not suffice for the requirements of the Surveyor-General's office. One of the copies should be printed on dry paper for correction in India and return to the engraver; if the corrections are numerous and several additions have been made to the proof—as may be the case when new geographical materials have meanwhile been acquired in India—it will be necessary to send a second proof out to India for examination and correction. If, however, the corrections are few and unimportant, it will be desirable to avoid the loss of time occasioned by a second reference to India; the engraver should be required to *certify on the second proof that it has been compared with the corrected first proof, and found correct in all respects.* Mr. Markham might then give the requisite order for printing as many copies as are required, and for the disposal of the copper plate. I make these suggestions because there is no sufficient establishment in this office for the careful comparison of a large number of proofs with the original drawings, and the engravers being ignorant of this circumstance, might suppose that the examination in this office would obviate the necessity for very careful examination on their own part. The signature of the vouching authority should always be affixed to such documents; and in addition to this, the number of each successive proof—whether first, second, &c.—and the dates of its passing through this office and the Surveyor-General's office, should also be written on it, that it may be readily identified when necessary, and that in cases of delay—such as very frequently occurred under the old arrangements—the cause of the delay may be traced to the proper quarter. I may state that the entire absence of all such information in a large number of the documents which have passed through my hands in this Office, have caused me much embarrassment, and materially delayed the completion of the work I had to do.

(11.) The following arrangements have been made regarding the disposal of the copper plates in England. On the 4th June I submitted a suggestion to the Secretary of State—with reference to Col. Thuillier's letter, No. 354, dated 22nd February 1872—that the copper plates should be despatched to India, ten at a time, by successive mails; first, those that are completed and specified in Col. Thuillier's letter as most urgently required in India; secondly, the completed plates not specified by Col. Thuillier; and finally, all the plates now or about to be placed in the hands of the engravers (*see paras. 1 and 7*), after completion to the extent of the geographical materials at present available in this country and about to be sent home by Col. Thuillier. I further suggested that a sufficient number of prints should be taken from each plate before its despatch to India to meet the probable requirements in this country for some time to come. My suggestions were duly sanctioned, but considerable delay has occurred in having them carried out. I am informed that the necessary supply of the following plates for stock in this office has been printed, and that the plates are now available for dispatch to India:—

1 (A.) S.E. section.

1 N.E. section.

8 S.W. section.

14 full plate.

15 full plate.

16 full plate.

27 (A.) N.E. and S.E. sections.

29 full plate.

44 (A.) N.W. and S.W. sections.

45 N.W. and S.W. sections.

51 N.E. section.

65 full plate.

66 full plate.

67 full plate.

69 N.E., N.W., and S.W. sections.

70 S.E.

these are equivalent to 10 full plates.

Instructions have been issued for the following plates to be printed for stock in succession to the foregoing :—

92 N.E. section.	108 full plate.
102 full plate.	111 full plate.
105 N.E. section.	115 full plate.
106 full plate.	116 full plate.
107 full plate.	119 full plate.

The above includes all the plates which are urgently required by Col. Thuillier and are not in the hands of the engravers.

The following plates will then have to be sent out in two batches :—

First.

4 full plate.	29 full plate.
5 N.E. and S.E. sections.	38 full plate.
6 N.E. and S.E. sections.	39 full plate.
7 full plate.	40 full plate.
24 full plate.	41 full plate.
25 full plate.	42 full plate.

Second.

43 full plate.	75 full plate.
55 full plate.	80 full plate.
56 full plate.	81 full plate.
62 full plate.	94 full plate.
63 full plate.	95 full plate.
70 full plate, re-engraved in sections.	105 S.W. section.
74 full plate.	109 full plate.

I trust the above plates will be forwarded to India with the least possible delay. Col. Thuillier, in his No. 402 (F), dated 5th August, has indented for 300 impressions of several of these plates or for the plates themselves, as the stock of impressions in India is entirely exhausted. He remarks that his office is quite competent to print the impressions if it possessed the plates, and he considers it very desirable on every account that the plates should be deposited in his office.

(12.) I have only to add that I have made over Mr. John Walker's brass scale, from which all measurements for the copper plates of the Indian Atlas have been taken, to the custody of Mr. Markham.

J. T. WALKER, Col., R.E.

India Office, 27th September 1872.

NOTE OF THE PROGRESS SINCE COLONEL WALKER'S DEPARTURE.

The engraving of the Indian Atlas plates entrusted to Messrs. Malby and Connell by Colonel Walker, as detailed in the preceding memorandum, has been steadily pushed forward since that officer's departure. Out of a total of 6 full plates and 25 quarter plates handed over to the engravers, proofs have been submitted of 5 full and 11 quarter plates. The engraving of the remaining plates is nearly completed, and proofs are now expected.

In addition to the plates mentioned above, five more quarter sections have

been handed over for engraving, the Surveyor-General having caused the blanks on the proofs to be completely filled up from the results of surveys in progress.

This makes the whole number of quarter plates at present being engraved in England 28, two having been completed and awaiting transmission to India.

The plates themselves are in various stages of completion, the amount of engraving requisite varying extremely, according to individual cases. A detailed statement showing the progress made with each plate is subjoined.

All the plates not actually in, or about to be placed in, the hands of engravers in this country have been forwarded to India for permanent deposit in the Surveyor-General's office at Calcutta.

- 1 S.E. Engraving completed up to extent of materials furnished. Proof sent to India 3rd January 1872.
- 44 (A) S.E. Proof sent to India 23rd January, revised and returned 12th April 1873; corrections being inserted on the plate.
46. Engraving completed as far as materials available, and proof sent to India 14th March 1873.
50. Proof of old work sent to India 25th April 1872. Engraving proceeded with in the interim, a portion of the materials being obtainable in this country. Proof from engravers delivered 22nd May 1873. Proof returned from India with additions and corrections, and handed to engravers 23rd May 1873.
- 51 N.W. Proof with additions and corrections marked on it delivered to engraver 23rd May 1873.
- 54 Engraving completed as far as materials available, about two-thirds being done, and proof delivered 11th June 1873.
- 63 N.W. Engraving completed as far as materials available, and proof delivered 16th June 1873.
- 64 S.W. Engraving and corrections completed as far as materials available. Awaiting reply from Colonel Walker concerning any further additional material.
- 69 S.E. Engraving completed up to extent of available materials, outline, writing, and hills for about a quarter being complete. Proof sent to India 3rd January 1873.
- 70 N.E. Engraving completed as far as materials available; outline and writing for about a half finished. Proof sent to India 3rd of January 1873. Returned with additions and corrections and delivered to engravers 24th May 1873.
- 70 N.W. Proof with additions and corrections handed to engravers 23rd May 1873.
- 70 S.W. Ditto.
- 71 S.E. Engraving completed as far as materials available; outline, writing, and hills for about three-quarters of plate finished. Proof sent to India 3rd of January 1873.
89. Proof of old work sent to India 25th April 1872. Engraving proceeded with in the interim, part of the materials being obtainable in this country. Engraving completed and proof delivered by engraver 22nd May 1873. Proof with additions and corrections returned from India and handed to engravers 23rd May 1873.

- 90 N.E. Engraving completed as far as materials available, about one-third being finished, and proof delivered to India Office 29th May 1873.
- 90 N.W. Engraving completed as far as materials available; outline, writing, and hills for about one-quarter of plate complete, and proof sent to India 30th January 1873.
- 92 S.E. Engraving completed as far as materials available, outline, writing, and hills for about one-third being ready, and proof sent to India 30th January 1873.
- 105 N.W. Proof with additions and corrections inserted, returned from India and delivered to engravers, 23rd January 1873.
- 105 S.E. Ditto. Is now completed and awaiting transmission to India.
118. Engraving completed as far as materials available, and proof sent to India; returned by Surveyor-General with additions and corrections, and delivered to engravers 22nd May 1873.

India Office, June 1873.

APPENDIX B.

RETURN to an ORDER of the FINANCIAL DEPARTMENT of the GOVERNMENT of INDIA* for the information of the INDIAN FINANCE COMMITTEE of the HOUSE of COMMONS, as to the SURVEYS carried on under the Government of India for the season 1870-71, the work performed and the cost thereof, corresponding with the actual expense shown in the Budget Estimates for that year. By Colonel H. L. THUILLIER, C.S.I., F.R.S., &c. Surveyor-General of India.

1. The Imperial Survey carried on under the Government of India is of three kinds :—

Trigonometrical, for the accurate fixing of all important places, and showing the latitudes, longitudes, and heights above the mean sea level of such a number of obligatory and other points as to form a complete basis for the connexion and starting of all other Surveys.

Topographical, on a trigonometrical basis by breaking up the principal triangles obtained with the larger instruments into secondary and tertiary triangles, by means of which the topography is depicted by plane table sketching on a minor scale.

Revenue or Fiscal, which is likewise a good Topographical Survey on a larger scale, with the depiction of the boundary of every village or parish, as well as of districts and other subdivisions in the revenue-paying champaign provinces.

2. The following is a general outline of the several heads of account of the expenditure incurred, and of the system prevailing, in a succinct and brief form, on the supposition that no previous acquaintance with the Indian system prevails, and has been prepared under the extreme haste with which the information has been called for. The allotted budget

	£
Trigonometrical	- 70,000
Topographical	- 70,000
Revenue	- 100,000
	£240,000

estimates for the entire department amount in round numbers to 240,000*l.*, distributed as per margin.

* No. 3494 dated 27th October with Despatch No. 323 dated 22nd August 1872 of Secretary of State.

3. The great Trigonometrical Survey is under special management, and the general operations are fully described in the chart of triangulation published with the Annual Administrative Report of that branch of the Department, showing precisely to what extent the great triangulation has passed over the whole of India, and what blanks remain to be filled up.

4. The several field or executive parties, as per margin,* were at work in the season referred to, for which the full details and the various particulars and cost of the operations will be found in the abstract report dated the 19th December, now rendered by the superintendent of this branch, Colonel Walker, R.E., and in his printed annual Administration

† Dated the 1st December 1871. Report for this season 1870-1.†

5. The Topographical Surveys, or representation of the Native States, or

No. 1. Originally raised for Jhelum and Rawul Pindi Survey, and from which all the Topographers were raised and transferred to other parties now employed in Gwalior or Scindhia's territory, from the Chumbul to the Nerbudda, east of meridian 76.

No. 2. Established in 1855-56, the old Hyderabad Party. In abeyance.

No. 3. The old Madras Party, brought up from Ganjam, Goomsur, &c., for the Orissa Tributary States in 1854-55. Now employed in the Madras Subsidiary States or Agencies extending from Ganjam parallel with the Coromandel Coast, through the Vizagapatam Agency, Jeypoor, and other petty States recently transferred to the Central Provinces.

No. 4. Emanated from No. 3 Party to work northward so as to cope with the immense area required to be done in this direction. Lately employed in the Chota Nagpore Province or Commissionership now extended to the North-East portion of the Central Provinces in Mandla, Belaspore, &c.

No. 5. Raised in 1862-63 for the Rewah or Baghelkund Bundelkund Native States, both of which have been completed. Bhopal, north of Nerbudda and south of the assumed limit of the Gwalior Survey, now in progress.

No. 6. Raised in 1863-64 for the Garo, Khasia, and Naga Hills, Eastern Frontier, South of the Assam Valley, and North of the Districts of Mymensing, Sylhet, and Cochar.

No. 7. Expanded from No. 1 Party in 1864-65. The Rajpootana Native States Agency West of the meridian of 76, and between the parallels of 25 and 30, embracing Odeypoor, Jodhpoor, Jesulmeer, Bikameer, &c.

or 2*l.* 4*s.* The average for the season 1870-71 was Rs. 23-3 annas.

8. The equipment, training, constitution, and procedure of these topographical parties is special and totally different to that of other Survey establishments required for revenue or minute land measurements on a large scale. One system and one scale of Survey for all India is not applicable or practicable, and therefore the machinery is adapted to the particular wants and necessities of so vast an empire, so as to deal with champaign rich revenue-paying districts as well as hilly, rugged, and unprofitable countries, in a way suitable to each.

9. The nature of, and the reasons for, the expense incurred on account of the Topographical Surveys will be understood from the following analysis of the actual outlay for a single season :—

* 6	Skeleton Principal
	Triangulation.
3	Topographical.
2	Astronomical.
1	Levelling.
1	Pendulum.
<hr/>	
13	total.

season referred to, for which the full details and the various particulars and cost of the operations will be found in the abstract report dated the 19th December, now rendered by the superintendent of this branch, Colonel Walker, R.E., and in his printed annual Administration

EXECUTIVE DEPARTMENT, OR FIELD ESTABLISHMENTS.

Salaries of 13 deputy and assistant superintendents, including military pay and allowances	-	-	-	Rs.	1,02,076	
Salaries of 42 surveyors and assistant surveyors, and of native establishments for Survey parties	-	-	-		1,60,586	
Travelling allowances to officers	-	-	-	7,420	}	
„ „ to establishments	-	-	-	31,074		
					38,494	
Special local allowances for exceptionally dear localities to officers	-	-	-	223	}	
Local allowances to establishments	-	-	-	11,302		
					11,525	
CONTINGENCIES.						
Purchase of stores, tents, &c.	-	-	-	1,232	}	
Rent of offices for each party or division Survey	-	-	-	3,318		
Feed and keep of elephants	-	-	-	4,399		
Postage charges	-	-	-	646		
Miscellaneous, line clearing, &c. &c.	-	-	-	22,966		
					32,561	
Total Topographical Survey				-	-	Rs., 345,242

10. There is an immense area remaining to be effected on the 1-inch scale by these topographical parties of all the portions of the native states not yet taken up, but urgently required for military, geographical, and other purposes. Each existing party has at least from 10 to 15 years work before it, and possibly more. The annual printed report by the Surveyor-General for this season, dated 15th January 1872, enters fully into more minute details connected with the work in question, its nature, precise locality, and cost, and may be referred to if required.

11. The topographical operations divided into provinces and Native states may be summed up as follows as to what has been already done, what remains to be done, with a rough approximate estimate of the time required to finish present projects. But there is no fixity to the wants and requirements of India, as its resources become better developed; the estimate cannot therefore be entirely depended upon.

General Summary of Topographical Surveys accomplished See Markham's Memoir on Indian Surveys 1871.

12. Orissa Tributary States. By No. 3 party, under Colonel Saxton.

Completed Sq. miles.	Remaining
16,184.	<i>nil.</i>

Bengal Provinces under the jurisdiction of the Lieut. Governor of Bengal.

Chota-Nagpore. By No. 4 party under Major Depree.

Sq. miles.	
28,636.	<i>nil.</i>

Khasia, Garo, and Naga Hills. By No. 6 party, under Major Godwin Austen.

Completed Sq. miles.	Remaining Sq. miles.	Likely to occupy
11,333.	23,674.	7 years.

North-Western Provinces. 13. None executed in these provinces under this branch of the department. The Himalaya Survey, extending from Kashmir and Ladak to the Nipal Frontier, now in progress in Kumaon and Gurhwal, is conducted by a party of the great Trigonometrical Survey, and is fully described in the separate report of that branch in conjunction with the Geodesical operations.

Punjab. 14. Hazara. The first Survey of this district was a military reconnaissance only, but based on the Great Triangulation. It has since been re-surveyed topographically by Lieutenant Colonel H. C. Johnstone, of the revenue branch, on special demand. Area completed, 750 square miles.

Kohistan Sind Sagur Dooab. 15. This embraces the districts of Jhelum and Rawul Pindi, with portions of Hazara, Shahpoor, and Bunnoo, and the Salt Range, admirably surveyed by Captain D. G. Robinson, R.E., on the 1-inch scale, from 1851 to 1859.

Area completed Sq. miles.	Cost Rs.
10,555.	214,538.

Protected Hill States, Simla, and surrounding country. 16. These were the first portions of the Himalayas topographically surveyed by the officers of the Great Trigonometrical branch. The scale was only half inch to the mile. Kashmir and Jamu, the territory of the Maharaja Runbhir Sing, was also accomplished by the same branch of the department, and will be accounted for in the trigonometrical report. The rest of the Punjab Province, all champaign and revenue-paying districts, has been well surveyed by the revenue branch of the department on the 4-inch scale, in close connexion with the Great Triangulation.

Central Provinces. 17. The Sathpoora range of mountains, comprising portions of Hoshungabad, Baitool, Chindwarra, and Nursingpoor districts, have been topographically delineated by the party No. 2, now in abeyance, which effected the Survey of the Berars and part of the Nizam's (Hydrabad) dominions.

Completed Sq. Miles.	Remaining.
7,020.	<i>nil.</i>

Mandla, Belaspoor, Balaghat, &c., by No. 4 party under Major Depree.

Completed.	Remaining Sq. Miles.	Likely to occupy
<i>nil.</i>	17,723.	9 years.

Sumbulpoor, Ryepoor, Bustar, &c., by No. 3 party under Colonel Saxton.

Completed.	Remaining.	Likely to occupy
42,376.	6,138.	6 years.

Native States much inter-mixed. Rajputana and Central India, political agencies; by Nos. 1, 5, and 7 parties, under Lieutenant Charles Strahan, Captain Riddell, and Captain George Strahan, R.E.

Completed.	Remaining.	Likely to occupy
68,697.	140,106	20 years, with three parties.

Bundelkund or Bundela states, as well as Baghelkund or Rewah, have been completed, and are included in the above area of 68,697. The area here remaining to be accomplished embraces Bhopal and Malwa as well as the rest of Rajputana and Scindhia's territories, &c.

Madras. 18. No. 3 party. This party, under Colonel Saxton, has done a large area in the Hilly Mallias of the Ganjam and Vizagapatam agencies. It has still

much to do in Jeypoor and other States of the above agencies, as also in Bustar and other adjoining Native States of the Eastern portion of the Central Provinces.

Ganjam and Vizagapatam agencies.

Completed.	Remaining.
10,041.	5,196.

19. The Topographical Survey of this State was commenced by the Madras Survey officers many years ago, and after a considerable suspension in the operations caused by various untoward circumstances, the entire jurisdiction was completed after a period of about 50 years from the date of its first commencement by the party No. 2 under the late Mr. Mulheran, deputy superintendent. The assigned districts (Berar) were also included in this field of Survey.

Nizam's dominion, Hydrabad, Deccan.

Completed Sq. miles.	Remaining
97,137.	<i>nil.</i>

20. The above is all that has been done by the present system of Topographical Surveys in the Madras presidency, but the officers of the old military institution acted as the pioneers of survey early in the present century in delineating the Southern Peninsula on the 1-inch scale, from which the existing sheets of the Indian Atlas have been published. A new Revenue Cadastral Survey of the whole of the Madras districts has been in progress for the last 15 years under separate superintendence in that presidency, but no new geographical results have been furnished therefrom up to date. The imperative necessity of utilising some of the Revenue Surveys for geographical purposes has been strongly insisted on.

22. A Topographical Survey on the small scale of $\frac{1}{4}$ inch to the mile, which may be more fairly termed a close reconnaissance, has been made of the Pegu division of British Burmah under the local administration, and independent of this department, on an independent basis, prior to the extension of the Great Triangulation in this direction. The area completed and mapped on the above scale is 32,250 square miles, the general map of which in four sheets has been lithographed in this office. It is probable that an entirely new Survey conducted on rigorous principles and based on the Great Triangulation, partially carried in this direction, will be necessary for the Pegu and Martaban division, as well as of the whole of the Tenasserim provinces never yet surveyed.

22. The total area of the Bombay Presidency including Native States is 191,948 square miles; of this the areas specified marginally have either been surveyed* or are under survey† leaving about 72,552 remaining for survey, of which about 50,000 square miles are applicable for topographical delineation, and the remainder will require more minute Revenue Survey. The above figures are very approximate, as the results of the Bombay Revenue measurements are altogether unknown, and how far any of the work may be susceptible of incorporation with the ordinary topographical maps for the purposes of geography and the Atlas of India it is impossible to say.

Remaining to be completed.
50,000.

Likely to occupy
25 years, for a single party.

But with additional working power the time may be decreased in proportion.

23. For the last 30 or 40 years no geographical contributions whatever have been made from the Bombay Presidency towards the filling up of the sheets of the Atlas, which are peculiarly blank throughout the northern division of the Presidency, but great exertions have lately been made by this department to alter this state of things, and to obtain proper agency for regular topographical surveys of the blank portions. There are now five regular parties belonging to the Imperial Survey Department employed in that Presidency, as per margin.

Gt. Trigonal Branch	} Katywar. Guzerat.
Topographical do.	
Revenue	} Kandeish. Nasik. Ashmednagur.

24. Up to the past season a general area of both Topographical and Revenue surveys combined, the areas as per margin, have been accomplished and are still remaining to be dealt with in Bengal and Bombay Presidencies, which, with existing agency and allowed financial means, may possibly occupy about 20 years in the execution; but fresh wants for new surveys, and on larger scales, are springing up constantly, and what sufficed 30 or 40 years ago does not come up to the expectations or wants of the present day, for engineering and other purposes. Consequently, the first survey of India, which is so urgently needed for all purposes of administration, and which is so moderate in its mean average cost per square mile, which may be taken at 2*l.* 11*s.*, will no doubt, when completed, have to give place to some extent to a more minute and superior style of survey, on improved scales, and executed at a higher cost.

General Combined Topographical and Revenue Survey Results.	
Completed.	'Remaining.
634,739 Sq. Miles	251,243 Top.
	211,356 Rev.
Sq. miles 462,599 total.	

25. By the joint efforts of the several branches of the Imperial Survey of India an area of 35,000 to 40,000 square miles is annually effected, mapped, and for the most part published in a preliminary style, within the same period. The progress and outturn of course depends much on many local causes over which the executives have but little control.

26. Since the reduction of the department on financial grounds in 1870, there are the marginally noted Revenue Survey parties at work in the several local jurisdictions under the immediate superintendence of two deputies, controlled generally by the Surveyor General, employed on a sort of Tithe Commutation Survey, village by village, in the rich British champaign districts, on the scale of 4 inches = 1 mile. The unit of the survey is the village, and from the boundaries thus defined, every local jurisdiction of the civil and criminal limits can be laid down by following the cluster of villages forming each circle of police or revenue collection.

REVENUE OR FISCAL SURVEYS.	
Punjab and Bahawalpoor	3½
North-Western Provinces	1½
Oudh	1
Upper Circle total	6
Central Provinces	3
Lower Provinces Bengal	4½
Lower Circle total	7½
Total Parties	13½

27. The position of the current surveys and the precise field of employment for each party is given in the margin. The budget allotment for these fiscal surveys is 100,000*l.* per annum, and this maximum is approached as near as possible with work of such peculiar and diversified character, influenced as it is by so many circumstances of localities affecting life and health, and where the period of maintaining the full working strength varies so greatly both from physical and local causes.

Jurisdiction.	Districts.	
Punjab	} Derahjat. Dehli Division. Bahawalpoor.	
N. W. Provinces		} Moradabad. Bareilly.
Oudh	Gonda.	
Central Provinces	} Chindwarra. Ryepoor. Chanda.	
Lower Provinces Bengal		} Luckimpoor. Nowgong. Seehsagar. Hazareebaug. Hoogly.

28. The mean average cost of effecting this description of work is about 45 rupees or 4*l.* 10*s.* per square mile. The average area surveyed annually by a full and complete Revenue Party is from 1,000 to 1,200 square miles on the traverse system of land survey, by theodolite and

chain periphery measurements of boundaries of villages and estates, all perfectly identified and susceptible of incorporation with the Great Triangulation, forming a complete topographical delineation of the country, useful alike for fiscal and for geographical purposes.

29. The village system, or definition of revenue boundaries and ascertainment of areas, forms again the basis for the more minute record of the measurement of "Fields" on a scale four times larger, or an approach to the cadastral system, for the record of every holding, which has heretofore been conducted according to the primitive native system of measuring land, in conformity with the knowledge and experience of the native landowners and cultivators of the soil, with and on which operation, checked and confined by the professional or English survey, the settlements with the people have heretofore been conducted. This rough and antiquated process by native agency, and according to native ideas and systems only, it is now in contemplation to exchange for the more reliable and correct method of a regular Cadastral Survey on an adequate scale, like that of the Ordnance Survey of Great Britain on the 25 inch = 1 mile scale, which it is believed will be found more worthy and reliable, as a basis for the revenue assessment and Government demand, of an empire depending so entirely almost on its land revenue.

30. There is still much remaining to be accomplished by this description of survey, viz., the greater portion of the North-Western Provinces, a proper re-survey of which has only recently been commenced, to supply the loss caused by the mutiny, and in order to meet the requirements of a new settlement. The Delhi Division west of Jumna River, transferred to the Punjab, together with the Derajat west of the Indus up to British frontier, now ripe for revenue or fiscal investigation. Also a few remaining districts in the Central Provinces, as well as some in Assam of the Lower Provinces. The above will occupy existing establishments many years. The total expenditure for this branch of the department for the season under report amounts to Rs. 889,433 including the Revenue Administrative Office.

31. With the above general explanation of the nature of and the reasons for the expenditure, on account of the revenue or fiscal surveys of this side of India, as conducted under the Imperial Government, further details as to progress and cost, with the budget actual expenditure, will be found in the annexed Report of the Superintendents of that branch of the department dated 21st December 1872.—Appendix A.

32. The administrative branch of the department consists of the following establishments at head quarters, Calcutta, under the immediate direction of the Surveyor-General, aided by three Assistants Surveyor-General.

Administra
Offices, Sur
veyor Gene
Department

ADMINISTRATIVE DEPARTMENT.		Rs.
1. Administrative officers, including correspondence office	-	82,500
2. DRAWING BRANCH.		
Compiling and Drawing of maps, plans, charts, &c.	-	53,922
Travelling of field office while on tour	-	4,969
<i>Contingencies.</i>		
Rent of offices, postage charges, service telegrams, presidency house rent of graded assistants, miscellaneous, &c.	-	20,112
Total Surveyor-General's office		Rs. 1,61,403

APPENDIX.

3. ENGRAVING BRANCH.

Establishment.

European engravers and plate printer, native engravers and apprentices, writer, native printers, pressmen, servants, &c.	Rs. 29,406
--	---------------

Contingencies.

Presidency house rent for European establishment, repairing tools, machinery, &c., purchase of chemicals, office furniture, &c., and miscellaneous	- - - - 4,879
--	---------------

Total Engraving Branch	Rs. 34,284
------------------------	------------

4. PUBLIC OBSERVATORY.

Establishment.

Superintendent, computers, observers, and servants -	- 6,029
--	---------

Contingencies.

Miscellaneous	- - - - 255
---------------	-------------

Total Public Observatory	Rs. 6,284
--------------------------	-----------

5. LITHOGRAPHIC BRANCH.

Establishment.

Superintendent and chief draftsman, chromo printer, draftsmen, writers, native printers, pressmen, servants, &c.	- 27,774
--	----------

Contingencies.

Purchase of type-printing materials, presses, &c., rent of office, purchase of oils, chemicals, ink, &c., repair of furniture, packing charges, and miscellaneous	- - - 5,727
---	-------------

Total Lithographic Branch	Rs. 33,501
---------------------------	------------

6. PHOTOGRAPHIC BRANCH.

Establishment.

Photographers, zincographers, printers, pressmen, servants, &c.	18,096
---	--------

Contingencies.

Cost of photographic chemicals, rent of office, purchase and repair of racks, shelves, presses, &c., and miscellaneous	- 10,734
--	----------

Total Photographic Branch	Rs. 28,830
---------------------------	------------

7. MATHEMATICAL INSTRUMENT MANUFACTORY.

Salary of officiating Superintendent and office establishment	5,216
---	-------

Manufactory Establishment.

Instrument maker and assistant, mechanics and labourers	- 21,584
---	----------

Store Establishment.

Store-keeper, clerks, and others	- - - - 2,280
----------------------------------	---------------

Contingencies.

Purchase of tools, stores and materials for workshops, purchase of new and second-hand instruments, rent of office, and miscellaneous	-	-	-	-	Rs. 22,434
Total Mathematical Instrument Manufactory					Rs. 51,514
Total administrative offices	-	-	-	-	3,15,816
Ditto, executive field establishments	-	-	-	-	3,45,242
Grand total Topographical Surveys, and Surveyor-General's Department					Rs. 6,61,058

33. The specific purposes for which these several establishments are required are as follows : No. 1 is for the conduct of the general business, correspondence, and accounts, entailed by the control and supervision of the department, the custody and maintenance of the records, the issue of published maps, and various miscellaneous duties. It is the geographical depôt for the whole of India. Clerical Office

34. No. 2 is for the geographical business connected with the examination, compilation, drawing, and reduction of maps on all scales, as rendered by the executives, and geographical materials derived thereon, preparatory to publication, for the revision of the proofs from the several printing presses, and the construction of the sheets of the Atlas of India, in manuscript, to be put into the engravers hands, as well as the colouring of all printed maps, and meeting the wants of the several local Governments. This branch is under the immediate superintendence of J. O. N. James, Esq., Assistant Surveyor-General, a departmental officer of great experience. Geographical Drawing and Compiling Branch

In 1870-71 the work completed was as follows:—

General maps and extensive compilations on various scales	-	14
Quarter sheets of the Indian atlas, 4 miles = 1-inch	-	32
Sheet maps of old Topographical Surveys, 1-inch scale, redrawn for photozincography	-	29
Miscellaneous maps, charts, and extracts	-	20
Maps coloured, corrected, &c.	-	23,321

35. No. 3 is for the copper-plate engraving of the final results of the survey on the sheets of the Indian Atlas, as well as other provincial and miscellaneous maps on various scales, as only very lately established in India and transferred from the geographer to the Secretary of State at the India Office. The European staff sent out from England is now training the native agency largely. Great advantages have already resulted from the conduct of this most important part of the work, so intimately connected with the Survey of India, under proper professional supervision and instruction at the head quarters of the department in India. This work in India commenced with a staff as per margin, and has been very recently increased, by a small number of Europeans and a considerable addition of native apprentices, who prove apt scholars, and will in time form a valuable class, capable of executing first-class engraving. Copper-plate engraving.

European	Hill Etchers	-	2
Do.	Outline, writing, and ornamentation	-	4
Native	Hill Etchers	-	2
Do.	Writing and outline	-	2
Do.	Apprentices	-	4
Total		-	14

36. No. 4 is for the purpose of showing mean time to the shipping of Calcutta, by observation of the sun's transit at noon, and dropping of the mean time ball Observatory.

for rating chronometers, as well as for taking meteorological observations hourly, day and night, the results of which are published monthly in abstract form, and weekly in the Government Gazette.

Lithographic
press.

37. No. 5 is for copying and printing maps for each branch of the department by the lithographic process, and issue for all subjects requiring revision and re-copying, and which are not adapted for reproduction by the photographic process. It is also necessary for the speedy publication of the maps on both the one-inch and quarter-inch scales, urgently demanded by all local officers, as preliminary productions before the engraving of the latter can be executed. All general and useful maps of provinces or districts are treated in this manner. An average of 100,000 copies of maps of various sorts are struck off annually by this process. The details of work produced in this branch of my office are given in a report by Capt. W. G. Murray, Assistant Surveyor-General in immediate charge.

Appendix B.

Photographic
Department.

38. No. 6 is of modern adoption, and enables us now to produce all the results of the current surveys, prepared expressly for this object, rapidly and effectively, which before were never printed or published in any form prior to the engraving on the small scale. By a combination of system in the preparation of the manuscript maps, they are now susceptible of immediate photographic reproduction and transfers to zinc without any hand copying at all, and the public service is immensely benefited thereby. The perfection to which this art is now brought, and the great facility with which the transfers are effected, owing materially to the beauty of the original drawings, but also in a measure to superior manipulation of the process, has proved of immense value to the department, and to all administrative officers interested in getting the results of good surveys for all local purposes. About 100,000 copies of maps are now turned out by this process alone annually.

Appendix C.*

39. The general results achieved in this branch of my office, with the details of expenditure, are well described in the separate report appended by Captain Waterhouse, Assistant Surveyor General.

Mathematical
Instrument
Workshops
and Depôt.

40. No. 7. Under the immediate superintendence of the Deputy Surveyor-General, this establishment is a valuable adjunct to the Survey Department, for the repair of all the instruments in use, as well as for the manufacture of many of the simpler instruments, and implements required for survey purposes, and which can be made better in this country. It also forms a depôt for the safe custody of all the instruments sent out from England on indent, from which all the supplies are drawn by executives under due control by heads of Departments. It is likewise largely made use of by the Public Works Department, and other branches of the public service, both military and civil. The details of work performed and cost of the same are fully accounted for in the separate report by the Offg. Superintendent of that Department annexed.

Appendix D.

Cartography.

41. The administrative printed annual Reports fully show in what manner and to what extent the results of all the Surveys are put to proper account, and treated by the several processes of Photozincography for the immediate reproduction and issue of the Standard sheets of both Topographical for Native States, and Revenue Surveys for British Districts and Provinces. Also by

* See also Captain Waterhouse's excellent work on the "Cartographic applications of Photography," published in 1870.

Lithography, for those older materials, all coloured and not adapted for photography, but which form admirable avant couriers, as preliminary productions, to satisfy the reasonable and pressing demands of local administrative officers, and again by engraving for the final reduced maps for incorporation in the great Atlas of India.

42. The great object is to supply every local officer and administration with some sort of printed results of the Surveys, and no time is lost in the Surveyor-General's Department in producing the maps as called for, either as preliminary or temporary issues, by either of the two former processes, according to the capability of the establishments, as well as in taking the final step of engraving for all the really disposable surveys which are ready in every way for that treatment. As shown above, 200,000 impressions of Maps are turned out annually independent of the Atlas Sheets, the preparation and issue of which have up to the present time been lamentably slow, from various conflicting causes unconnected with the administration of the Survey Department in this country.

43. The above extensive issues showing an immense increase over former years, before the introduction of the photozincographic or carbon transfer process, may be said to be remarkable.

44. Every effort has been made for some years past to deal with the enormous out-turn of all the Surveys on this side of India, and great success with small means has been achieved. All the published maps are now regularly sent to the India Office for inspection at the new Geographical Department there, and for sale through London agents. There is no part of the executive field of our operations which is not published in some form or other, for distribution to officials and sale to the public.

45. The general results of the utilisation of the Survey materials, and their final embodiment into the Atlas of India, are given with much detail in my two printed special reports cited marginally, showing the precise sheets already published, both full and only partially complete—those in course of engraving both in England and in India—those for which Surveys were partially available—and the entire blanks, as well as regarding the nature and extent of the materials available towards the preparation of a complete Map of all India, and the filling up of the remaining sheets of the Atlas now blank.

46. Of the total number of sheets composing the Atlas, according to the published Index Map, the numbers of those already engraved, in hand or remaining, are abstracted marginally, Much has been done of late years, but very much still remains to be done, and of that already published much is now obsolete and will be superseded by better Surveys, and require fresh editions of the sheets to be engraved.

47. The last printed catalogue of maps published and available at the Surveyor General's Office, gives the best idea of what is done with the Survey materials. The Government Gazettes likewise notify the outturn of our several printing establishments monthly. Agents are appointed in several large stations

for the dissemination and sale of all available maps, to which very moderate prices are affixed, and the object is to afford every possible facility to the public to obtain any and all of our publications.

48. In like manner a catalogue has been published of the maps available at the Geographical Department at the India Office, which affords further facilities to persons in England desirous of procuring any of the Maps of the Indian Surveys.

Surveyor-General's Office,
Calcutta, 27th December 1872.

H. L. THUILLIER, Colonel,
Surveyor-General of India.

Four Enclosures, Appendices A. to D.

APPENDIX C.

STATEMENT EXPLANATORY of the NATURE of, and the REASONS for, the EXPENITURE incurred on ACCOUNT of the GREAT TRIGONOMETRICAL SURVEY OF INDIA, prepared for submission to the EAST INDIA FINANCE COMMITTEE of the HOUSE OF COMMONS, in compliance with RESOLUTION No. 3494, dated Simla, the 17th October 1872, of the GOVERNMENT OF INDIA in the FINANCIAL DEPARTMENT, by Colonel J. T. WALKER, R.E., F.R.S., &c., Superintendent of the Survey.

THE NATURE OF THE OPERATIONS.

Introductory observations.

(1.) The primary object—the *raison d'être*—of the Great Trigonometrical Survey of India, is to furnish a basis for all Geographical and Topographical operations within the limits of the empire of British India, by means of which errors generated in the course of the several local surveys may be practically eliminated, and lines of latitude and longitude may be drawn on the maps showing the exact positions on the face of the earth of all places indicated thereon. The Great Triangulation was commenced in the year 1800, when it appears to have been ascertained that the Maps 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 taken to fix the positions of some of the most important places in the Presidency, for it was not until the end of the last century that a Trigonometrical Survey was generally allowed to be the only accurate basis for the mapping of a country. Proposals for a Geographical Survey of Southern India, on such a basis, emanated from Major Lambton—of H. M.'s 33rd Regiment of Foot—in the year 1800, and being warmly supported by the Hon. Colonel Wellesley, afterwards the great Duke of Wellington, were sanctioned by Lord Clive, the then Governor of Madras. The circumstance that at that time a large accession of territory in the centre of the Peninsula had been recently acquired by the successes of the British troops in the Mysore campaign, which opened a free communication with the western coast, doubtless contributed to the readiness with which the Madras Government assented to the proposals for constructing a trigonometrical basis for the geography of the Peninsula, which would also serve the purpose of connecting the surveys of the newly acquired provinces with those of other portions of the Presidency already

completed or in progress. By the year 1817 the triangulation had covered the provinces under the Madras Government, and reached the southern limits of provinces which were politically connected with the Bengal and Bombay Governments. Consequently the Marquis of Hastings—who was then Governor General—directed that the operations should be taken under the direct and immediate control of the Supreme Government, and that what had hitherto been known as the “Geographical Survey of the Southern Peninsula” should become “the Great Trigonometrical Survey of India.”

(2.) In the course of the progress of the Survey it soon became obvious to Major Lambton that the operations “would involve many more objects than what immediately appertain to geography.” He saw that before the latitudes and longitudes of the trigonometrical stations could be computed it would be necessary to determine the figure of the earth and the lengths of the polar and the equatorial axes, or in other words that geodetic investigations must proceed *pari passu* with the trigonometrical and linear measurements, in order that the latter might be correctly utilized. Such has been the experience of all great national surveys, and consequently great efforts have been made, in every instance, to carry on the operations with sufficient attention to accuracy and precision to permit of their satisfying the requirements of delicate geodetic investigations as well as furnishing a basis for geographical purposes. The additional operations, which are required for purely geodetic purposes, are astronomical observations of the latitudes of a few of the principal trigonometrical stations, combined astronomical and telegraphic determinations of the differences of longitude, and pendulum observations.

Extensive trigonometrical operations necessarily geodetic also

(3.) The Geographical Surveys of India have been and still are, for the most part, executed by special departments, topographical and fiscal; *e.g.*, the Topographical Survey of India and the Revenue Surveys of the Bengal and Madras Presidencies, all of which work on the basis of the G. T. Survey. But a large amount of geographical work has been done by this Survey also; in the first twenty years of its existence Major Lambton completed maps of a considerable portion of the Madras Presidency; in the next twenty-five years little or nothing was done beyond the triangulation; but in the last twenty-seven years the Trigonometrical Survey has undertaken and nearly completed the topographical delineation of the whole of the Himalayan mountains, up to the furthest points to which Europeans can penetrate; it has also carried out, by a special native agency, geographical explorations of extensive Trans-Himalayan regions which Europeans cannot safely enter, and these are still being urged forward and are progressing satisfactorily. And now that the time is fast arriving when the Great Triangulation will be completed, the members of this Survey are being gradually transferred to topographical operations, as occasion offers. To distinguish the latter operations from the corresponding performances of the Topographical Survey Department, they will be here designated “Trigotopographical.”

The geographical operations of the G. T. Survey

(4.) To the above must be added the Levelling operations which are undertaken in order to connect together and reduce to a common datum all the levels which have been taken all over India; in the course of the several surveys for canals, railways, and other purposes. It has always been a part of the operations of this survey to determine the heights of its principal stations, of the summits of mountains—more particularly the peaks of the Himalayas—and of all places of importance in the vicinity of the triangulation, by the well-known method of vertical angles. Owing, however, to the errors to which such determinations

Reduction of all levels to a common datum.

are liable in consequence of the uncertainties in determining the amount of terrestrial refraction, the results were not considered sufficiently accurate to serve the purpose of connecting systems of levels together. Consequently in the year 1856 this Survey commenced executing certain main lines of levels for correcting its trigonometrical determinations of height, and connecting together the lines of levels which had been executed by other departments, and furnishing permanent bench-marks, or points of reference, to which all future systems of levels may be referred and thus reduced to a common datum. The economical advantages of this measure should be very great, in that, with comparatively little extra expense, all the numerous systems of levels, which have been executed for various special objects, may be rendered available for general purposes. Already a great quantity of valuable work has been rescued from comparative oblivion—from manuscript records accessible to only a few persons—and reduced to the G. T. S. datum and published for general information.

Reduction of observations and publication of results.

(5.) The preceding observations will, I trust, serve to give an explanation, sufficient for the present purpose, of what may be called the field, or out of door, operations of this Survey; but it will be obvious that a very large amount of work is also necessary for combining the results of the field operations, and preparing them for publication and general utilization.

First. The exact lengths of the base-lines, on which the triangulation depends for its initial and verificatory *linear* elements, must be determined with great accuracy; for this purpose an exact knowledge of the thermal expansions of the standards of length and of their relations to European standards is necessary, and this requires numerous very delicate and laborious investigations.

Secondly. In all triangulations every fact of observation, whether linear or angular, should be so combined together as to give to each fact its proper weight, neither more nor less; there may not be any arbitrary adjustment of discrepancies. Error must arise in the course of the very best and most accurate operations, for the agents employed are but men and the instruments used are manufactured by mortal hands; and these errors, though individually small and inappreciable, are liable to accumulate and eventually become disagreeably large. To ascertain how to disperse them in a legitimate manner for a survey of such vast extent as this, was long, for us, a great and direful problem in the distance, now I am happy to say it is a problem satisfactorily solved, and applied to a large portion of the triangulation; the labour has been very great, but it has been well rewarded. This work is necessarily one which could only be undertaken within the last few years as the field operations approached completion; pending the final reduction of the operations it was the practice to supply "Preliminary Charts" containing full numerical data of the latitudes, longitudes, azimuths, heights and distances of the survey stations, in manuscript, to topographical and fiscal surveyors and all other persons requiring them, in order to satisfy immediate wants.

Thirdly. The publication of the results. Of late years the growing requirements of the public service has necessitated the formation of photographic, zincographic, and type printing offices at the head quarters of the Survey to satisfy the demands for data; these work with the computing office and under the immediate direction of its superintendent, Mr. Hennessey. Here the preliminary charts are now photozincographed and published for general use, instead of being merely prepared in manuscript as formerly; and the maps of the trigo-topographical surveys, and of Major Montgomerie's trans-Himalayan explorations, the charts of levels, and all other maps by officers of this Survey, are also photozincographed for publication; and the numerous computation-

forms which are required for departmental use are zincographed. Here too the annual administration (general) reports of the Department are printed, and the tables of heights which are compiled from the levelling operations, and last, though not least, the final "accounts of the operations" of the Survey, the first volume of which was published in 1870, while materials for several subsequent volumes have been printed and will be published as soon as possible.

II.—THE COST OF THE OPERATIONS.

(6.) The Government of India being desirous that the statements under preparation for submission to the East India Finance Committee of the House of Commons should be explanatory of the accounts submitted to Parliament, the figures corresponding with those prepared in the Financial Department of the Government; and further that, as it is impossible, in the short time allowed, to furnish more than a general outline, the statements should be prepared with reference to publications which treat more fully of the subject, from which useful additional information may be obtained, I proceed to show the cost of the operations during the official year 1870-71, the last year for which accounts of actual expenditure have been published by the Government; full details of the nature of the corresponding operations are given in Major Montgomerie's "general report" for that year, when he was officiating as my *locum tenens*; to this document are appended extracts from the narrative reports of the executive officers in charge of the several operations, and a memorandum, by Major Montgomerie, on the Trans-Himalayan explorations.

The accounts of the official year 1870-71 taken as an illustration of the cost of the operations.

(7.) The actual cost of the operations in 1870-71 is represented by the following figures in the Civil Budget estimate of the Government of India for 1872-73.

Salaries of Superintendent and 22 Deputy and Assistant Superintendents (including Military Pay and Allowances) - -	Rs.	Rs.
		1,94,278
Salaries of 52 Surveyors and Assistant Surveyors and of Native Establishments for Survey parties - - -		2,16,489
Office Establishment at Head Quarters -		48,322
Travelling Allowances to Officers -	13,007	
" to Establishments -	42,717	
		<u>55,724</u>
Local allowances to officers - - -	2,983	
" to Establishments -	8,503	
		<u>11,486</u>
<i>Contingencies.</i>		
Purchase and carriage of Stores - - -	4,877	
Service telegrams - - - -	128	
Rent of Offices - - - -	3,624	
Postal charges - - - -	1,289	
Feed and keep of Elephants - - -	9,309	
Inspecting and preserving Stations -	6,500	
Trans-Himalayan Explorations - -	3,349	
Miscellaneous - - - -	63,274	
		<u>92,350</u>
	Rs.	<u><u>6,18,649</u></u>



(8.) The accounts which are drawn up in this Department show that the corresponding expenditure in each of the several branches of the operations may be taken as follows :—

Expenditure at Head Quarters.

	Rs.	Rs.
Administration including Superintendent and Correspondence Office - - -	36,141	
(XIV.) { Drawing of Maps and Charts,	10,548	
(XV.) { Computations and reductions of		
and { observations, printing the results		
(XVI.) { by type, and printing the Maps	50,984	
{ and Charts by Photozincography		
Contingent expenditure for purchase of stores, chemicals, &c., but mainly for payments of expenses incurred all over India in repairing and preserving the stations of the Survey -	14,612	
	<u> </u>	1,12,285

Trigonometrical Operations.

(I.) The Brahmaputra Meridional Series	34,512	
(II.) The Assam valley Triangulation -	34,044	
(III.) The Bider Longitudinal Series -	38,110	
(IV.) The Belaspur Meridional Series -	38,890	
(V.) The Bangalore Meridional Series Northern Section (Bombay party)	29,098	
(VI) The Bangalore Meridional Series Southern Section (Madras party)	34,865	
	<u> </u>	2,09,519

Trigo-Topographical Operations.

(VII.) The Survey of Guzerat - -	59,177	
(VIII.) The Survey of Kattywar - -	66,860	
(IX.) & (XVI.) The Survey of Kumaon and Gurhwal and the Trans-Himalayan Explorations - - -	90,047	
	<u> </u>	2,16,084

Geodetic Operations.

(X.) Astronomical.—Extra party No. 2	11,814	
(XI.) Astronomical.—Extra party No. 1	23,633	
XIII.) Pendulum.—Extra party No. 4 -	23,562	
	<u> </u>	59,009

Levelling Operations.

(XII.) Extra party No. 3 - - -	21,752	
	<u> </u>	21,752

Total - Rs. 6,18,641

The Roman numerals above given on the left-hand side of the several items of expenditure correspond with the sections of the General Report of the operations of the year.

(9.) An explanation of the reasons why the expenditure on account of operations of such a different nature as the topographical operations in Kumaon and Gurhwal and the Trans-Himalayan Explorations is lumped together in the accounts of this department is necessary. The amount actually expended in the payment of the explorers was Rs. 5,542 ; it varies materially from year to year within the sanctioned maximum of Rs. 8600, and depends on the amount of work done and the rewards paid for good work. But these sums by no means indicate the total outlay on the operations ; the journals and field books of the explorers have to be translated into English and very carefully analyzed and corrected before they can be published, and the observations have to be examined and reduced ; this work happens to have been done for the most part by the staff of the Kumaon and Gurhwal Survey and has occupied a large amount of the time of the persons employed on it ; the actual expense may be roughly estimated as at least Rs. 15,000, and consequently the cost of the purely topographical operations may be taken as so much less than the total amount of both which is given on the preceding page.

III.—THE AMOUNT OF WORK EXECUTED.

(10.) In para. 1 of Major Montgomerie's report the out-turn of work is stated to be as follows: "Principal Triangulation with great theodolites, 59 triangles, covering an area of 11,203 square miles with a total direct length of 403 miles, and observations for 3 azimuths of verification ; secondary triangulation with smaller theodolites, an area of 10,076 square miles on which the positions of 1676 points were fixed and the heights of 467 were determined ; trigo-topographical surveying, on the one inch to the mile scale 301 square miles, on the two inches to the mile 2,291 square miles, and on the six inches to the mile 60,027 acres ; boundary lines and check lines, 780 miles ; main lines of double levelling, 380 miles, by means of which the heights of 166 points of reference were finally determined ; astronomical latitude observations, 1,353, by which the latitudes of 15 points were determined ; geographical exploration, the reduction of 289 miles of Route-Survey by which the geography of an area of about 13,000 square miles of *terra incognita* has been unravelled."

At page 25 of the report a tabular abstract gives the out-turn work by the several survey parties in greater detail. At pages 56 to 60 of the Appendix to the report corresponding details are given for the photozincographic printing and drawing offices. These may be epitomized as follows:—

Maps and Charts of levels and triangulation newly drawn for publication	- - - -	30
(This is exclusive of 42 maps drawn by the topographical survey parties and sent in to the Head Quarters' Office ready for publication)		
Photozincographs ; 68 sheets of maps	6,465 copies printed in all.	
„ 16 sheets of numerical charts	839	„
„ various plates and diagrams, 13,205		„
Zincographs ; forms for computation, &c.	10,402	„
Type printing ; 819 pages composed ;	234,828	„

IV.—ESTIMATES OF THE RELATIONS BETWEEN THE COST AND THE OUT-TURN OF WORK.

(11.) The cost of a survey is invariably assessed on the area surveyed. There is probably no better way of showing the relations between the outlay and the out-turn; but the way is most unsatisfactory; it does not give an accurate idea of the intrinsic value of the work done, nor any indication whether the expenditure has been thrifty or wasteful. It is analogous to estimates of the cost of railroads at so much per mile; there are some railroads which would be cheap at half a million sterling the mile, others which would be dear at a hundredth part of that amount. All such estimates are worthless without a full knowledge of the nature of the operations in each instance, the exact amount of work done, and the difficulties met with and overcome. All that can be said of them is that they are better than no estimates at all, and on this understanding I proceed to give such estimates as may be legitimately drawn from the above figures.

(12.) *Estimated Cost of the Triangulation.*

Outlay as above	-	-	-	-	Rs. 2,09,519
Area embraced; Principal Triangulation	-	11,203	square miles.		
Secondary	„	7,019	„	„	
Total	-	18,222			

Rate, $11\frac{1}{2}$ rupees, or 23s. per square mile.

The operations of the year are singularly illustrative of the dangers attending estimates of this nature, and the illusions to which they may give rise. On the Brahmaputra Series no triangulation was done; the surveyors were wholly employed in preparatory work; they were selecting sites for and building new stations, and clearing the lines between them, the country being a dead level plain, covered with trees and in parts with dense jungle; the theoretical cost of the triangulation is therefore *infinity*. The Bider longitudinal Series was being carried through a very malarious and deadly district; the officer in charge died of fever; much delay occurred, and that in the middle of the field season, in filling his place; the series was advanced a distance of 37 miles only, and the area embraced by the triangulation (principal and secondary) was 1,097 square miles, giving a rate of about Rs. 35 per square mile. The Belaspur Series traverses one of the wildest parts of India, covered with dense forest and having much flat ground; the advance was 52 miles, and the area triangulated over was 1,190 square miles, giving a rate of Rs. 33 per square mile. On the other hand, the northern section of the Bangalore Series passes over a delightful country for triangulation, with hills high enough to give commanding views but not too high to ascend easily, and with very little necessity for line clearing. The advance was no less than 161 miles; the area triangulated over was as much as 6,849 square miles, giving a rate of little more than Rs. 4 per square mile. Though these facts are very highly creditable to the executive officer, Lieutenant Rogers, yet in really difficult ground his progress would have been far slower.

(13.) *Estimated Cost of the Topography.*

First, the surveys of Kattywar and Guzerat which, being on the same scale, may be noticed together. The operations consist in first constructing a net-

work of minor triangulation, emanating from the Great Triangulation, as a basis on which the details of the ground are afterwards drawn by the method of plane tabling, as in the topographical surveys which are immediately under the directions of the Surveyor-General, but with this addition, that a large number of boundaries are traversed with theodolites and chains for fiscal purposes, and the further difference that the scale of the field survey is ordinarily twice as large, *i.e.*, 2 inches, instead of 1 inch to the mile. The areas finally surveyed and mapped amounted to 1,757 square miles in Kattywar, and to 534 in Guzerat, or in all 2,291, on the 2-inch scale; in addition to which 301 square miles of wild and unhealthy hills in the Gir of Kattywar were surveyed on the inch scale; assuming the latter as equivalent in cost to half the area on the larger scale, the out-turn of work may be treated as covering an area of 2,442 square miles on the 2-inch scale, and the outlay being Rs. 1,26,037, the rate of cost is Rs. 52 per square mile.

Secondly. The Survey in Kumaon Gurhwal. This is usually conducted on the scale of one inch to the mile, but during the year under review the survey party was diverted, under orders received from the Government of India, from its ordinary operations to make a survey of the Kosi Valley, on the scale of 6 inches to the mile, "to facilitate the investigation into the practicability of the construction of a railway" up the valley to the new hill station of Ranikhet. This work was necessarily done in far more detail than the ordinary topographical surveys in India; several contour lines were laid down and the levels of a large number of points were determined, for future reference by the railway engineers. The area completed and mapped was 60,027 acres, say 94 square miles; and taking the outlay as Rs. 75,000, for the reasons already given in para. (9), the rate of cost is a trifle under Rs. 800 per square mile.

Estimated Cost of the Levelling Operations.

(14.) These are executed with the utmost possible care and precision; the lines are twice levelled, independently, by two persons, and the results are compared station by station; corrections for *dislevelment* are applied as in astronomical observations. 308 linear miles of line were levelled over, and the outlay was Rs. 21,752; thus the rate of cost is about Rs. 70 per linear mile.

(15.) These are all the estimates that can well be given. Similar estimates are not possible in the case of the geodetic operations; nor would it be of any use for me to endeavour to investigate the cost of the mapping, the photozincography, and the type printing in this way. But what I have already done will I trust suffice for the requirements of the Parliamentary committee. I need only add that further details of the cost of the operations of this Survey may be found in a report, dated 20th October 1850, by Colonel A. S. Waugh, Surveyor General of India and Superintendent of the Great Trigonometrical Survey, which is printed in the return to an order of the Honourable the House of Commons, dated 12th February 1850.

J. T. WALKER, Colonel, R.E.
Supdt. Great Trigonometrical Survey of India.

Dehra Dun,
The 19th December 1872.