SURVEY OF INDIA

GENERAL REPORT

1927 TO 1928

From 1st October 1927
To 30th September 1928

PUBLISHED BY ORDER OF

BRIGADIER E. A. TANDY, R.E.,

SURVEYOR GENERAL OF INDIA.

Printed at the Photo.-Litho. Office,
Survey of India,
CALCUTTA,
1928.

Price One Rupee, or One Shilling and Nine Pence.

THE FIRST AIR SURVEY OF AN INDIAN DISTRICT.

THE ABOVE IS A PORTION OF ONE OF THE 10,000 PHOTOGRAPHS OF MALDA DISTRICT, BENGAL, FOR THE PREPARATION OF REVENUE MAPS ON THE SCALE OF 16 INCHES = 1 MILE.

Photographed in Season 1927—28.

Photo-engraved & printed at the Offices of the Survey of India, Calcutta, 1928.

India. SURVEY OF INDIA dept.

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PREFACE.

THE WORK OF THE SURVEY OF INDIA.

The department is primarily responsible for all topographical surveys and explorations, and for the maintenance of geographical maps of the greater part of Southern Asia. Also for geodetic work, which includes:—the main trigonometrical framework, extending in some cases far beyond the frontiers of India, and control networks of precise levelling based on tidal observatories; tidal predictions and the publication of Tide Tables for nearly 40 ports between Suez and Singapore; the Magnetic Survey; astronomical, seismographic, and meteorological observatories at Dehra Dūn; and geodetic investigations of an international character, in regard to which India enjoys a unique position between the greatest highlands of the world and a deep ocean extending to the Antarctic. Indian geodesy has thus disclosed by far the largest known anomalies of gravitational attraction in the earth's crust, and these have led to some of the most important developments of modern geodetic research, whilst the Great Trigonometrical Survey of India enjoys an international reputation as a very valuable contribution to estimates of the size and figure of the earth. The calculations of astronomy and some important data in physics depend ultimately on these terrestrial measurements.

In the past the department has also carried out the original large-scale revenue surveys for most of India, and was still conducting this work for Central and Eastern India and Burma up to 1905, when all revenue surveys were handed over to the Provinces concerned, together with officers and staff as required, in order to concentrate the energies of the department on a complete new series of modern topographical maps on the scale of 1 inch to 1 mile. It was hoped to complete this series by 1930, but owing to retrenchment and the war little more than half has been done up to date, in spite of the reduction of the scale of survey for less important areas. Thus, although new surveys covering an area about equal to that of England are carried out every year, the maps of half the country are still very old and only kept up to date roughly by means of rather perfunctory information supplied by local officials; the old maps are also about 2 miles out of position, being based on a longitude of Madras determined in 1815.

Boundary surveys and records of international, state, and provincial frontiers have always formed an important item of topographical work; and in recent years there has been considerable progress in the preparation of Guide Maps for important cities and military stations, where the one-inch scale is quite inadequate.

Miscellaneous. While expending on topographical and geodetic work all funds alloted by Imperial Revenues, the department is steadily developing the policy of aiding local surveys in various ways, on payment by those concerned. These miscellaneous operations include: all forest and cantonment surveys: many riverain, irrigation, railway, and city surveys, and surveys of tea gardens, mining areas, &c., with a great deal of control levelling for the same: administrative assistance and officers are also given in aid of the revenue surveys of various Provinces and States. The Printing offices do much work for other Government departments, such as printing special maps, illustrations for Archeological Reports, all diagrams for Patents, &c. The Mathematical Instrument Office gives valuable aid to all Government departments by ensuring a high standard of instrumental equipment, especially in connection with optical work, and by the manufacture and repair of high-class instruments which would otherwise have to be imported from abroad.

Military, &c. The department is also responsible for all survey operations required by the Army, and has been rapidly developing measures to meet the greatly increased complexity of modern military requirements, especially in connection with air survey. In view of its high military importance, air survey work for various civil purposes is receiving all possible encouragement and assistance, while the latest methods of stereo-photography are being studied experimentally.

Administration is by the Surveyor General under the Education, Health and Lands Department of the Government of India. The Headquarters Office is at Calcutta under the Assistant Surveyor General, and there are seven Directors, one for each of the five Survey Circles into which the country is divided, one for the Geodetic Branch at Dehra Dūn, and one for the Map Publication and other technical offices at Calcutta.

ERRATA.

Survey of India

General Report, 1926-1927.

1. *Page 2, para. 3*—

Under column "1925-26" against the entry "Gross actual cost" *substitute* Rs. "54,11,135" for Rs. "64,11,135".

2. *Page 30*—

Under columns 11 and 12 *delete* the word "Acres" and *enter* the words "Square miles".

3. *Page 32*—

Delete the entries against No. 6 Party and *enter* the following, under columns 1, 2, 5, 6 and 11:—

1	2	3	4	5	6	7	8	9	10	11	12	13
			Sq	uare	mile	s.				Acr	es.	
No. 6.	Central Provinces and Hyderābād.	...	...	34	93	...	...	...	...	43	...	...

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GENERAL REPORT

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INTRODUCTION AND SUMMARY.

1. **Annual Reports** are published in three separate volumes as follows:—

General Report.
Geodetic Report.
Map Publication and Office Work Report.

The first two are for the survey year ending 30th September while the last is for the financial year up to 31st March.

The Map Publication Report contains *all the INDEX MAPS* showing the progress of map publication on all scales, with reports on publication and issues, printing and drawing, and of such offices as the Mathematical Instrument Office, which have to conform with the financial year.

The Geodetic Report includes full details of all scientific work.

This General Report only gives brief abstracts of the above (*vide* Abstracts II and III in the Table of Contents) but gives complete reports of the survey operations of the ordinary field parties and detachments. Abstracts I and IV (*vide* Table of Contents) summarise these latter reports and enable the reader to look up such portions as may concern him. There is one index map at the end, showing the progress of modern topographical surveys and compilation. Maps of sorts are of course available for all parts of the Indian Empire, but some are very old, and all previous to 1905 were based on the old longitude of 1815, (which was over 2 miles out), and are excluded from the index map.

2. **General.** Brigadier E. A. Tandy, R.E., held the post of Surveyor General throughout the year.

The post of Assistant Surveyor General was filled by Major Kenneth Mason, M.C., R.E.

3. *The total cost* of the Department for the past financial year ending 31st March 1928, as compared with that of previous years, was as follows:—

	1925-26	1926-27	1927-28	REMARKS.
	Rs.	*Rs.*	*Rs.*	
Gross actual cost ...	54,11,135†	59,64,926(*a*)	54,27,768*	(*a*) Including Rs. 3,03,336 for English Charges (High Commissioner) on Stores, and loss or gain by exchange.
Deduct receipts and credits	21,60,926	23,28,180	23,32,191*	
Net actual charges ...	32,50,209	36,36,746	30,95,577*	

*These figures are not final.

†The figure 64,11,135 entered in the report for 1926-27 is a printing error.

The total area of new surveys of all kinds completed during the year was 47,242 square miles (p. 26).

4. *Organization.* The whole area of India and Burma is divided for the purposes of the Survey of India into five Circles. The limits of these are shown by blue lines on the index map at the end of the book. In order that civil administrations and the public may know which Director to address on survey matters a list of Provinces and States comprised in each Circle is given in the loose slip containing Survey Notices.

With the approval of the Government of India, the Director, Eastern Circle has been appointed as a technical adviser to the Government of Bihār and Orissa on survey matters, for which the Bihār and Orissa Government will make an annual contribution of Rupees two thousand.

Cantonment Surveys and Maps.—As a result of the recent innovations in the administration of military lands and cantonments, the procedure relating to cantonment surveys and maps has been revised.

The Cantonment Survey Party will be stationed at Dehra Dūn and its cost will be met by annual contributions from the military budget. The total contribution each year will not ordinarily exceed Rs. 60,000 of which Rs. 27,000 will represent the standing cost of maintaining the Cantonment Survey Party. Revised rules on the subject have been published in Army Instructions (India) No. B 79, dated 24th April 1928.

5. Notable events of the survey year were as follows:—

Mālda Air Survey. The Bengal Government has set a lead to all India by initiating a 16-inch air survey of the Mālda district for Settlement purposes and has placed the contract with the Air Survey Company, Limited. The air photography was carried out during the summer and the drawing and publication of the maps is well in hand. (See pp. 68, 69 and Appendix I, pp. 82-84).

Air Survey Committee. The Director, Geodetic Branch, Survey of India, has been appointed *ex officio*, the Secretary of the Air Survey Committee, the formation of which was referred to in para. 5 of the *General Report* for 1926-27.

Manœuvres.—A Northern Command Survey Staff Exercise was held at Abbottābād in October 1927 under the direction of Lieut.-Colonel S. W. S. Hamilton, D.S.O., R.E. (pp. 41, 44, 45, 47).

Indian Science Congress. Dr. J. de Graaff Hunter, M.A., SC.D., F.INST.P., as President of the Mathematics and Physics Section, delivered an instructive lecture on the Figure of the Earth at the 15th Session of the Indian Science Congress, in January 1928 at Calcutta.

Exploration. Mr. G. E. Barton, M.A., recipient of the Cambridge University Worts grant for geographical research, spent three months at the Geodetic Branch Office in Dehra Dūn on his return from a journey in Western China, and has given the department much valuable scientific information regarding Yünnan and adjacent territories. Mr. Barton proceeded on a second expedition in the same regions in May 1928 and has promised the department the benefit of his further results.

Dr. Wilhelm Filchner of Berlin spent a month at the Geodetic Branch Office on his return, in April, from a 2½ years scientific expedition in Tibet and Chinese Turkistān. Dr. Filchner compared his magnetic instruments against the Survey of India standards at the magnetic observatory in Dehra Dūn, and has also given the department the benefit of his geographical results.

H. R. H. the Duke of Spoleto, who will lead the Italian expedition to the Karakoram in 1929, visited India during the year to make preliminary preparations and was given all available information regarding this area.

The Himālayan Club was founded on 17th February 1928 at New Delhi with the objects of "encouraging and assisting Himālayan travel and exploration, and extending knowledge of the Himālaya through science, art, literature and sport." The initiation of this Club was due to the Hon. Sir Geoffrey Corbett, Secretary to the Commerce Department, and to Major Kenneth Mason, Assistant Surveyor General. Among some 120 Founder Members may be noted the following retired members of the Department: Sir Thomas Holdich, Sir Sidney Burrard, Colonel C. H. D. Ryder and Colonel C. P. Gunter. Field Marshal Sir William Birdwood was elected President, and Major General K. Wigram and Brigadier E. A. Tandy, Vice-Presidents.

International Congresses. Captain G. Bomford, R.E., attended the International Conference on Wireless Longitudes at Leyden, which met to discuss the results of the longitude observations taken at 50 observatories all over the world in the autumn of 1926, in which he participated as an observer at Dehra Dūn.

Empire Surveyors' Conference, 1928.—Lt.-Colonels R. H. Thomas, D.S.O., R.E., and C. M. Browne, C.M G., D.S.O., R.E., represented the Survey of India at the Empire Surveyors' Conference which was held in London and Southampton from the 2nd to 13th July 1928. Captains T. M. M. Penney, R.E., and G. Lennox, I.A., attended privately.

35 delegates from different parts of the Empire attended the Conference. Among them were the Surveyor Generals of Ceylon and Federated Malay States; Deputy Surveyor General of Gold Coast; Assistant Surveyor General of Nigeria; Liaison Officer of Air Ministry of Australia; Director of Land Registration and Surveys, Cyprus; Directors

of Surveys, Northern Rhodesia, Sierra Leone, Tanganyika and Uganda; Secretary, Royal Geographical Society, London; Directors of the National Physical Laboratory, Teddington and of the Science Museum, London; and Crown Agents for the Colonies. Colonel Sir G. P. Lennox-Conyngham, K.B.E., F.R.S., Professor of Geodesy, and Mr. F. Debenham, Department of Geography, of the Cambridge University, Dr. J. W. Evans, C.B.E., F.R.S., F.G.S., Geologist and Colonel M. O'C. Tandy, D.S.O., O B.E., R.E., were also invited and attended the Conference.

An extract from Lieut.-Colonel Thomas' report is reproduced below:—

"This Conference, the first of its kind held, proved very instructive and interesting, no pains having been spared by those responsible for its inception to ensure its success; a varied and instructive programme was arranged, and the papers read and discussed touched on problems with which surveyors, especially those working in undeveloped parts of the Empire, might from time to time be confronted".

The Conference of Empire Surveyors had the cordial support of His Majesty's Government, and was opened by the Secretary of State for the Colonies. At a Government luncheon on the opening day the Secretary of State for War was in the Chair, supported by the Chief of the Imperial General Staff, the Directors of Military Operations and Intelligence, the Secretary of the War Office and others, while at another Government dinner at the close of the Conference, the Secretary of State for the Colonies presided, supported by a number of eminent officials, amongst whom were two Sea Lords of the Admiralty.

International Geographical Congress, 1928.—Lt.-Colonels Thomas and Browne also attended the International Geographical Congress held at Cambridge from the 18th to 25th July, 1928, as official delegates of the Survey of India. Captain G. F. Heaney, R.E., and Lieut. D. R. Crone, R.E., attended as members.

The Congress was opened by the Vice-Chancellor of the University of Cambridge in the Senate House. 112 delegates attended, besides a large number of distinguished professors and eminent scientists, from different parts of the world. The delegates and others present were received with hospitality by His Majesty's Government and other public and private bodies. At the dinner given by His Majesty's Government in Trinity College, the Right Hon'ble Sir Austen Chamberlain, K.G., M.P., Secretary of State for Foreign Affairs, presided.

The papers read and the discussions thereon proved most instructive and the Maps and Atlases exhibited were interesting and appreciated by all.

Adventures and Casualties.—The gallant act of Inter-Class Surveyor Riaz Bahadur Khan of No. 10 Party in risking his life to save a Kachin khalasi is referred to on p. 75.

Man-eating tigers and wild elephants infested some of the jungles under survey by No. 1 Party and some of the Eastern Circle Parties, but no casualties occurred on this account.

Five deaths occurred in No. 10 Party from cholera, which was very prevalent in the Irrawaddy Delta (p. 75).

U. Pe, A.T.M., Sub-Assistant Superintendent and Surveyor Amar Singh of No. 10 Party, accompanied the Civil Officer on an expedition amongst the Head-hunting Nāgā Tribes in the unadministered territory to the North-West of Burma (p. 75).

New buildings. The Haig observatory at Dehra Dūn has been rebuilt and the seismograph and the tidal machine have been moved to it from the Burrard Observatory. The zenith telescope has also been placed there. The lower floor of the Walker observatory has been transformed into an office for the training school; an equatorial reflecting telescope and astronomical models of the solar system have been set up in the upper floor for demonstration to officers under instruction and visitors, (p. 14).

A new pendulum apparatus made by the Cambridge Instrument Company has been received from England. This consists of three pendulums and a vacuum box in which they are swung. The vacuum box was specially designed by Colonel Sir G. P. Lenox-Conyngham, F.R.S., late of the Survey of India, to eliminate flexure. The pendulums are of nickel steel with knife-edges and mirrors of stellite. They have a coefficient of expansion per degree centigrade of $+1{\cdot}7 \times 10^{-6}$ and so are about eleven times less sensitive to temperature changes than the brass pendulums hitherto used in India. The pendulums were adjusted for length and standardized by Major Glennie at Cambridge in 1927.

A portable wireless receiver designed by the Marconi Wireless Telegraph Company was obtained at the same time. The receiver employs 1 detector, 1 note magnifier and 1 low frequency amplifier, together with a Phazing Unit when greater selectivity and freedom from atmospherics is required. A local oscillator is included in the receiver. Time-signals from Bordeaux and Rugby should be received by the set without difficulty anywhere in India using a small frame aerial and a 30-foot vertical aerial with the Phazing Unit. This apparatus has been successfully used in the field by No. 14 Party (p. 13).

A co-ordinatograph was manufactured by the Mathematical Instrument Office for the Air Survey Company Limited (p. 84).

A Wild Photo-theodolite, such as was used by Major Mason on his Shaksgam Exploration in 1926, has been purchased and is now in use in Chitrāl. Two *Wild Precise Theodolites* have also been obtained for geodetic triangulation in Burma.

Dr. Hunter has been invited to write a comprehensive article for the proposed 14th edition of the *Encyclopædia Britannica*, dealing with the subjects Geodesy, Figure of the Earth, Geoid and Isostasy. Previous contributions by Dr. Hunter have been supplementary to those of the 11th edition and have comprised four separate articles.

Distinguished visitors to the Geodetic Branch Office during the year included H. E. the Lord Irwin, Viceroy and Governor-General of India; H. E. the late Sir Alexander Muddiman, Governor of the United Provinces; the Hon'ble Khan Bahadur Sir Muhammad Habibullah, K.C.I.E., Kt., Hon'ble Member for E. H. & Lands Department; and Members of the Medical Research Institute Committee and of the Indian Tariff Board.

Colonel W. L. J. Carey, D.E.O.S., and several other ordnance officers, visited the Mathematical Instrument Office on the 3rd January

and 21st February 1928 and discussed the supply and repair of instruments used by the Army in India.

Lectures and Instruction. Lt.-Col. R. H. Phillimore, Director, Geodetic Branch, delivered a lecture on "Surveys in War" at Dehra Dūn on the 20th June 1928.

Major Kenneth Mason, Assistant Surveyor General, gave two lectures at Simla on 2nd and 3rd August on "A Hundred Years of Himālayan Exploration" and "The Dujailah Redoubt Night March".

No. 18 Party (Air Survey) of the Frontier Circle gave short courses of instruction during August, September and October 1927 to Military Officers in the work of interpreting air photographs and converting them into maps.

At the request of the Chief Ordnance Officer, Allahābād Arsenal, an artificer of the Arsenal (Staff Sergeant F. L. Greenaway, R.A.O.C.,) was given facilities for studying the methods of repairing instruments used by the Army in India, in the Mathematical Instrument Office.

While on leave Captain Bomford visited the works of Messrs. E. R. Watts & Co., and other firms in England, to select a type of staves with Invar strips suitable for levelling.

Mr. A. T. Brendish, assistant in the Photo Zinco. Office at Dehra Dūn, while on leave in England, commenced a course of map reproduction with the Ordnance Survey at Southampton, and visited other firms and institutions recommended by the Director General of the Ordnance Survey.

6. Appreciations. His Excellency the High Commissioner for 'Irāq has, on the completion of the Turco-'Irāq Boundary Commission, brought to the notice of the Government of India the excellent work of Major C. G. Lewis, R.E., and the Survey of India detachment under his command. Colonel L. F. Nalder, the Frontier Delimitation Commissioner, in a letter to His Excellency, also drew particular attention to Major Lewis' outstanding capability, experience and tact, and to Mr. Muhammad Hasan's energy.

The Director, Frontier Circle has received appreciations of the work done by Rai Sahib Maya Das Puri, for the Settlement Operations of Peshāwar district from the Revenue Secretary to the Chief Commissioner, North-West Frontier Province. The Surveyor General has personal knowledge of the great difficulties under which this work was commenced, and heartily congratulates Rai Sahib Maya Das Puri and all members of the Detachment on the success with which it has been accomplished.

The following is an extract taken from the Government of Bengal, Revenue Department Resolution No. 10,072 L. R., dated 24th May 1928, published in the Annual Report on the Survey and Settlement Operations in Bengal for the year 1926-27:—

"As usual, the Director, Eastern Circle, Survey of India, inspected the traverse work carried on in this Presidency, and both he and the Officer-in-charge of the Photo Litho office inspected the Bengal Drawing Office and made some valuable suggestions for improvement in the drawing and typing of the maps and their reproduction. The Director, Eastern Circle, also gave valuable assistance and advice in connection with the survey of a forest area in Chittagong from the air. The

Governor in Council has noticed with pleasure that these officers of the Survey of India were satisfied with the work done by the Survey Department of the Local Government".

The Deputy Director of Military Intelligence, General Staff Branch, has expressed his appreciation of the work of No. 18 Party (Air Survey), Frontier Circle.

The Government of Burma has expressed its thanks to Captain Calvert for the prompt and efficient manner in which he conducted the special survey operations at the Burma oil-fields at Yenangyaung and Chauk last October and November. Captain Calvert was specially selected for the work and the results of his survey will be most valuable.

The Burma Oil Company tendered its thanks to the Surveyor General and the Director, Geodetic Branch, for the loan of Messrs. K. K. Das and H. C. Banerjee for their Eotvös torsion balance survey.

The General Committee of the Lahore Municipality recorded its deep appreciation of the excellent work done by No. 22 Party, during the Lahore City Survey and specially thanked Rai Sahib Dhani Ram Verma, the Superintendent in charge.

The Chief Commissioner, North-West Frontier Province, expressed his appreciation of the good services rendered by Khan Sahib Muhammad Husain Khan during the survey of Madda Khel country carried out under his charge. He observed that the Khan Sahib showed conspicuous skill and tact in overcoming various difficulties and that he had faced considerable risks.

7. Awards.—The following honours were conferred during the year :—

Companion of the Order of the Indian Empire.	Colonel C. P. Gunter, O.B.E., R.E.
Officer of the Order of the British Empire.	Major C. G. Lewis, R.E.

Assistant Commissary and Lieut. W. Smith, M.B.E., Head Draftsman, Army Section, No. 6 Drawing Office, Simla, was promoted to Deputy Commissary and Captain with effect from the 13th February 1925, and to be Commissary and Major on the 13th February 1928.

Conductor R. M. Batt, Draftsman, Army Section, No. 6 Drawing Office, has been promoted to be Assistant Commissary with the rank of Lieutenant with effect from the 4th November 1927.

Mr. Lalbir Singh, Sub-Assistant Superintendent, and Surveyors Hari Singh Thapa, Thakur Singh, Tara Singh and Gaj Bahadur Singh were awarded Certificates of Honour for their work in Nepāl. The awards to Mr. Lalbir Singh and surveyor Hari Singh Thapa were made by the Hon'ble Member of the Education, Health and Lands Department, on the occasion of his visit to the Geodetic Branch Office on 13th April 1928. Surveyor Amar Singh was also awarded a Certificate of Honour in recognition of his devotion to duty during the rebellion in Southern Kurdistān in 1919 and for his services during the Nāgā Expedition, 1927.

The honorary rank of Jemadar was conferred on pensioned Soldier Surveyor (Havildar) Ghulam Haidar on the 15th October 1927.

Bonuses were sanctioned by the 'Irāq Government to 5 surveyors and 21 khalasis of the Turco-'Irāq Boundary Delimitation Commission.

8. Personnel.—Casualties, retirements, and recruitments were as follows:—

Class I Officers:—Colonels H. Wood, R.E., and C. P. Gunter, C.I.E., O.B.E., R.E., Lieut.-Colonel V. R. Cotter, I.A., and Messrs. J. O. Greiff and C. C. Byrne retired. Major H. E. Roome, M.C., R.E., reverted to the Home Establishment. No military officers were recruited.

Messrs. P. Ray, R.S., and S. S. McA'Fee Fielding were confirmed as Superintendents.

Messrs. M. D. Puri, R.S., and H. B. Simons from Class II were promoted to fill temporary posts in Class I Service.

Class II Officers:—Mr. A. C. Bose retired. Mr. K. S. Gopalachari, B.A., was invalided. Mr. E. Claudius died.

Mr. H. H. Creed reverted from temporary employment under the Government of Bengal, and Captain C. B. Sexton was temporarily transferred in his place.

Mr. W. H. Strong, M.B.E., reverted from foreign service under the Anglo-Persian Oil Company.

Messrs. J. B. Lal and D. N. Saha were promoted from the Upper Subordinate Service to Class II Service.

Seven candidates were appointed to Class II Service on the result of the examination referred to in last year's report.

Upper Subordinate Officers:—Messrs. Ram Singh, R.S., K. Narayanasvami Chetti and A. P. Ghosh retired. Mr. J. P. Vastav was invalided. Messrs. Nur Muhammad and U. Po Kye died. The geodetic computers of the Computing Office Dehra Dūn were transferred to the Upper Subordinate Service. Five Lower Subordinates were promoted to the Upper Subordinate Service.

I.—ABSTRACT OF SURVEYS IN EACH PROVINCE AND STATE.

9. The annual expenditure of surveys in the Indian Empire must amount to something like three crores of rupees, or say two million pounds, if we include cadastral surveys, carried out locally by Provinces and States, and miscellaneous surveys for engineering projects, *e.g.*, railways, canals, mines, roads, rivers, harbours, cities, &c.

The prime duties of the Survey of India are geodetic, topographical and geographical, and cost little more than a tenth of this total (about Rs. 33,00,000); but the department is also developing co-operation with local survey agencies, with a view to mutual economy, and is now doing miscellaneous outside work costing about Rs. 23,00,000, on payment by those concerned, besides advising and co-operating in other directions and lending officers to Provincial Surveys as required. The following abstract shows the nature and *locale* of the field operations actually carried out by the Department during the past year, grouped under the following sub-heads:—

Air Surveys.	Riverain Surveys.
Exploration.	Boundary Surveys.
Topographical Surveys.	Geodetic.
Forest Surveys.	Framework.
Cantonment and City Surveys.	Levelling.
Cadastral Surveys.	Special and Miscellaneous.
Railway Surveys.	Training.

10. N. W. F. Province and Kashmīr.

Topographical surveys in Dīr, Swāt & Chitrāl & in tribal territory (pp. 42, 43).

Cantonment and city surveys at Razmak; & revision survey at Peshāwar and Nowshera (p. 80).

Cadastral and boundary surveys in Peshāwar and Dera Ismail Khān districts (pp. 53-54).

Framework. Triangulation in the Dīr, Swāt, Chitrāl and in the Gilgit Agency (p. 43); in Peshāwar district and North Wazīristān (p. 16).

11. Baluchistān.

Topographical surveys in Kalāt State, Bolān Pass & Sibi districts (p. 44-45).

Geodetic. Gravity and deflections in Las Bela State and Chāgai (p. 16).

Framework. Triangulation and traversing in Kalāt State (p. 45).

12. Punjab, Punjab States and Delhi.

Air survey of Multān (p. 46).

Topographical surveys in Rāwalpindi, Lahore and Shekhūpura districts (p. 43); in Delhi Province (p. 43); and in Multān, Muzaffargarh, Jhang and Lyallpur districts (p. 53).

Bāzār survey at Pahārganj, (New Delhi), (p. 80).

Riverain surveys, Gujrānwāla, Shāhpur, & Montgomery districts (pp. 48-50).

Boundary surveys in Gurgaon district (pp. 50).

Framework. Traversing in Gujrānwāla, Shāhpur, Montgomery and Kāngra districts (pp. 49, 50); rectangulation in Multān, Muzaffargarh, Jhang and Lyallpur districts (pp. 51-53).

Levelling. Two lines of high precision levelling, *viz.*, Jhang *viâ* Sargodha, Lāla Mūsa, Wazīrābād to Ghakkar; and Sahāranpur to Ludhiāna (p. 17). Secondary levelling from Jabboānā to Kot Māldeo (p. 81). Tertiary levelling in Multān, Muzaffargarh, Jhang and Lyallpur districts (p. 53).

Miscellaneous. Kāngra Valley development survey in Kāngra district (p. 50).

13. Rājputāna Agency, Ajmer and Bīkaner.

Topographical surveys in Jaisalmer State (p. 45); in Jaipur, Jodhpur, and Kishangarh States and in the Ajmer district (p. 60).

Forest surveys in Ajmer district (p. 60).

Framework. Triangulation for topographical surveys in Jaipur, Jodhpur, & Kishangarh States and in the districts of Ajmer & Merwāra (p. 60).

Miscellaneous. Four-inch survey of the Kailāna Tank Catchment Area in the Jodhpur State (p. 60).

14. Central India Agency and Gwalior. *Nil.*

15. United Provinces.

City surveys. Revision of Mussoorie City map, (p. 57).

Boundary surveys in Bulandshahr district (p. 49).

Levelling. Three lines of high precision *i.e.*, Hāthras *viâ* Muttra & Delhi to Meerut, Sahāranpur to Ludhiāna & Dehra Dūn to Sahāranpur (p. 17).

Special surveys. Revision of Mussoorie & Landour Guide map (p. 57).

16. Central Provinces.

Topographical surveys in Bālāghāt, Bhandāra, Chānda, Drug, Nāgpur and Mandlā districts, and the Chhuīkhadān, Kawardhā, Khairāgarh and Nāndgaon Feudatory States (p. 58), also in the Jashpur and Surgujā States (p. 56, 57).

Topographical surveys in the Yeotmāl district (p. 62).

Framework. Triangulation in Bālāghāt, Drug, Bilāspur and Mandlā districts; in the Feudatory States of Kawardhā, Chhuīkhadān & Koreā (p. 58).

17. Bombay Presidency, States of Western India and Baroda.

Topographical surveys in Karāchi district & Khairpur State (Sind) (p. 45).

Cantonment & city surveys. Revision at Poona, Kirkee & Belgaum (p. 80).

Geodetic. Gravity & deflections in Karāchi & Hyderābād districts (p. 16).

Levelling. The following lines of high precision levelling:—Anjār to Mamuāra connection of Standard Bench-mark at Bhūj; Nakhtarāna Motā to Lakhpat; and Unhia Tar to Tatta Sukkur to Hyderābād (Sind) (p. 17). Secondary levelling for Lloyd barrage project (p. 81).

18. Hyderabad.

Topographical surveys in Adilābād, Karimnagar, Nalgonda, Nānder, Medak and Nizāmābād districts (p. 62); in Raichūr district (p. 65).

Special 3-inch survey of part of Hyderābād City and environs (p. 62).

19. Mysore and Coorg.

Topographical surveys in the Chitaldrug district (p. 65).

Special surveys. Large-scale surveys of private estates in the Kadūr and Hassan districts (p. 65); revision of the 16-inch maps of the Civil and Military Station, Bangalore, (p. 64).

20. Madras Presidency and Madras States.

Topographical surveys in the Guntūr & Kistna districts (p. 62); in the Anantapur & Bellary districts (p. 65); in Coimbatore, Madura, Rāmnād and Trichinopoly districts and in Pudukkottai State (p. 66).

Forest surveys in the Kistna forest division (p. 63).

Special surveys. Large-scale surveys of private estates in the Coimbatore, Malabar and Nīlgiri districts and in Cochin State (p. 66, 67); 4-inch survey of mining concession areas in Sandūr State (p. 65).

Framework. Triangulation in part of the Agency Tracts falling in the Godāvari, Kistna and Vizagapatam districts (p. 63); traversing in the Tanjore and Trichinopoly districts and in Pudukkottai State (p. 67).

21. Bihār and Orissa.

Air survey of Orissa coast for the committee on Orissa floods, (p. 69).

Topographical surveys in Hazāribāgh, Palāmau & Rānchī districts (p. 57); in Hazāribāgh, Rānchi, Mānbhūm, Cuttack and Balasore districts (pp. 70, 71); in Keonjhar, Mayūrbhanj and Nīlgiri States (p. 71).

Forest surveys in the Chaibāsa and Porāhāt Forest Divisions (p. 70), and the State forests of Mayūrbhanj (p. 72).

Framework. Triangulation in Gayā, Hazāribāgh, Shāhābād districts (p. 57); in Gayā, Hazāribāgh, Patna, Balasore, Cuttack and Puri districts and Dhenkānāl States (p. 72).

Levelling of high precision levelling from Balasore to Howrah (p. 17).

22. Bengal Presidency and Sikkim.

Air survey in Mālda district for Settlement surveys (pp. 68, 69, 82-84).

Topographical surveys in Jalpaiguri and Rangpur districts and Cooch Behār State (p. 72).

City surveys in Calcutta (p. 72).

Forest surveys in Darjeeling and Buxa forest divisions (p. 73).

Framework in Jalpaiguri, Rangpur and Mymensingh districts and Cooch Behār State (p. 73).

Levelling of high precision levelling from Balasore to Howrah (p. 17.)

23. Assam and Bhutān.

Topographical surveys in Goālpāra, Gāro Hills and Bhutān (p. 72, 73).

Tea-garden surveys in Sylhet district (p. 71).

Forest surveys in the Goālpāra and Gāro Hills Forest Divisions (p. 73).

Framework in Gāro Hills, Khāsi and Jaintiā Hills and Sylhet districts and Bhutān (p. 73).

24. Burma, Andamans and Nicobars.

Topographical surveys in the Hanthawaddy, Myaungmya, Pyapon (p. 74); Insein, Pegu and Thaton districts (p. 76); Nāgā Tribal area (p. 75).

Forest surveys in Kathā, Mansi and Mu Forest Divisions (p. 78-79).

Framework in the Prome, Sandoway, Thayetmyo districts (p. 74); in Hanthawaddy and Insein districts (p. 77).

II.—ABSTRACT OF GEODETIC OPERATIONS.

DIRECTOR:—Dr. J. de Graaff Hunter, M.A., Sc. D., F. Inst. P., from 1-10-27 to 6-11-27 and from 28-6-28.
Lt.-Colonel R. H. Phillimore, D.S.O., R.E., from 7-11-27 to 27-6-28.

25. General.—Besides geodetic work, the Director, Geodetic Branch administers the following offices at Dehra Dūn; *No. 2 Drawing Office*, the *Forest and Cantonment Office* and the *Publication and Stores Office*, whose work is reported in the annual Map Publication and Office-work Report; and also the following Survey operations which are reported in other parts of this General Report:—*Levelling* carried out in aid of special engineering projects, *vide* para. 176; *Cantonment Surveys* (para. 173); *Training School* (para. 178).

26. Geodetic.—Purely geodetic operations include miscellaneous computations and research, preparation and publication of records, observatory work (astronomical, magnetic, seismological and meteorological); important series of triangulation, geodetic levelling, precise latitudes, longitudes, azimuths, and gravity determinations, in all parts of India; and prediction of Tides at 38 eastern ports between Suez and Singapore.

These geodetic operations are fully described in the Annual Geodetic Reports of the Survey of India. A combined Geodetic Report for years 1922-25, was published during the year; separate reports for each succeeding survey year are now in the press. The following is a brief abstract of the geodetic operations described in the Geodetic Report for the current year, which includes complete Index maps and detailed results.

Geodetic Operations for 1927-28.

27. Observatory Section.—As the astrolabe had been taken out to the field by No. 14 Party, the bi-weekly time observations were taken regularly with one, and occasionally with two transit instruments.

The reception of wireless time-signals from Bordeaux was carried out regularly by day. The wireless time-signals from Rugby which were initiated about the third week of December 1927, were also regularly received from the commencement of January 1928. From time to time during the summer months, when it was found impossible on account of atmospherics to receive the signals during daylight for periods exceeding one week, arrangements were made to pick up the night signals emanating from these stations instead.

The results of the longitude operations, undertaken during October and November 1926, were scrutinized in the light of data received from the other observatories participating in the project. These confirm the value provisionally obtained and make the longitude of Dehra Dūn 0·02 seconds of time east of that obtained in 1894-96. The reception of the daily time signals from Bordeaux and Rugby are being continued in order to see if there is any variation in longitude.

Besides the bi-annual comparison of seven tapes belonging to the field detachments of No. 17 Party, against Standard Bar I_s, thirteen pairs of new staves, received from that party for determination of graduation errors, were compared against Bar 1 1900 (T. S.). 20 levels received from the same source were examined and adjusted at the close of the field season.

A 50-feet measuring tape made of non-corrosive steel by the Poldi steel works was received from the M. I. O. Its suitablity for base line or general survey use was investigated.

In accordance with the Director's decision to make the Observatory Section responsible for the maintenance of theodolites and other instruments stored in the Publication and Stores Office, five theodolites were cleaned and adjusted in the Section.

The reflecting telescope by Browning, which had hitherto been kept in the old Haig Observatory, was dismantled and re-erected on the upper storey of the Walker Observatory. A model of the solar system, showing the relative size and position of the different planets, sun and earth on the scale of 10,000 miles to 1 inch, was set up in the grounds of the Geodetic Branch Office for the benefit of visitors and for instructional purposes.

The magnetographs recorded 3 magnetic storms of great intensity, and 35 earthquakes were recorded by the Omori Seismograph. Of these 3 were of considerable and 1 of great intensity.

During April 1928, a weekly training class under Mr. R. B. Mathur was started, in order to impart practical instruction in the use and adjustment of surveying instruments, and computations connected therewith, to geodetic and other computers of the Computing and other sections, some of whom were recently brought on to the Upper Subordinate cadre of the department.

This Section is also concerned with the periodical supply of meteorological and magnetic data, and correct time daily to certain local offices. A scheme to broadcast correct time daily in Dehra Dūn and Mussoorie, through the agency of the Electric Supply Company, is under consideration and may be introduced in the near future.

The Haig Observatory was rebuilt during the year and the zenith telescope installed on the old latitude pillar. Regular observations with the latter were commenced in September 1928. The seismograph and the tide-predicting machine were removed from the Burrard to the Haig Observatory in June and August 1928.

The observatories were visited by Their Excellencies the Viceroy and the Governor of the United Provinces and by other high officials in the month of April 1928.

Short Catenary Base.—Since 1925 Dr. Hunter has designed a *short catenary base* apparatus, that will provide a base of sufficient accuracy for trans-frontier triangulation, or triangulation with an expeditionary force or boundary commission.

His latest pattern has now been tested in the Frontier Circle, and was used during the survey tactical exercise held at Abbottābād in October 1927, when it was so favourably reported on that two sets have been supplied to the Artillery Survey Section to form part of their equipment.

The base takes the form of a crinoline chain 264 feet long, suspended as a catenary; and provision is made for three intermediate supports, which however are not always essential. Arrangements are made for application of a constant horizontal tension to the chain. Targets are provided at the terminal points, to which theodolite observations can be taken from points suitable for the extension of the base, and this

"short catenary base" may be used in a manner similar to a subtense bar. The tapes for the two new sets have been standardized in the Observatory Section and tables drawn up giving :—

(*a*) lengths of sections of the base under standard tension and temperature.
(*b*) catenary correction for variation in number of intermediate supports.
(*c*) correction for temperature.
(*d*) correction for slope.
(*e*) reduction to sea-level.

Further experiments will be made in the direction of using invar tapes instead of the ordinary steel crinoline chain, of which the present pattern is made.

28. Computing Office.—The most notable contribution to geodesy during the year was the interesting address on the Figure of the Earth, delivered by Dr. J. de Graaff Hunter, as President of the Mathematics and Physics Section of the 15th Indian Science Congress, held at Calcutta in January 1928.

Numerous calculations, dealing with the investigation into the most suitable Figure of the Earth were undertaken. Other computations, for the assessment of accuracy of triangulated heights, for the determination of plumb-line deflections in terms of the International Spheroid, and for the adjustment of the 'Irāq and Turco-Persian boundary triangulations were carried out. The remodelling of various professional forms was completed. About 190 requisitions for data both for departmental and extra-departmental purposes were complied with. Contoured degree-sheet charts for correcting the co-ordinates of the topographical triangulation in 1/M sheets 38 & 43 of the Frontier Circle, were prepared on a large scale. 47 degree sheet triangulation pamphlets (including most of the 'Irāq triangulation) were compiled, and 41 were printed off. 31 old triangulation pamphlets, which were out of stock, were reprinted by photozincography. As the existing star-charts were not properly adapted for use in the Himālayan region to the north as well as in South India, separate star-charts for latitude 15° and 30° were prepared and printed.

An enlarged edition of Part III of the Auxiliary Tables, 5th edition, has been reprinted. The tables relating to Lambert's conical orthomorphic projection have been added as an important feature of this edition. The separate star-charts above mentioned have also been included. Part IV of the Auxiliary Tables is under compilation.

The Geodetic Report Vol. I, 1922-25, has been published, Vol. II, 1925-26, is in the press and Vol. III, 1926-27 has been prepared for press. The editing of Vol. IV, 1927-28, has been taken in hand.

29. Tidal Section.—Tidal predictions for 37 Indian ports for the years 1929 and 1930 were run off on the tide-predicting machine.

The self-registering tide-gauges at Aden, Basra, Bombay, Karāchi, Madras, Rangoon, Bassein and Elephant Point (Rangoon River) continued to register the tides throughout the year. Bassein, Rangoon, Elephant Point and Basra observatories were inspected.

About the middle of November 1927, a passing steamer collided with and damaged the observatory at Kidderpore. In consequence the

registration of tides at that port was interrupted till the tide-gauge was re-installed in August 1928.

The readings of actual times and heights of high and low water during daylight hours on the tide-poles at Bhāvnagar, Chittagong and Akyab continued to be received and were dealt with.

The harmonic analysis for Bassein for the year 1926 was completed, the port being treated as an open sea port.

The printing and publication of the 1929 tide-tables is expected to be completed by the end of October 1928. Advance copies of the tide-tables of 17 ports for 1929 were despatched to the Hydrographer to the Admiralty by the end of March 1928.

The 'Irāq Government having agreed to pay the cost of preparation of a new set of charts, giving the monthly mean values of the heights and times of high and low-waters corresponding to the mean times of the moon's transit, 16 such charts for the port of Basra were prepared during the year and have been used in the predictions for the tide-tables of that port for 1929.

The tidal station at Basra was not previously under the control of this Department, but as the predictions were of a low order of accuracy, Mr. D. H. Luxa, the tidal assistant, with the approval of the 'Irāq authorities, inspected the automatic tide-recorders used by the Port Directorate along the Shatt-al-'Arab. He also saw the tidal data and records, available in the Chief Engineer's Office at Tanūmah, and instructed the officers responsible for the working of the automatic tide-recorders at Tanūmah, Abādān and Fāo. The Survey of India has asked the port authorities to send certain records, as recommended by Mr. Luxa. It is hoped thereby to increase the precision of future predictions.

30. Gravity and Deflection Observations.—(No. 14 Party).—In Sind and Baluchistān the force of gravity as well as plumb-line deflections in the meridian and prime vertical were observed at 13 stations:—

3 stations near the coast in Las Bela State.
4 stations in the Indus Delta.
1 station at Hyderābād (Sind).
5 stations in Chāgai district, Baluchistān.

Gravity observations alone were made at 3 stations in Chāgai district. Observations were taken by Major E. A. Glennie, D.S.O., R.E., and Mr. B. L. Gulatee, M.A. Except for one considerable northerly deflection near the Rann of Cutch, no exceptional results were obtained.

31. Triangulation.—(No. 15 Party).—Secondary triangulation was carried out in the North West Frontier Province at the special request of the Director, Frontier Circle, to form a reliable framework in this area, from which the accumulated mass of minor work could be adjusted and brought into the same terms. The work consisted of two short extensions; the first from the Great Indus Principal Series about Campbellpore to the neighbourhood of Peshāwar, a total length of 60 miles; and the second running from the North Baluchistān Series, north-west of Bannu, up the Kurram valley as far as Pārachinār, and in the opposite direction to Razmak, a total length of 90 miles. The

observer was Captain G. H. Osmaston, M.C., R.E., who used a small Wild universal theodolite with very satisfactory results.

32. High Precision Levelling.—(No. 17 Party).—Out of a total length of 13,300 miles of levelling of high precision required for the new geodetic level-net of India, 334 miles were completed during interval 1927-28, bringing the total completed up to date to 5,333 miles.

A total of 1,431 miles of high precision levelling was done. This includes branch lines not reckoned in the net mileage:—

In fore direction only.—361 miles

(a)	Muttra-Delhi-Meerut in U. P. and Delhi ...	154
(b)	Sahāranpur-Ludhiāna in U. P. and Punjab	138
(c)	Nakhtarāna Motā-Lakhpat in Cutch ...	62
(d)	Unhia Tar-Mughalbhīn in Sind ...	7

In back direction only.—235 miles

(a)	Wazīrābād-Ghakkar in Punjab ...	11
(b)	Basta-Howrah in Orissa and Bengal ...	145
(c)	Mughalbhīn-Tatta in Sind	79

In both directions.—$2 \times 302 = 604$ miles

(a)	Jhang-Wazīrābād, Punjab	2×201
(b)	Balasore-Basta, Orissa	2×18
(c)	Hāthras-Muttra, United Provinces ...	2×27
(d)	Dehra Dūn-Sahāranpur, United Provinces	2×56

Revision in one direction only.—231 miles

(a)	Sukkur-Daur, Sind	113
(b)	Hyderābād-Daur, Sind	92
(c)	Anjār-Mamuāra, Cutch	26

The standard bench-mark at Bhūj in Cutch State, the construction of which was not completed when the net-line through Bhūj was run in 1922-23, was connected during the year.

Captain Bomford investigated the effect of refraction in lines of levelling, where the ground slopes continuously in one direction; and also the best method of levelling across large rivers. Some account of these researches are given in Geodetic Report Vol. IV. Levelling from Sahāranpur to Dehra Dūn and the crossing of the Indus river between Sujāwal and Tatta in Sind were done in accordance with the deductions he made from his investigations.

Secondary and tertiary levelling.—Reports of these works will be found under Part X of this report (p. 81.).

Torsion balance survey.—A special detachment of No. 17 Party under Mr. K. K. Das assisted by Mr. H. C. Banerjee was sent to Assam to assist the Burma Oil Company in its torsion-balance gravity survey of the oil-fields of Assam.

33. Miscellaneous.—*Organization.*—The Government of India sanctioned the incorporation of the Geodetic Computers of the Computing Office in the Upper Subordinate Service of the Survey of India with effect from 1st April 1927.

Tertiary levelling of the Haveli irrigation project of the Punjab Government was transferred from No. 17 Party, Geodetic Branch, to No. 23 Party (Rectangulation), Frontier Circle.

The commercial levelling group of No. 17 Party, which hitherto had a separate budget, was amalgamated with the main party.

III.—ABSTRACT OF MAP PUBLICATION AND OFFICE WORK.

34. Full Reports of the work of all drawing, printing, and miscellaneous offices of the department, with *Index Maps* showing the progress and present state of map publication on various scales have been published separately in the *Map Publication and Office Work Report* for the financial year ending 31st March 1928. The following extracts from the full Report show the most important result of all this work, in the shape of Publications and Issues, etc.

Table I *(a)*—Maps published at Calcutta, during the year 1927-28.

Class of maps.	Scale.	New publications.	Reprints and new editions.	Number of sheets printed.	Value Rs.
GENERAL MPAS.	*Departmental.*				
Maps of India	Various	1	2	3,900	4,850
GEOGRAPHICAL SERIES.					
Southern Asia	1:2,000,000	2	1	1,711	6,482
India and Adjacent Countries ...	1:1,000,000	1	22	11,380	20,350
Carte Internationale du Monde	1:1,000,000	...	2	588	1,764
TOPOGRAPHICAL MAPS.					
Quarter-inch, Modern ...	1″=4 miles	22	14	16,182	24,784
,, (Prely.) ...	Ditto	4	6	4,920	7,540
,, (Provl.) ...	Ditto	...	19	5,644	8,574
Half-inch, Modern ...	1″=2 miles	41	15	31,270	94,898
,, (Prely.) ...	Ditto	...	...	...	...
One-inch, Modern ...	1″=1 mile	158	101	149,431	2,81,228
,, (Prely.) ...	Ditto	4	4	3,901	5,992
,, (Provl.) ...	Ditto	...	...	...	...
Old style sheets	Various	...	42	7,132	10,877
SPECIAL MAPS.					
Administration report maps ...	1″=8 miles	...	1	50	19
Provincial maps	Various	...	1	1,009	1,261
Plans of Cities and Cantonments	Ditto	5	2	4,861	11,722
Index maps	Ditto	68	38	131,175	26,495
Miscellaneous maps ...	Ditto	21	28	27,223	19,088
Total ...	.....	**327**	**298**	**339,877**	**4,75,924**
	Extra-departmental.				
Maps...	Various	206	52	152,818	46,934
Plans and diagrams ...	Ditto	199	50	121,801	9,228
Illustrations	.....	357	18	186,892	84,284
Miscellaneous	.....	51	62	208,317	6,541
Total ...	.....	**813**	**182**	**669,323**	**96,937**
Grand Total ...	.....	**1,140**	**480**	**1,069,200**	**5,72,861**

Table I *(b)*—Maps published at Dehra Dūn.

Class of maps.	Scale.	New publications.	Reprints and new editions.	Number of sheets printed.	Value.		
	Departmental.				*Rs.*	*as.*	*p.*
Cantonment maps ...	Various	18	132	12,900	25,800	0	0
Forest maps ...	,,	161	34	11,478	11,349	8	8
Miscellaneous ...	,,	...	1	2,171	81	7	0
Total ...	...	**179**	**167**	**26,649**	**37,230**	**15**	**3**
	Extra-departmental.						
Maps	Various	151	24	65,487	7,494	1	0
Plans and diagrams ...	,,	117	...	44,954	4,480	10	8
Charts	4″ = 1 mile	227	...	30,768	3,156	0	0
Total ...	...	**495**	**24**	**141,209**	**15,130**	**11**	**8**
Grand Total ...	...	**674**	**191**	**167,758**	**52,361**	**10**	**11**

Table I *(c)*—Maps published at Quetta.

Class of maps.	Scale.	New publications.	Reprints and new editions.	Number of sheets printed.	Value.		
	Departmental.				*Rs.*	*as.*	*p.*
Plans and diagrams ...	Various	57	...	2,429	532	9	0
Charts	,,						
Total ...	...	**57**	...	**2,429**	**532**	**9**	**0**
	Extra-departmental.						
Maps	Various	8	41	2,886	1,628	6	0
Plans and diagrams ...	,,	51	...	11,220	818	12	0
Charts	,,	3	...	1,440	321	4	6
Total ...	...	**62**	**41**	**15,546**	**2,768**	**6**	**6**
Grand Total ...	...	**119**	**41**	**17,975**	**3,300**	**15**	**6**

Table I *(d)*—Maps published at Peshāwar.

Class of maps.	Scale.	New publications.	Reprints and new editions.	Number of sheets printed.	Value.		
		Departmental.			*Rs.*	*as.*	*p.*
Military maps ...	1″=1 mile	3	...	200	91	0	0
	3″= ,,	2	...	30	17	0	0
Miscellaneous ...	Various	26	...	1,417	335	0	0
Total ...	...	**31**	...	**1,647**	**443**	**0**	**0**
		Extra-departmental.					
Miscellaneous plans and diagrams.	Various	15	...	836	421	15	0
Total ...	...	**15**	...	**836**	**421**	**15**	**0**
Grand Total ...	...	**46**	...	**2,483**	**864**	**15**	**0**

TABLE II.—ABSTRACT OF MODERN TOPOGRAPHICAL MAPS.

	One-inch sheets.	Half-inch sheets.	Quarter-inch Degree sheets.
Topographical maps published in 1926-27	149	37	22
Do. do. published in previous years.	2,426	665	183
Total published ...	**2,575**	**702**	**205**
Number of sheets in India ...	**6,218**	**1,630**	**450**

35. Notes.—*Calcutta.*—In addition to the work shown in Table I(*a*) material for the original mapping of the Eastern and Burma Circles, and for the compiled mapping of all Circles, and also for the new Catalogue of Maps (under preparation) and for numerous extra-departmental maps, was supplied. Nine indexes, in colours, for the General and Map Publication Reports and Supplement, were printed.

The work of surprinting the minute mesh on stock copies for the Army Department, which during the year involved several thousand sheets, is nearing completion.

36. *Dehra Dūn.*—In addition to the work shown in Table I(*b*) above, 115,199 prints of 1,150 originals, consisting of plane-table sections, triangulation charts and pamphlets, and forest maps were printed.

37. *Bangalore.*—The Photo. Zinco section of No. 4 Drawing Office, Bangalore, reproduced 52 maps of estates, forests, etc., on payment for Indian states and private individuals; also 458 plane-table sections for parties. It also prepared 288 vandyke plates. The total number of pulls in the hand presses were 9,013.

Table III.—Letterpress publications.

(a) Published at Calcutta.

1. General Report of the Survey of India, 1926-27.—(475).*
2. Do. , Supplement to, 1926-27.—(75).
3. Map Publication and Office Work Report, 1926-27.—(300).
4. Hand-book of Topography, Ch. VIII, 1927.—(600).
5. Do. do. Ch. XI, 1927.—(600).
6. Do. do. Ch. I, revision of Appendix III.—(750).
7. Correction slips, to Handbooks, Type Table, Border Specimen, etc.—(19,570).
8. List of maps published, issued monthly.—(800).
9. Do. do. (F. O. U. O.), issued quarterly.—(175).
10. Survey Notes, issued monthly.—(350).
11. Government of India and Circular orders, etc.—(1,800).
12. Type Specimen Book for Drawing Office.—(200).
13. Index to names—Calcutta-Howrah guide map.—(2,300).
14. Notes of the Vandyke Process.—(100).
15. Camp Officer's Record book.—(200).
16. Instructions and Application form for candidates, Class II Service.—(600).
17. Annual Indents for European Stores.—Various.
18. Calendar for 1928.—(3,500).

(b) *In Hand at Calcutta.*

1. *Hand-book of Topography, Ch. VI., Revised Edition.*
2. *Do. do. Ch. X., Revised Edition.*
3. *Do. do. Ch. IV., Field Traverse Table only.*
4. *Correction slips to Handbooks, Type Table, Border Specimen, etc.*
5. *Descriptions of Conventional Signs for Topo. maps.*
6. *Catalogue of maps.*
7. *Price List of Survey of India maps.*
8. *Government of India and Circular orders.*

(c) Published at Dehra Dūn.

1. Geodetic Report, Vol. I, 1922-25.—(500).
2. Professional Paper No. 21, Irrigation & Settlement Surveys, 1926.—(400).
3. Hand-book of Topography, Ch. IV.—(750).
4. Do. Addendum. Ch. VII.—(250).
5. Tide Tables, Indian Ports for 1928.—(5,525).
6. Report to International Union of Geodesy & Geophysics.—(1,030).
7. Levelling Pamphlet Addendum, No. 39.—(125).
8. Do. do. do. ,, 40.—(100).
9. Do. do. do. ,, 41.—(300).
10. Do. do. do. ,, 73.—(300).
11. Secondary Levelling Lines ,, 90 B.—(200).
12. Do. ,, 90 C.—(200).
13. Triangulation Pamphlets.—(100 of each).
14. Catalogue of Maps of Cantonments & Military Stations—Public edition.—(300).
15. Routes in the Western Himālaya & Kashmīr, corrections.—(510).
16. Auxiliary Tables Part I, reprint.—(100).
17. Traverse Tables.—(50).
18. Time of reception of Radio Signals.—(800).
19. Circular by the Surveyor General in regard to Air Surveys.—(1,000).*
20. Notices of the Survey of India.—(1,650).
21. Annual Report on standard bench marks.—(500).
22. List of Publications (letterpress) of Survey of India.—(150).
23. Correction slips, Various.—(2,060).
24. 148 Professional forms.—(1,62,300).
25. Miscellaneous jobs.—(1,73,844).

*Numbers in brackets after each item denote the number of copies printed.

Table III.—Letterpress publications.—*(Concld.).*

(d) In Hand at Dehra Dūn.

1. *Geodetic Report, Vol. II, 1925-26.*
2. *Hand-book of Levelling.*
3. *Tide Tables, Indian Ports, 1929.*
4. *Levelling Pamphlet No. 53.*
5. *32 Secondary Levelling Lines.*
6. *11 Triangulation Pamphlets*
7. *Auxiliary Tables—Part III.*
8. *Accounts Pamphlet.*
9. *Qualification Report form for Lower Subordinates, Revised.*
10. *Correction slips to Forest Map Office catalogue.*
11. *Government of India Orders (Administrative) 1919 to 1924.*

38. Map Issues.—The following Table shows the number of maps issued during the year.

Table IV.—Maps issued by Survey units.

D = Departmental X = Extra-departmental.		On book transfer (to Government officials).		On cash payment.		Free issues.		TOTAL.	
		Number of copies.	Sale Value. Rs.	Number of copies.	Sale Value. Rs.	Number of copies.	Face Value. Rs.	Number of copies.	Sale Value. Rs.
Calcutta	D	63,313	90,676	60,154	84,846	68,737	1,05,459	192,204	1,75,522*
	X	443,308	68,457	134,243	15,968	12,507	2,896	590,058	84,425*
Dehra Dūn	D	14,845	17,419	1,567	3,627	7,857	13,937	24,269	21,046*
	X	71,124	12,269	2,567	3,748	64	20	73,745	16,017
Simla	D	.....	.....	60	128	12	18	72	146
Rāwalpindi ("A" Company)	X	650	702	400	504	.....	.....	1,050	1,206
Quetta ("E" Company)	D	6	9	64	96	.....	.....	70	105
Peshāwar (No. 18 Party)	D	.....	.....	.....	.....	1,647	443	1,647	443
	X	200	187	636	235	.....	.....	836	422
Mussoorie	D	.....	.....	302	595	.....	.....	302	595
Bangalore	D	1,499	3,334	4,907	9,964	.....	.....	6,406	13,298
Shillong	D	.....	.....	501	1,055	.....	.....	501	1,055
Maymyo	D	570	1,005	318	675	.....	.....	888	1,680
Totals	...	595,515	1,94,058	205,709	1,21,441	90,824	1,22,773	892,048	3,15,960

* These figures do not include the value of free issues.

39. Map Record and Issue Office :—The total proceeds from the sale of maps, which excludes the value of free issues, show a decrease of Rs. 19,121 from the last year's figures, while the actual number of copies issued fell by 198, 723.

The reason for this decrease may be ascribed to the fact that smaller sums were placed at the disposal of the military authorities for the purchase of maps during the last financial year.

The value of Departmental Book-Debit issues remained practically the same, but in the case of Extra-Departmental issues, it increased by 4,667.

Cash sales, on the other hand, decreased by 41,309 copies of Departmental issues and increased by 10,101 copies for Extra-Departmental issues, while free issues show an increase of 8,858 Departmental and 8,969 Extra-Departmental copies.

New steel almirahs, with a total capacity of 2,102 shelves, were erected during the year, leaving a balance of 3,758 shelves still to be provided.

40. Dehra Dūn Map Office.—Most of the issues from Dehra Dūn are forest, Cantonment. and other special maps for Government departments.

41. Stock of Maps.—*Calcutta.* A comparison of Table I(*a*) with Table IV shows that, during the year, 399,877 departmental sheets were published at Calcutta, while 192,204 sheets were actually issued. Some 7,600 copies of superseded maps were withdrawn from stock, the net increase of stock being, therefore, about 200,000 and the total stock in hand about 5,200,000.

Dehra Dūn. The corresponding figures for Dehra Dūn are 167,758 published, 160,068 sheets issued, stocks in hand have increased by 7,690 sheets (320 new maps). The total stocks in hand in Dehra Dūn are estimated at 333,077 sheets.

42. Mathematical Instrument Office.—The demands on the office for the supply and repair of instruments and the workshop outturn all show a considerable increase compared with recent years (*vide* 1, 2 and 6 in the following Table). Demands by Public Works Department, Military and Railways were unusually high.

Up to 31st March 1927.	1925-26.	1926-27.	**1927-28.**
	Rs.	*Rs.*	**Rs.**
1. Total value of stores issued ...	4,20,340	5,17,410	**5,60,829**
2. Value of repairs carried out to order ...	1,34,008	1,40,144	**1,54,092**
3. Value of instruments, etc., returned to Store by those who no longer require them	51,045	99,369	**63,760**
4. *Book Value of Stock*			
(*a*) In Serviceable Store	2,55,474	2,48,669	**2,87,839**
(*b*) In Repairable Store	81,527	80,559	**97,799**
(*c*) In Material Store	2,16,136	1,94,132	**2,01,072**
5. *Value of New Instruments and Materials*			
(*a*) Manufactured in Workshops ...	1,75,874	2,40,642	**2,92,781**
(*b*) Purchased locally	43,326	83,016	**93,964**
(*c*) Imported through the Stores Department, London ...	92,003	1,82,919	**2,47,624**
6. *Workshops*			
(*a*) Value of work done	4,31,269	4,71,518	**5,49,208**
(*b*) Cost of employees (including pension contribution) ...	1,60,659	1,70,980	**1,76,572**
(*c*) Average number of employees ...	No. 412	No. 458	**No. 461**

IV.—ABSTRACT OF TOPOGRAPHICAL WORK.

43. The following Tables show the progress of the topographical programme assigned to the Department in 1905 and the out-turns and cost-rates of different parties during the year under report.

44. Progress. It was hoped in 1905 that maps on the scale of 1 inch to 1 mile would be available for the whole Indian Empire within 25 years; but the work has been greatly retrenched and delayed from various causes, and in 1913 the Secretary of State sanctioned a scheme for the reduction of the scale of survey in the less populous areas. Allowing for the surveys to be carried out on the reduced scales of ½ inch and ¼ inch to 1 mile, under this scheme, we may roughly regard half the work as being completed by 1925; though there is a tendency to revert to the 1 inch scale in special cases owing to the pressing requirements of geologists and engineers, combined with the modern military view that this is the smallest scale suitable for tactical operations. Table B gives an idea of the work ahead according to present policy, and the state of the work is shown in the *Index Map* at the end of this volume.

Revision of modern surveys has also become necessary in some important frontier tracts and is already much needed in some other areas. Also some areas surveyed on smaller scales have had to be resurveyed on a larger scale. The figures for this work are given in italics at the end of Table A.

Table A.—Progress of Topographical Surveys since 1905.

Scales of survey mostly 1 inch to 1 mile, but including 2-inch, 1½-inch, ½-inch and some ¼-inch work occasionally.

Survey years.	Old Northern Circle.	Old Southern Circle.	Old Eastern Circle.	TOTALS.
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
1905-10 ...	70,784	44,675	52,885	168,344
1910-15 ...	116,958	70,765	51,654	239,377
1915-20 ...	33,713	59,916	40,654	134,283
1920-25 ...	82,777	106,619	66,703	256,208
Totals to 1925 ...	**304,232**	**281,975**	**211,896**	**798,207**

Table A.—*Concld.*

The Burma Circle was separated from the Eastern Circle in 1922-23. The Northern and Southern Circles were reformed as three Circles in 1925-26. The above totals are therefore redistributed amongst the present five Circles (with slight adjustment based on revised estimates), as follows:—

Survey years.	Frontier Circle.	Central Circle.	Southern Circle.	Eastern Circle.	Burma Circle.	TOTALS.
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Up to 1925 ...	172,382	213,774	200,051	89,587	122,309	798,103
1925-26 ...	4,906	11,621	14,137	6,029	6,012	42,705
1926-27 ...	7,964	6,036	13,753	10,889	5,543	44,185
1927-28 ...	**6,297**	**4,035**	**14,840**	**14,173**	**7,897**	**47,242**
Up to 1928...	**191,549**	**235,466**	**242,781**	**120,678**	**141,761**	**932,235**
Balance remaining.	340,066	*202,534*	*100,769*	*164,557*	124,114	932,040
Total programme.	**531,615**	**438,000**	**343,550**	**285,235**	**265,875**	**1,864,275***

Revision and Re-survey of the above work.

Up to 1927 ...	*4,003*	*284*	*1,007*	*70*	*1,016*	*6,380*
1927-28 ...	1,101	*Nil*	*1,743*	*Nil*	*Nil*	2,844

* These totals are exclusive of 54,995 square miles, surveyed in Nepál on the ½-inch scale.

Table B.—Analysis of balance remaining on 1st October 1928.

Proposed scale of survey.	Frontier Circle.	Central Circle.	Southern Circle.	Eastern Circle.	Burma Circle.	TOTALS.
	Sq. miles.	Sq. miles.	Sq. miles.	Sq. miles.	Sq. miles.	Sq. miles.
1½-inch & over	47,593	...	...	...	...	47,593
1-inch ...	57,166	47,137	100,769	115,130	103,577	423,779
½-inch ...	205,131	148,739	...	49,427	20,537	423,834
¼-inch ...	80,176	6,658	...	...	...	86,834
Totals.	**340,066**	**202,534**	**100,769**	**164,557**	**124,114**	**932,040**

Table C.—Areas and Cost rates of Surveys, 1927-28.

Party and Locality. Character of country.	Scale and description of work.		Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1927 to Septr. 30th 1928.	Overall cost rate of Topographical Survey.	Remarks.
"A" Company.—Punjab and North-West Frontier Province.				Rs.	Sq. m.	Rs.	Rs.	**FRONTIER CIRCLE.**
High mountains (up to 25,000 ft.) partly above snowline.	½-inch & ¼-inch	**Triangulation**	4,250	... (a)				(a) Cost rates will be given in next years report.
Ditto ditto ...	**Half-inch**	Original survey ...	296	... (a)				
Sub-montane (up to 17,000 ft.) partly wooded.	**One-inch**	Original survey ...	994	... (a)				
Ditto ditto ...	**One-inch**	Original survey ...	190	32·2(b)	**2,642**	1,99,725 (e)	**76**	(b) This cost rate is based on full area 920 sq. miles surveyed during summer 1927.
Medium bare hills	**One-inch**	Original survey ...	25	... (c)				(c) Areas too small to give reliable cost rates.
Plains	**1½-inch**	Revision survey	1,088	27·2				(d) Surveyed by men under instruction.
Riverain Area (Delhi) ...	**Two-inch**	Resurvey ...	13	... (c)				(e) Includes Rs. 4,988 cost of Military escorts chargeable to Army estimates and excludes Rs. 8,800 cost of Northern Command Survey Exercise.
Wooded Hills (Murree) ...	**Four-inch**	Resurvey ...	36	98·5(d)				
"E" Company.—Baluchistān, Rājputāna and Sind.								
Difficult Rugged hills ...	One-inch	**Triangulation**	2,089	8·2				
Flat Pat area	One-inch	**Triangulation**	1,045	10·7				
Bare rocky hills	Half-inch	**Triangulation**	1,054	8·5				
Difficult rugged hills ...	**One-inch**	Original survey ...	779	38·7				
Flat Pat area, some hills ...	**One-inch**	Original survey ...	2,354	29·5				
Irrigated Plain with jungle ...	**One-inch**	Original survey ...	270	41·3				
Rolling desert	**Quarter-inch**	Original survey ...	1,313	2·3(g)	**4,716**	1,81,988 (f)		(f) Excludes the following Reproduction Sections Rs. 13,888 Instruction to Officers etc. Rs. 46,899 Buildings Rs. 5489 purchase of two lorries Rs. 10,000.
No. 22 Party.—Punjab.								(g) Survey only. Fair Mapping not done by "E" Company.
Chenāb and Rāvi riverain tracts, level plain, fairly open.	24-inch cadastral survey and base-line traverse.		1,505 (Linear miles).	56·9 (per linear mile).				
Kāngra District, Sites for summer health resorts undulating ground, lightly forested.	One-inch=100 feet survey, including traversing, levelling, and planetabling, without mapping.		281 acres.	25·9 (per acre).				
No. 23 Party.—Punjab.								
Haveli Irrigation project Cultivated plains and desert country with scrub jungle.	**Four-inch**	Special survey ...	2,645	45·1	**2,645**	.....	**45·1**	

Table C.—Areas and Cost rates of Surveys, 1927-28.

Party and Locality. Character of country.	Scale and description of work.		Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1927 to Septr. 30th 1928.	Overall cost rate of Topographical Survey.	Remarks.
No. 1 Party.—Bihar & Orissa.				Rs.	Sq. m.	Rs.	Rs.	**CENTRAL CIRCLE.**
Plateaus & jungle-clad hillocks	**One-inch**	Triangulation ...	2,434	7·1				
Bihār and Orissa and Central India.								
Low hills and narrow valleys mostly covered with thick jungle.	**One-inch**	Re-survey ...	3,619	20·8	**3,619**	1,28,399	**35·5**	
No. 5 Party.—Central Provinces.								
Generally flat-topped and densely wooded hills.	**One-inch**	Triangulation ...	3,577	4·0				
Heavily wooded low hills and cultivated plains.	**One-inch**	Original survey ...	2,704	21·8				
Heavily wooded low hills.	**One-inch**	Supplementary survey	265	16·0	**2,969**	(a) 87,358	**29·4**	(a) Includes Rs. 6,713 debitable to C. P. Feudatory States, but excludes Rs. 21,666 debitable to C. P. Government for supervision of C. P. surveys.
Rājputāna Detachment.—Ajmer-Merwāra & Rājputāna.								
Open and cultivated flat areas with hills.	**One-inch**	Triangulation ...	2,135	2·5				
Do. Do. Do.	**One-inch**	Original survey ...	1,066	23·1	**1,066**	(b) 38,806	**36·4**	(b) Includes the cost of triangulation of 2,135 sq. miles.
Kailāna Tank Catchment area								
Low rugged hills.	**Four-inch**	Special survey† ...	76	305·1	.....	23,194		† Includes special contouring and triangulation.
Mayo College grounds Ajmer, Ajmer-Merwāra.	**Sixteen-inch**	Special survey* ...	269 Acres.	23 per acre.	**269** Acres.	639		* Includes theodolite traverse.

Table C.—Areas and Cost rates of Surveys, 1927-28.

Party and Locality. Character of country.	Scale and description of work.	Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1927 to Septr. 30th 1928.	Overall cost rate of Topographical Survey.	Remarks.
No. 6 Party.—Hyderābād, Central Provinces & Madras.			Rs.	Sq. m.	Rs.	Rs.	**SOUTHERN CIRCLE.**
Jungle-clad hills upto 4,000 feet	One-inch **Triangulation** ...	2,266	8·2				
Low wooded hills & undulating ground; also open cultivated plains.	**One-inch** Original survey ...	5,094	19·4				
Cultivated plains & undulating ground.	**One-inch** Revision survey ...	1,451	9·7	(a) **7,043**	1,52,814	**21·6**	(a) Includes 1,678 sq. miles revision survey.
Open flat rice fields ...	**One-inch** Supplementary survey	271	19·4				
Reserved forest & intricate hills	**Two-inch** Revision survey ...	38	32·3				
Hyderābād City & environs with gardens & stony hills.	**Three-inch** Revision survey ...	189	25·0				
No. 7 Party.—Mysore, Hyderābād and Madras.							
Open, undulating, with occasional wooded hills & rocky outcrops.	**One-inch** Original survey ...	4,803	17·2				
Mining concession; wooded hills.	**Four-inch** Original survey ...	20·5	(b) 144	(c) **4,803**	1,00,200	**20·7**	(b) Includes cost of triangulation and traversing.
Tea estate, part cleared & part wooded.	**Eight-inch** Original survey ...	2,648 acres or 4·1 sq. miles.	(b) 2·0 (per acre).				(c) Excludes 25 sq. miles estate survey.
Coffee estate, open and cleared	**Sixteen-inch** Original survey ...	359 acres or ·5 sq. miles.	(b) 3·6 (per acre).				

Table. C.—Areas and Cost rates of Surveys, 1927-28.

Party and Locality. Character of country.	Scale and description of work.	Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping)	Total area of Topographical Survey.	Total expenditure October 1st 1927 to Sept. 30th 1928	Overall cost rate of Topographical Survey.	Remarks.
No. 8 Party. Madras Presidency and States.			Rs.	Sq. m.	Rs.	Rs.	**SOUTHERN CIRCLE.—*Concld.***
Tea estates, hilly	Sixteen-inch **Triangulation** ...	11,360 acres or 18 sq. miles.	67·0 (per acre).				
Cultivated plains	One-inch **Traverse** ...	1,556 (linear miles).	18·0 (per linear mile).				
Densely wooded hills ...	Sixteen-inch **Traverse** ...	22 (linear miles).	27·0 (per linear mile).				(*d*) Includes 65 sq. miles of revision survey and excludes 25 sq. miles of estate survey.
Mostly wooded hills ...	**One-inch** Original survey .	436	26·0				
Cultivated plains & wooded hills	**One-inch** Supplementary survey	4,236	18·0	(*d*)	(*e*)		(*e*) Excludes Rs. 50,038 on account of estate surveys.
Cultivated plains	**1½-inch** Revision survey ...	65	26·8	**4,737**	1,13,832	**24**	
Tea estates	**Sixteen-inch** Original survey ...	13,672 acres or 21 sq. miles.	2·9 per acre.				
Coffee & rubber estates ...	**Sixteen-inch** Original survey ...	2,457 acres or 4 square miles.					

Table C.—Areas and Cost rates of Surveys, 1927-28.

Party and Locality. Character of country.	Scale and description of work.	Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1926 to Septr. 30th 1927.	Overall cost rate of Topographical Survey.	Remarks.
			Rs.	Sq. m.	Rs.	Rs.	**EASTERN CIRCLE.**
No. 4 Party.—Bihār and Chotā Nāgpur.							
Open Plateau and plains and densely wooded scarps.	One-inch **Triangulation** ...	3,797	5·0				
Open plateau and densely wooded hills and valleys.	**One-inch** Supplementary survey	3,785	29·6	**3,785**	1,31,178	34·7	
No. 9 Party.—Orissa.							
Flat cultivated plains with wooded hills.	One-inch **Triangulation** ...	556	6·0				
Flat cultivated plains interscted by numerous rivers.	One-inch **Traverse** ...	2,810	13·4				
Flat cultivated plains, undulating forest-clad plains and hills.	**One-inch** Original survey ...	2,859	35·7	**2,859**	1,43,232	50·0	
No. 12 Party.—Assam, Bhutān and Bengal.							
Plains, partly open, but mostly covered with elephant grass, Sāl and Simul jungle and in Bhutān steep wooded hills.	One-inch **Triangulation** ...	895	7·2				
	One-inch **Traverse** ...	1,058(a)	16·4(b)				(a) Linear miles. (b) Per linear mile.
	One-inch Original survey ...	2,547	43·9				
	One-inch Supplementary survey	295†	43·9				
Steep hills, partly wooded ...	Four-inch **Triangulation** ...	30	57·1	**3,910**	1,83,743	46·9	†Excluding 179 linear miles new railway survey.
	Four-inch Original survey ...	30	161·7				
	Four-inch Supplementary survey	20	161·7				
Gāro Hills and Khāsi Hills Densely wooded hills, generally low and undulating.	Half-inch **Triangulation** ...	963	7·2				
	Half-inch Original survey ...	1,018	16·6				

Table C.—Areas and Cost rates of Surveys, 1927-28.

Party and Locality. Character of country.	Scale and description of work.		Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1927 to Septr. 30th 1928.	Overall cost rate of Topographical Survey.	Remarks.
No. 10 Party.—Lower Burma.				Rs.	Sq. m.	Rs.	Rs.	**BURMA CIRCLE.**
Densely wooded hills ...	One-inch	**Triangulation** ...	1,350	7·73				
Cultivated plains with jungle and high grass.	Four-inch	**Traverse** ...	501 (Linear miles).	46·31 (per linear mile).				
Do. do. ...	One-inch	**Do.** ...	94 (Linear miles).	11·09 (per linear mile).				
High wooded hills ...	**Half-inch**	Original survey ...	1,001	7·59				
Cultivated plains cut up by creeks	**One-inch**	Original survey ...	376	44·95				
Do. do. and Delta forest	**One-inch**	Supplementary survey	3,144	35·21		(a)		
Low wooded hills and Delta forest	**Four-inch**	Original survey ...	18	599·17	**4,539**	1,89,598	**32·21**	(a) Includes Rs. 19,380 debitable to Burma Government P. W. D.; Rs. 2,559 debitable to Burma Government on account of Yenangyaung Survey and Rs. 17,457 debitable to Burma Government Forest Department.
No. 11 Party.—Lower Burma.								
Open cultivated plains ...	One-inch	**Triangulation** ...	1,700	10·2				
Undulating and wooded ...	One-inch & Four-inch	**Traverse** ...	164 (Linear miles).	74·2 (per linear mile).				
Mostly open cultivated plains; also low wooded hills.	**One-inch**	Supplementary survey	2,883	39·0				
Undulating and wooded ...	**One-inch**	Original survey ...	78					
Open cultivated plains ...	**1½-inch**	Original survey ...	67	38·4		(b)		
Undulating and wooded ...	**Four-inch**	Original survey ...	9	269·2	**3,037**	1,64,521	**54·0**	(b) Includes Rs. 10,211 debitable to Burma Government Forest Department but excludes Rs. 544 to be recovered for the private survey of a rubber estate.
No. 21 Party.—Upper Burma—*Reserved forests.*								
Steep rugged hills densely wooded	Four-inch	**Triangulation** ...	500	22·3				
Densely wooded hills ...	Four-inch	**Traverse** ...	399 (Linear miles).	137·3 (per linear mile).		(c)		
Do. do. ...	**Four-inch**	Original survey ...	321	342·0	**321**	2,10,569	**656·0**	(c) The whole cost is debitable to the Burma Government Forest Department.
				TOTAL	**7,897**			

Table C.—Areas and Cost rates of Surveys, 1927-28.

Party and Locality. Character of country.	Scale and description of work.			Area in sq. miles of each description of work.	Cost rate per sq. mile (including computations and mapping).	Total area of Topographical Survey.	Total expenditure October 1st 1927 to April 30th 1928.	Overall cost rate of Topographical Survey.	Remarks.
No. 20 Party.					Rs.	Sq. m.	Rs.	Rs.	**GEODETIC BRANCH.**
Cantonments in N. W. F. P., Bombay and Delhi.	12-inch	**Traversing**	...	25·7 (Linear miles).	43 (per linear mile).				
	16-inch	**Traversing**	...	102·4 (Linear miles).	58 (per linear mile).				
	16-inch	**Levelling**	...	45·6 (Linear miles).	21 (per linear mile).		(a) 18,350		(a) Excludes a further expenditure of Rs. 7,600 incurred on office and drawing establishments.
	12-inch	Original survey	...	3·3 sq. miles.	812 (per sq. mile).				
	16-inch	Original survey	...	1·1 sq. miles.	716 (per sq. mile).				
	16-inch	Revision survey	...	14·5 sq. miles.	463 (per sq. mile).				*Note*:—Figures refer to Peshāwar, Nowshera, Razmak cantonments and Delhi (Pahārganj).

Table D.—Average monthly out-turns, 1927-28.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

Party.	Locality.	PLANETABLING.											TRIANGULATION.			TRAVERSING.				MISCELLANEOUS.			Remarks.
		½-inch.		1-inch.		1½-inch.		2 inch	4 inch														
		Original survey.	Supplementary or revision survey.	Original survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Re-survey.	Original survey.	Original survey 1"=100 ft.	4-inch re-survey.	4" Original survey.	For ½-inch survey.	For 1-inch survey.	For 24-inch survey.	Main Circuits.	For Riverain surveys.	For Murabba-bandi.	For Rectangulation.	Traversing for 1"=100 ft. survey.	1100 ft. squares corners laid out.	Tertiary levelling for spot levels for contouring.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			Square		miles.						Square		miles (a)										**FRONTIER CIRCLE.**
"A" Company.	Dīr, Swāt and Chitrāl.	77	...	37	...	...	...	...	...	...	...	...	260	...	...	...	...	...	...	...	...	...	(a) Exceptionally difficult country for triangulation owing to inaccessibility of stations. Average height of stations 17000 ft.
	Lahore and Shekhūpura Districts.	...	...	...	...	...	34	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Delhi Province	...	...	... (b)	...	...	...	22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
"E" Company.	Kalāt State, Bolān Pass, Sibi and Karāchi Districts.	...	...	42	...	...	...	...	...	...	...	... (c)	...	...	...	...	...	...	...	...	...	...	(b) Area varies from almost featureless plain to high rugged hills.
	Jaisalmer and Jodhpur States.	...	...	...	...	...	...	...	...	...	...	450	...	...	...	...	...	...	...	...	...	...	(c) By one surveyor only.
	Kalāt State ...	...	...	...	...	...	...	...	...	...	...	...	(d) 1265	... (e)	...	...	...	...	...	...	...	...	(d) By a triangulator of some experience.
	Kalāt State ...	...	...	...	...	...	...	...	...	...	...	...	...	450	...	...	...	...	...	...	...	...	(e) By beginners.

Table D.—Average monthly out-turns, 1927-28.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

Party.	Locality.	PLANETABLING.											TRIANGULATION.			TRAVERSING.				MISCELLANEOUS.			Remarks.
		½-INCH.		1-INCH.		1½-INCH.		2 INCH	4 INCH														
		Original survey.	Supplementary or revision survey.	Original survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Re-survey.	Original survey.	Original survey 1″=100 ft.	4-inch re-survey.	¼″ Original survey.	For ½-inch survey	For 1-inch survey.	For 24-inch survey.	Main circuits.	For Riverain surveys.	For Murabba-bandi.	For Rectangulation.	Traversing for 1″=100 ft. survey.	1100 ft. squares corners laid out.	Tertiary levelling for spot levels for contouring.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
										Square			miles.				Linear.			miles.			
No. 22 Party.	Panjab:—Rāvi riverain tract.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	22	...	...	...	...	...	**FRONTIER CIRCLE.—** *Concld.*
	Chenāb riverain tract.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	43	...	...	...	...	...	...	
	Crown waste land.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30	...	19	...	...	32	...	
	Jumna River Sites at Pālampur and Baijnath.	...	...	...	...	...	...	...	...	...	9	...	...	...	...	...	...	...	...	...	...	...	
		...	...	...	...	...	...	...	...	41	...	...	...	...	...	14	...	...	...	8	..	17	
No. 23 Party.	Punjab ...	...	...	...	...	...	...	...	12	...	...	...	...	...	...	...	...	...	39	...	...	...	
Settlement Survey Detachment.	Malandri area District Peshāwar.	...	...	...	...	...	...	...	..	...	...	...	...	...	11	...	...	...	...	...	...	...	

Table D.—Average monthly out-turns, 1927-28.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

Party.	Locality.	PLANETABLING.											TRIANGULATION.			TRAVERSING.				MISCELLANEOUS.			Remarks.
		½-inch.		1-inch.		1½-inch.		2 inch.	4 inch.		16 inch.												
		Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original survey.	Original survey.				For ½-inch survey.	For 1-inch survey.	For 4-inch original survey.			For 16-inch survey.		Tertiary levelling for 4-inch original survey.	Tertiary levelling for 16-inch work.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	23	24
				Sq. miles.						Acres.			Sq. miles.			Linear miles.				Linear miles.			
No. 1.	Bihār & Orissa Central Provinces.	...	...	31	...	...	...	...	...	...	...	...	...	304	...	...	...	...	...	...	...	...	**CENTRAL CIRCLE.**
No. 5.	Central Provinces.	...	...	33	51	...	...	...	...	...	...	...	...	447	...	...	...	...	...	...	...	...	
Rājputāna Detachment.	Ajmer-Merwāra & Rājputāna.	...	...	29	...	...	...	...	...	...	...	...	...	666	...	...	...	...	...	...	...	...	
	Jodhpur or Mārwār State, Rājputāna.	...	...	...	...	...	...	...	4	...	...	...	...	...	48	...	...	...	...	63	...	...	
	Mayo College, Ajmer.	...	...	...	...	...	...	...	...	...	124	...	...	...	...	...	...	...	...	...	...	...	
	Kailāna Tank, Jodhpur or Mārwār State, Rājputāna.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	...	...	30	...	

Table D.—Average monthly out-turns, 1927-28.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

Party.	Locality.	PLANETABLING.											TRIANGULATION.			TRAVERSING.				MISCELLANEOUS.			Remarks.
		½-inch.		1-inch.		1½-inch.		2 inch.	4 inch.	3 inch.	8 inch.	16 inch.											
		Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Revision survey.	Original survey.	Revision survey.	Original survey.	Original survey.	For ½-inch survey.	For 1-inch survey.	For 16-inch survey.	Main Circuits.	For 1-inch survey.	For 1½-inch survey.	For 16-inch survey.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
				Sq.	miles.								Sq.	miles.			Linear		miles.				**SOUTHERN CIRCLE.**
No. 6	Hyderābād, Central Provinces and Madras.	...	...	31	101 (a)	...	...	18	...	18 (b)	...	...	...	342	...	...	...	...	...	...	...	...	(a) Previously surveyed on ½-inch scale. (b) Previously surveyed on 1-inch scale.
								Acres.			Acres.												
No. 7	Mysore, Hyderābād and Madras.	...	...	43	...	...	...	...	2999	...	548	427	...	...	...	...	...	...	...	...	...	...	
												Acres.			Acres.								
No. 8	Madras and Madras States.	...	...	35	40	...	14	...	...	...	...	383	...	...	2371	...	68	...	13	...	...	...	

Table D.—Average monthly out-turns, 1927-28.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

Party.	Locality.	PLANETABLING.											TRIANGULATION.			TRAVERSING.				MISCELLANEOUS.			Remarks.
		½-inch.		1-inch.		1½-inch.		2 inch.	4 inch.	4 inch.										Levelling.			
		Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original survey.	Original survey.	Supplementary survey.			For ½-inch survey.	For 1-inch survey.	For 4-inch survey.	Main Circuits.	For 1-inch survey.			For 1-inch survey.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			Sq. miles.										Sq. miles.			Linear miles.							**EASTERN CIRCLE.**
No. 4	Bihār & Chotā Nāgpur.	...	...	...	36	...	...	...	...	...	...	...	...	304	...	...	...	...	...	...	...	...	
No. 9	Orissa ...	...	...	25	...	...	...	...	...	...	...	...	...	334	...	...	61	...	...	...	...	...	
No. 12	Assam, Bhutān and Bengal.	39	...	25	19	...	...	...	7½	5	...	...	169	149	15	...	41	...	...	...	...	...	

Table D.—Average monthly out-turns, 1927-28.

All out-turns are given for surveyors (excluding pupils and men under training) for a month of 24 working days.

Party.	Locality.	PLANETABLING.											TRIANGULATION.			TRAVERSING.				MISCELLANEOUS.			Remarks.
		½-inch.		1-inch.		1½-inch.		2 inch.	4 inch.														
		Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original or re-survey.	Supplementary or revision survey.	Original survey.	Original survey.				For ½-inch survey.	For 1-inch survey.	For 4-inch survey.	Main Circuits.	For 1-inch survey.	For 4-inch survey.	For				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			Sq.	miles.				Sq.	miles.				Sq.	miles		Linear		miles.					**BURMA CIRCLE.**
No. 10	Lower Burma	133	...	28	56	...	...	...	3	...	...	...	...	1157	...	...	63	60	...	...	...	...	
No. 11	Lower Burma	...	...	35	28	26	...	...	2	...	...	...	...	242	...	...	24	20	...	...	...	...	
No. 21 (Burma Forest).	Burma Reserved Forests.	...	...	...	...	...	...	...	3	...	...	...	...	...	I55	...	...	17	...	...	...	...	

Table D.—Average monthly out-turns, 1927-28.

All out-turns are given for one surveyor (excluding pupils and men under traning) for a month of 24 working days.

Party.	Locality.	PLANETABLING.											TRIANGULATION.			TRAVERSING.				MISCELLANEOUS.			Remarks.
										16 INCH.	16 INCH.	12 INCH.											
										Revision survey.	Original survey.	Original survey.				For 16-inch survey.	For 12-inch survey.						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
										Acres.					Linear miles.								**GEODETIC BRANCH.**
No. 20 Party.	N. W. F. P. & Delhi Provinces.	...	...	...	...	...	...	...	...	335·49	311·11	281·60	...	...	...	19·50	15·06	...	...	...	...	...	

V.—SURVEY REPORTS, FRONTIER CIRCLE.

DIRECTOR:— Colonel C. P. Gunter, C.I.E., O.B.E., R.E., to 28-3-28.
Lieut.-Colonel S. W. Sackville Hamilton, D.S.O., R.E., from 29-3-28.

45. Summary.—The units administered by the Frontier Circle were "A" and "E" Survey Companies Nos. 13, 18, 22 and 23 Parties, Settlement Survey Detachment and No. 6 Drawing Office. No. 22 (Riverain) Party was transferred from Central to this Circle and No. 24 Party was transferred from this to Central Circle from 1st April 1928. No. 13 Party was also under the Administrative control of D. E. C., and D. G. B. during part of the year.

46. *Training.*—4 R.E. Officers, 3 Class II Officers, and 9 Upper Subordinates, all probationers, 23 Soldier Surveyors, 4 pupil Surveyors and 5 pupil Draftsmen commenced or continued their training in field and recess work in "A" and "E" Survey Companies, and No. 6 Drawing Office. One of the pupil draftsmen was discharged as unlikely to become efficient, and one of the Soldier Surveyors under first period of training was reverted to his regiment.

47. *Special.*—Lieut.-Colonel Sackville Hamilton, while in charge of No. 13 Party, made extensive tours and conferred with several Directors and officers in charge of parties and offices, in connection with the preparation of the Field Service Manuals (Surveys) which will be published by Army Headquarters.

He also edited the report on the Northern Command Survey Staff Exercise which took place in October 1927, and which he attended as Director with Major E. O. Wheeler, M.C., R.E., as Deputy Director.

A Field Survey Company under the Command of Captain W. J. Norman, M.C., R.E., was provided for the Exercise by "A" and "E" Companies, a Reproduction Section by "E" Company, and the Air-Survey Section by No. 18 Party. The R. A. Survey Section and the R. A. F. also took part. The detailed report is being published by Army Headquarters.

While in Bengal, Lieut.-Colonel Sackville Hamilton visited the Mālda district Air Survey as a result of which he submitted proposals to expedite and cheapen the cost of reproduction of air surveys by the employment of the Typon Process.

48. The field work of Units was as follows:—

"A" Survey Company. Topography on ½-inch, 1-inch, 1½-inch and 2-inch scales in sheets 43 B, 44 I, 53 H/2 and 4 inches=1 mile Survey in 43 F and G. Some triangulation was carried out in advance.

"E" Survey Company. Topography on ½-inch scale in sheet 40 J; on 1-inch scale in sheets 34 O, 39 C and D; 40 D. Some triangulation was carried out in advance.

No. 13 Party. Material for Field Service Manuals (Surveys) was collected and Mālda District Air Survey was inspected.

No. 22 (Riverain) Party. Traverse, plotting and compilation of Settlement *musāvis* in Montgomery district in sheets 44 B and F. Traverse and base lines in Gujrānwāla and Shāhpur

districts in sheets 43 H and 44 E. *Murabbābandi* in Montgomery district in sheet 44 B. Demarcation of boundary between the Punjab and United Provinces of Āgra and Oudh, in Gurgaon and Bulandshahr districts in sheet 53 H. Traverse levelling and detail survey on scale 1 inch = 100 feet at Pālampur and Baijnāth in sheet 52 D for the Kāngra Valley Development Scheme.

No. 23 Party. Topography on 4-inch scale and traversing, levelling, and demarcation of rectangles for the Punjab Government in the area commanded by the Haveli Irrigation project in sheets 39 N, O and 44 A, B. At the C. R. E.'s request, a detail survey of two small plots in Karāchi was completed on the scale 100 feet = 1 inch to show one-foot contours, one plot being in the New Infantry Lines area 0·26 square miles and one plot in the Rest Camp area 0·04 square mile.

Settlement Survey Detachment. Traversing and surveying in the Dera Ismail Khān district. Boundary survey in a portion of Malandri area in Peshāwar District, North-West Frontier Province.

No. 18 (Air Survey) Party compiled the Chittagong 4-inch forest map (para. 65) and the guide map of Multān and surrounding country. It also attended the Survey Tactical exercise in October 1927.

"A" Survey Company.

Officer Commanding.—{Capt. W. J. Norman, M.C., R.E., from 1-10-27 to 30-4-28. Major C. G. Lewis, O.B.E., R.E., from 1-5-28 to 30-9-28.

49. General.—The field headquarters during the cold weather were at Rāwalpindi where technical mobilization stores for 2 survey sections are kept. Recess headquarters were at Murree.

Original survey of tribal territory in the N.W.F.P. has been continued and in addition four sheets including Lahore and surrounding country, originally surveyed in 1911-12, have been revised. This has entailed a hot as well as a cold weather field season. In addition there is a permanent drawing section and fair mapping has been carried out continuously throughout the year.

Close liaison with H. Q. Northern Command has been maintained. The company took part in a most instructive survey exercise in October.

The Average strength during the cold weather was 2 Class I Officers, 2 Class II Officers, 2 U. S. Service Officers and 32 L. S. S. Officers and during the hot weather, 4 Class I Officers, 4 Class II Officers, 5 U. S. S. Officers and 30 L. S. S. Officers.

Personnel.—Major C. G. Lewis, R.E., on return from foreign service took over command of the company on April 30th from Capt. W. J. Norman, M.C., R.E., who proceeded on leave; Lt. I. M. Cadell, R.E., was lent to No. 6 Drawing Office for 3 months during the cold weather; Lts. D. M. Burn, R.E., and I. H. R. Wilson, R.E., were transferred to "E" Company for the cold weather and rejoined "A" Company for the hot weather field season; Lt. D. R. Crone was posted to the company for the survey exercise in October only.

Of Class II officers, Mr. A. A. Graham left the company on May 1st, on proceeding on leave; Mr. T. M. C. Alexander was posted to No. 24 Party for the cold weather and rejoined "A" Company in April; R. S. Nanak Chand Puri (Class II) joined the company in May.

Of U. S. S. officers, Mr. Laltan Khan was with "E" Company for the cold weather; both he and Mr. Lalbir Singh joined "A" Company for the hot weather; Mr. Chiragh Shah joined the company in April.

50. Field work was organized as follows:—

Cold weather.—Mr. Afraz Gul Khan (U. S. S.) with 10 surveyors revised 1,088 square miles on the 1½-inch scale in Lahore and Shekhūpura Districts, Punjab (Sheet 44 I).

Mr. Mohammad Husain Khan (U. S. S.) with 1 surveyor surveyed 25 square miles on the 1-inch scale in Madda Khel country, N. W. F. P. (Sheet 43 B).

One surveyor was sent to Delhi to revise the riverain area in sheet 53 H/2 on the 2-inch scale.

Mr. C. M. Aslam (Class II) connected the triangulation carried out by this company in sheets 38 M & N and 43 A & B in 1926-27 to the new series run by No. 15 Party during the year.

Summer.—Lt. I. M. Cadell, R.E., with Messrs. Mohammad Husain Khan and Afraz Gul Khan (both U. S. S.) was in charge of 8 surveyors carrying out original survey on the 1-inch and ½-inch scales in Chitrāl. Lts. Burn and Wilson and Mr. Chiragh Shah (U. S. S.) triangulated in advance for survey on the ½-inch scale. Mr. Laltan Khan (U. S. S.) with 3 surveyors commenced the survey in the Murree Hills on the 4-inch scale.

51. Areas surveyed.—A total of 1,162 square miles was surveyed comprising:—

25 square miles of original survey on the 1-inch scale in Madda Khel country, N. W. F. P. in sheet 43 B.

13 square miles of re-survey on the 2-inch scale in Delhi Province, sheet 53 H.

1,088 square miles of revision and re-survey on the 1½-inch scale in Lahore and Shekhūpura Districts, Punjab, sheet 44 I.

36 square miles of re-survey and revision survey on the 4-inch scale in Rāwalpindi District, Punjab, sheets 43 F & G, for the Murree Hills Guide Map.

52. Fair Mapping.—Mr. Graham, with Messrs. C. M. Aslam and Mohammad Husain Khan, was in charge of the fair-mapping during the cold weather. 10 surveyors and 6 draftsmen were employed on drawing. During the hot weather the fair-mapping was organised in two sections.—Mr. N. C. Puri and Mr. Aslam were in charge, and were assisted by Messrs. Alexander and Lalbir Singh.

At the beginning of the year large arrears of mapping had accumulated, owing to the transfer of work from No. 18 Party and to the favourable political situation which enabled large areas of tribal territory to be surveyed. The bulk of these arrears were worked off during the year.

53. Northern Command Survey Exercise.—A field survey company was provided for the Northern Command survey exercise in October. The vandyke section was provided by "E" Company, the air-survey section by No. 18 Party and the remainder by "A" Company. The R. A. Survey Section and the R. A. F. also took part.

The demands of the army for maps from air photographs and for triangulation data were met. Many technical difficulties were encountered which have yet to be solved, and it was discovered that further training is desirable in several directions.

A great deal of useful data was obtained for the revision of the Field Service Manual and Chap. VIII of the Topo. Hand Book. Full reports are filed in the office of the Director, Frontier Circle.

"E" Survey Company.

Officer Commanding.—Major E. O. Wheeler, M.C., R.E.

54. General.—The field headquarters were at Sibi (Baluchistān) and recess headquarters at Quetta.

The survey between Karāchi and Hyderābād adjacent to the N.W. Railway was completed and that of the Kachhi and Sarawān areas of Kalāt State commenced. Sheet 40 J, of which a large portion was surveyed on ¼-inch scale during 1922-23, was completed. The survey of the area was easy, but owing to climatic conditions and lack of water and habitation, administration was difficult. 4,188 square miles were triangulated in advance for subsequent seasons.

55. Average strength during the field season was 3 Class I Officers, 6 Class II Officers (3 on probation), 13 Upper Subordinate Officers (9 on probation), and 34 Lower Subordinate Officers.

Personnel.—1 Class II and 9 Upper Subordinate probationers, 8 soldier surveyors and 1 pupil surveyor joined the unit for instruction. 5 Class II probationers were transferred to other units.

56. Field work was organized as follows:—

Winter—

Camp (1).—Mr. A. M. Talati, L.C.E., (Class II) assisted by Messrs. Ponnappa and Laltan Khan (U.S.S.) with Lt. I. H. R. Wilson, R.E., 1 Class II probationer, 4 Upper Subordinate probationers, 2 surveyors and 8 soldier surveyors surveyed 1,314 square miles on the one-inch scale in sheets 34 O and 39 D.

Camp (2).—Mr. F. J. Grice (Class II) assisted by Mr. J. C. Berry (Class II) and Mr. Khushal Khan (U.S.S.) with 5 Upper Subordinate probationers, 5 surveyors and 8 soldier surveyors surveyed 1,559 square miles on the one-inch scale in sheets 34 O and 39 C.

Camp (3).—Mr. Sardar Khan (U.S.S.) with 3 soldier surveyors surveyed 270 square miles on the one-inch scale in sheet 40 D.

1st Class surveyor Torabaz Khan surveyed 1,313 square miles on the ¼-inch scale in sheet 40 J.

Instructional Camp.—Mr. A. M. Talati, (Class II) assisted by Messrs. Ponnappa and Khushal Khan (U.S.S.) and two senior surveyors gave six weeks instruction to 11 probationer officers and 8 soldier surveyors before the latter were distributed to their regular camps.

Summer—

1st Class surveyor Ahmad Shah with 2 surveyors surveyed 260 square miles on the one-inch scale in sheet 34 O/4.

Triangulation and Traversing.—Messrs. Hurley and Thomas (Class II Probationers) triangulated 3,134 square miles in sheets 34 L and 34 P for survey in subsequent seasons on the one-inch scale, and Mr. Thomas (Class II Probationer) 1,054 square miles in sheet 35 I for survey on the ½-inch scale. Mr. Thomas at the same time gave instruction in triangulation to Mr. Khushal Khan (U.S.S.).

57. Areas surveyed.—Original survey of 3403 square miles on the one-inch scale; 1,313 square miles on the ¼-inch scale. The one-inch work lay almost wholly in sheets 34 O and 39 C and D, in Kalāt State and in the Bolān Pass and Sibi districts of Baluchistān, only one sheet, 40 D/1, being in the Karāchi district of Sind. The ¼-inch work lay in sheet 40 J, in Jaisalmer State (Rājputāna Agency) and Khairpur State (Sind).

58. Recess duties.—Fair drawing was organized in two sections, one in charge of Mr. A. M. Talati, (Class II) assisted by Mr. Najamuddin (Class II) and Mr. Sardar Khan (U.S.S.) and the other in charge of Mr. A. J. A. Drake, (Class II) assisted by Mr. J. C. Berry (Class II) and Mr. Khushal Khan (U. S. S.). A section of 4 computers was under Mr. C. T. Hurley (Class II).

Drawing Section.—Mr. F. J. Grice (Class II) with the permanent section of 3 draftsmen, reinforced by 2 surveyors, accompanied the unit to field headquarters to complete the fair drawing of the Karāchi guide map and two ½-inch sheets remaining from the previous year. This section also carried out numerous jobs on payment, the most important being a directory map of Karāchi for the *Karāchi Daily Gazette*.

This section continued as shown above for a few weeks in recess until all work in hand was completed. The personnel was then distributed to the regular fair-drawing sections.

Reproduction Section.—Vandyke operator Attar Singh with 7 men remained in Quetta throughout the year and carried out many reproduction jobs, including the Karāchi Directory map referred to above.

59. Survey Exercise with Royal Artillery.—A reproduction section and one survey section from "E" Company participated in the Survey Exercise described on p. 44.

No. 18 (Air Survey) Party.

Officer in charge.— Captain G. F. Heaney, R.E., from 1-10.27 to 11-5-28.
Lieut. H. W. Wright, R.E., from 12-5-28 to 31-7-28.
Captain W. J. Norman, M.C., R.E., from 1.8-28.

60. General.—During the year the chief items of importance were the Survey Tactical Exercise in October 1927, the Chittagong forest survey and the Multān survey. The two latter were referred to in last year's report, but owing to shortage of personnel and the demands of training for the Tactical Exercise, progress on them was very slow till after the party had returned to Peshāwar at the end of October. Considerable progress has been made during the year in the training of new personnel, and much has been learnt about the organization of work under active service conditions.

61. *Personnel.*—The strength of the technical portion of the party is now 3 Upper Subordinate Officers, 9 Surveyors and 1 Photographer, excluding the personnel of the Reproduction Section.

Mr. Mohammad Hasan rejoined from leave early in March after being on deputation with the Turco-'Irāq Boundary Commission the previous summer, and at the end of that month Mr. Chiragh Shah was transferred to "A" Company, on his promotion to U. S. S. He had been employed continuously on air survey, chiefly of Waziristān, since early 1924, and had compiled most of the Frontier Air Survey maps now under publication.

62. Areas surveyed.—110 square miles were compiled on the 4-inch scale for publication on the 3-inch scale of a map of Multān and surrounding country. 800 square miles of the forest survey on the 4" scale in the Chittagong District of Bengal were compiled leaving about 500 square miles to complete. Nothing was handed over to the Settlement Officer, Chittagong, as details as to the form of the map had not been decided. Maps of 398 square miles on the 1-inch scale and of 25 square miles on the 3-inch scale were compiled during the tactical exercise in October from photographs taken by No. 5 Squadron R. A. F.

63. Multān Guide-map.—The field work for this map was described in last year's report. On return to recess quarters it was decided to compile it on the scale 4 inches = 1 mile.

An attempt was made to compile a rectified mosaic by re-photographing strips of prints and enlarging or reducing to the correct scale with an enlarging lantern. This attempt was unsuccessful as the prints were not clear enough to re-photograph satisfactorily. Owing to shortage of personnel there was nobody who could be put exclusively in charge of this and beyond sorting and arranging photographs and strips, ilttle more could be done till after the survey tactical exercise in October.

After the return of the party to field headquarters at Peshāwar, Mr. Kuttappa, S.A.S., was placed in charge and given 3 surveyors of whom one had six weeks experience of air survey, and the other two were taught everything from the beginning. After a month a trained surveyor was added to the above.

64. *Compilation.*—The method adopted was as follows:—

All strips were plotted on celluloid by the Arundel resection method where the overlap was sufficient. Where overlap was insufficient photographs were pasted down on strips of brown paper by superimposing points lying along the lines joining principal points, and the detail traced on celluloid. The control strips were then pantagraphed on tracing paper to fit the fixed points and the detail was transferred to the compilation. Using the fixed points of control strips or in their absence, suitable points of detail already transferred to the compilation, the plotted cross strips were scaled by pantagraph, between control strips and added to the map. This framework was then used to build up the remainder of the work, from strips not having 50 overlap, in which the accuracy of position of detail was not so reliable.

The pantagraph was used for the scaling of traced strips, rather than photography for these main reasons. Firstly, bromide paper being opaque cannot be adjusted in position as readily as the tracing paper used

with the pantagraph ; secondly, the scale was not always constant throughout a strip ; and thirdly, the enlarging camera had its limitations.

The method of compilation was to pantagraph the detail in the "Key" or control strips to the correct scale and transfer it to the compilation sheets.

65. Chittagong 4-inch forest survey.—A short account of this survey was included in last year's report. After the return of the party to field Headquarters in Peshāwar, at the end of October, modifications were introduced into the procedure described in last year's report, the chief one being that the form lines were eventually drawn direct on the fair sheets.

Considerable difficulty was experienced in training the new personnel in the use of the stereoscope without which it is quite impossible to detect the courses of streams, etc., in the low jungle-covered hills forming the greater part of the area. Even after the men had attained a certain proficiency, most of their work had to be rejected, so that until the beginning of March the out-turn was very small. The impossibility of accomplishing anything without the use of a stereoscope has however provided excellent training in spite of the fact that the out-turn has until recently been unsatisfactory.

66. Survey Tactical Exercise.—"A" Survey Company and the R. A. Survey Section were organized on a provisional basis, the objects being to work out and test the War Establishment of an air-survey section, to try out its capabilities in rapid compilation and map reproduction and to gain experience in co-operation between the R. A. F., the Air Survey Section and ground surveyors. These three objects were successfully accomplished and a mass of valuable data were obtained.

No. 18 Party was organized as an Air Survey Section of "A" Survey Company and given a provisional establishment. It was located at West Ridge, Rāwalpindi, and worked in the closest co-operation with a flight of Bristol fighter machines from No. 5 Squadron sent over for the photography. The exercise lasted 17 days, during which copies of maps on the 1-inch and 3-inch scales were printed in three colours by the Reproduction Section and issued by the time required; the first in 8 days from the commencement of the photography and the remainder in equivalent periods.

The strips of air photographs were joined up, and minor control fixed, by the Arundel method. The points fixed by ground survey were marked on oblique photos for recognition by the men compiling. The strips were reduced to the correct scale by pantagraph.

The detailed report is being published by the General Staff Branch, Army Head Quarters.

67. Reproduction.—The equipment of the Reproduction section was augmented by an Imperial size hand-press at the end of September 1927. This was employed on the Tactical Exercise and afterwards set up at the field headquarters of the party at Peshāwar, where it has been used in printing maps and diagrams for the military authorities and others, and of forms for departmental use.

68. New instruments received.—The Hilger stereoscope and contour plotter referred to in last year's report while possessing many

good points were found to be rather bulky and also too sensitive to movements in the room. The latter defect is serious.

The instrument as supplied has no parallactic grids, and so its use is limited. The M. I. O. has been unable to fit these grids.

The Barr and Stroud Topographical Stereoscope was received in February 1928. This instrument should be most useful for producing contoured maps of hilly country where speed of production is unimportant. Since it has been received, however, there has been no work in the party suitable for a thorough test.

No. 22 (Riverain) Party.

Officer in charge.—Mr. Dhani Ram Verma, R.S.

69. General.—This party works chiefly for the Punjab Government, but undertakes special surveys for other Government Departments and Municipalities who pay for the work. The headquarters of the party remained at Lahore throughout the year as usual.

The party's programme for the year comprised:—(*i*), traversing the riverain estates along the Rāvi river and *chāhāt* (holdings on wells) in the Crown waste land north of the river, laying down base-lines in sheets 44/B & F, and plotting and compiling settlement *musāvis* for cadastral surveys by the Settlement Department of the Punjab Government; (*ii*), main-circuit traversing along the Chenāb river and laying down base-lines in sheets 43 H and 44 E for the Settlement Department of the Punjab Government; (*iii*), *murabbābandi* of Crown waste land north of the Rāvi river in sheet 44 B for the same Department; (*iv*), Punjab-U.P. boundary survey on the Jumna river in sheet 53 H for the two Governments concerned; (*v*), Kāngra Valley Development survey on scale 1 inch = 100 feet in sheet 52 D for the Public Works Department of the Punjab Government.

70. *Personnel.*—The party consisted of 3 Upper and about 61 Lower Subordinate Officers distributed as under:—

Mr. Jamna Prasad, R.S., (U. S. S.), *Camp (1)*, with 10 traversers, (later decreased to 4 traversers), for the Rāvi River programme. Babu Roda Ram (L. S. S.), *Camp (2)*, with 8 traversers was also engaged on this work.

Mr. Bakhshi Harnam Singh (U. S. S.), *Camp (3)*, with 2 traversers for the Chenāb river work; the strength was increased later to 7 traversers for the programme in Montgomery district.

Mr. Badlu Ram (U. S. S.) and Babu Jalaluddin (L. S. S.), with 17 computers and 16 draftsmen under them respectively, supervised the computing and plotting sections at headquarters during the field season.

Babu Jalaluddin (L. S. S.) *Camp (4)*, with 3 traversers and 2 levellers during June, and 8 surveyors from mid-August to end of September for the Kāngra Valley Development survey.

During the year eight traversers were transferred and 4 *purely temporary* traversers were discharged. 8 surveyors and 2 levellers joined; the latter were re-transferred to their unit.

71. *Areas surveyed.*—(*a*) 3·5 square miles of resurvey on 4-inch scale of the Jumna river for the Punjab-U. P. Boundary demarcation in Gurgaon and Bulandshahr districts in sheet 53 H were completed.

(*b*) 281 acres of original survey were completed on scale 1 inch = 100 feet of the sites at Pālampur and Baijnāth for the Kāngra Valley Development Scheme.

(*c*) Minor traverses for cadastral surveys of the Rāvi riverain estates and *chāhāt* (wells) in the Crown waste land in Montgomery district in sheets 44/B & F amounting to 204 square miles.

(*d*) Main and minor traverses along the Chenāb river in Gujrānwālā and Shāhpur districts in sheets 43 H and 44 E, 72·3 square miles.

(*e*) Main and minor traverses for *murabbābandi* of Crown waste land in Montgomery district in sheet 44 B, 92 square miles.

(*f*) The area covered by main and minor traverses to form basis for the Kāngra Valley Development Survey in sheet 52 D was 281 acres.

(*g*) Crown waste land demarcated with 1,100-foot squares covered 92 square miles.

72. *Plotting Section.*—During the field season the plotting section under Babu Jalaluddin plotted traverse *chāndās* on *musāvis* and compiled boundary *musāvis* for cadastral surveys by the Settlement Department. The section also prepared four-inch compilation sheets of the Rāvi riverain and *packa* areas traversed and made their traces for the Settlement Officer, Montgomery.

73. *Computing Section.*—During the field season the section under Mr. Badlu Ram computed the traverse work of the season. The rectangular coordinates of the traverse stations were gradually supplied to the Plotting Section for plotting *musāvis*.

74. *Riverain surveys.*—(*a*) *Camps* (*1*) and (*2*) carried out minor traversing of the riverain estates along the Rāvi river and *packa* villages and *chāhāt* (wells) in the Crown waste land on the right bank of the river in Montgomery district for cadastral surveys by the Settlement Department. This was based on the main-circuits run in this and previous seasons. Village boundaries were traversed and the areas within them were covered with a traverse net-work to provide points to facilitate internal measurement by the *patwāri*.

The boundaries of the *kilābandi* villages on the left bank of the Rāvi river and those of the *kishtwār* villages adjoining the Crown waste land and the whole district boundary lying in the *packa* area, were specially surveyed by theodolite traverse. Offsets to inflections in the boundaries were taken by optical squares.

Base-lines were laid out about 1 mile apart beyond the flood line on both sides of the Rāvi river in Montgomery district and demarcated with permanent mark-stones to serve as bases for future survey and demarcation of boundaries and fields in the bed of the river.

The country covered by traverse operations was level plain, partly cultivated and partly wooded.

24-inch *musāvis* of the *kilābandi* villages were reduced by pentagraph to the 4-inch scale for compilation of *kilābandi* boundaries.

All the traverse stations marked during the field season were plotted on 4-inch sheets.

Plotted and boundary *musāvis* (settlement mapping sheets) of *kishtwār* and *kilābandi* villages on the scale of 1/2640 and traces of 4-inch plot sheets were supplied to the Settlement Officer, Montgomery.

(*b*) *Camp* (*3*) carried out main and minor traverses for laying out base-lines along the Chenāb river in Gujrānwālā and Shāhpur districts in the gap left without base-lines in the previous riverain surveys. Base-lines were laid out about one mile apart beyond the flood line on both sides of the river and demarcated with permanent mark-stones to serve as bases for future survey and demarcation of boundaries and fields in the bed of the river.

75. *Murabbābandi.—(By camps 1, 2, and 3).* This was undertaken for the Settlement Officer, Montgomery. It consisted of the demarcation of the Crown waste land, covered with dense unclassified forests north of the Rāvi river in Montgomery district, by 1,100-foot squares, proposed to be brought under irrigation from the Buralia Extension of the Lower Chenāb Canal.

406 linear miles of main and minor traverses were executed for location of corners of 4,400-foot squares. The positions of the corners of these squares were determined on the ground with the help of the computed data of the traverse points previously fixed close to them and marked by stones. The corners of 2,200-foot squares falling on the sides of, and inside, the main squares were dealt with in the same manner and were marked by bricks, these corners assisted in correct alignment of the lines to be cleared for sub-dividing. The 4,400-foot squares were broken up into 1,100-foot squares, which are marked by bricks, covering an area of 92 squares miles.

76. *Punjab—U.P. boundary demarcation.—(directly under the O. C. Party).* This was undertaken for the Punjab and U. P. Governments. It consisted of survey on scale 4 inches = 1 mile of the present course of the Jumna river in *mauzās* Karauli and Shikārgāh Tilauri in Gurgaon and Bulandshahr districts in sheet 53/H to enable the Local Governments to decide their transfer from one province to the other when demarcating the new boundary at those villages.

Two traces were prepared, showing distinctively the course of the river as surveyed in the field season 1925-26 and its present course. These were supplied to the Local Governments.

The resurvey of the river was carried out by measurement from the surrounding detail, village trijunction pillars and pillars of the new inter-provincial boundary fixed in the field season 1925-26.

77. *Kāngra Valley Development Survey.—(Camp 4).* This was undertaken for the Superintending Engineer, P. W. D., 3rd Circle, Lahore. It was a planetable survey on scale 1 inch = 100 feet with 10-foot contours of the sites for summer health resorts to be erected at Pālampur & Baijnāth in Kāngra district in sheet 52 D. Main and minor traverses were carried out to provide points for the planetablers. The traverse was computed *pari passu* at the party headquarters. Connection was made to the topographical triangulation crried out by old No. 18 Party (Himālaya). Lines of tertiary level aggregating 56·3 linear miles were run at suitabe intervals to provide heights for 10-foot contouring of the area.

The entire cost of the survey was debited to the Public Works Department, Buildings & Roads Branch, Punjab.

78. *Recess Duties.*—(*a*) The compiling and plotting section consisting of about 16 draftsmen, etc., was first under the supervision of Babu Jalaluddin and then under Messrs. Badlu Ram and Bakhshi Harnam Singh. The section prepared 4-inch pentagraphic reductions of the *musāvis* of the last settlement of the riverain villages on the Jumna river in the Punjab and the United Provinces for compilation of riverain boundaries and prepared indexes, miscellaneous traces, and rough field traverse charts for the use of the traversers in the next field season.

(*b*) The computing section consisting of 12 computers was supervised by Mr. Badlu Ram and computed all the year's traverse work.

(*c*) The traverse chart section consisting of about 5 computers and draftsmen was supervised by Babu Jalaluddin and Mr. Bakhshi Harnam Singh. It prepared manuscript traverse charts (supplementary) for degree sheets 44/B, E and F and incorporated the base-lines laid out on the Chenāb river in the manuscript traverse chart for degree sheet 43 H completed last year.

No. 23 (Haveli Project) Party.

Officer in charge.—Mr. H. B. Simons.

79. General.—The party continued the traversing, surveying, rectangulating and levelling of the area commanded by the Haveli Irrigation Project for the Punjab Government. At the request of the Chief Engineer, Irrigation Works, Punjab, the original programme, which consisted of surveys on the 4-inch scale was considerably changed.

To define the limits of the Haveli Canal Project more clearly, extensions were added necessitating further traversing, rectangulation etc. The tertiary levelling which hitherto had been carried out by the Geodetic Branch, was handed over to the party, and a section of two computers and 12 levellers was transferred from No. 17 Party from 1st November 1927.

To enable the increased programme to be carried out the party commenced work on 15th October 1927, with field headquarters at Multān. At the close of the field season the recess headquarters were transferred from Karāchi to Solon to maintain closer touch with the Irrigation Officers of the Punjab Government.

80. *Personnel.*—The personnel of the party was increased owing to the alteration of the programme, and the field strength was 5 Class II Officers, one Upper Subordinate Officer and 101 Lower Subordinates who were distributed as follows:—

Mr. F. W. Smith (Class II) assisted by Mr. Abdul Majid (U. S. S.) with 3 computers, 4 traversers, and 17 rectangulators carried out the following programme:—

(1) traversing and embedding the corner stones of the main 2,400-acre rectangles of the new area to the north, on the right and left banks of the Jhelum and Chenāb rivers,

(2) traversing and embedding the corner stones of the main 2,400-acre rectangles of the Vinoi Forest, north of Khānewāl railway junction,

(3) traverse to fix points for planetabling and connecting the rectangulation of the Irrigation Department with the Haveli work in the Lower Chenāb Canal Extensions area, between the railway line from Jhang to Shorkot Road and the old eastern limits of the Haveli Project,

(4) sub-dividing to 25 acres the 100-acre rectangles of 1926-27 on the right bank of the Chenāb river south of Muzaffargarh,

(5) sub-dividing to 25 acres the small blank in the extension to the extreme south of the Haveli Area between the river Panjnad and the limits of the Sutlej Valley Project,

(6) sub-dividing to 100 acres and 25 acres the new area in the extreme north and the Vinoi forest respectively, and

(7) re-demarcating with pegs the corner of the 27·8-acre rectangles originally traversed by the Irrigation Department for the Lower Chenāb Canals. Nearly all the corner stones of the area had disappeared and the refixing delayed work considerably.

Mr. Jiya Lal Sahgal (Class II) with computer Syed Nayar Hasan, 19 surveyors and rectangulators, and 13 levellers sub-divided to 25 acres the 100-acre rectangles east of the Chenāb river and between the Rāvi river and roughly latitude 30°-25′. On completion of this work all were employed on planetabling. The section under Sayed Nayar Hasan completed the tertiary levelling of all areas which had been sub-divided to 25 acres and the new extensions. Owing to the delay caused by the re-embedding of the corner stones of the 27·8-acre rectangles mentioned above the levelling section did not close work till the middle of May 1928.

Messrs. Duni Chand Puri and Nanak Chand Puri, R.S., with 17 and 19 surveyors respectively were employed on original survey on the scale of 4 inches = 1 mile.

Two draftsmen were employed at headquarters throughout the field season on reduction of boundaries from village *musāvis* and other miscellaneous work.

81. *Area surveyed.*—The total area of 795·63 square miles was rectangulated of which 127·2 square miles was original work sub-divided to 100 acres and 263·60 square miles to 25 acres in the extensions. 404·83 square miles of area previously divided to 100 acres only was further sub-divided to 25 acres. 458 linear miles were traversed, 286 points were fixed for planetabling and 2,644·9 square miles of original survey on the scale of 4 inches = 1 mile was completed. For levelling 82,443 stations were observed, 81,173 proving useful. The country comprises cultivated plains watered by inundation canals, and desert country with scrub jungle which was very thick in places.

82. *Traversing* covered only the extensions and was connected to Nānak Sar S., Ballol S., Jhang Church and the old rectangulation.

83. *Rectangulation.*—The positions of the corners of the main 2,400-acre rectangles for the new work were computed from the traverse and marked by stones. These rectangles were later sub-divided to 100 and 25 acree according to requirements.

84. *Topographical Surveys.*—With the exception of 5 sheets the whole area commanded by the Project falling in 1-inch sheets Nos. 39 N/4, 6, 7, 8, 10, 11, 12, 13, 14, 15 and 16, 39 O/1, 2, 5, 6, 9, 13, 44 A/3 4, 7, 8, 44 B/1, 2, 3 and 5 was surveyed on the scale of 4-inches = 1 mile.

85. *Tertiary Levelling* was carried over all areas rectangulated to 100 or 25 acres, also over the pegs of the 27·8-acre rectangles of the Lower Chenāb Canal extensions, to connect the heights of this area with those of the Haveli Project.

86. *Recess Duties.*—Mr. F. W. Smith with 10 surveyors compiled and fair drew the contour charts from the spot heights. Mr. Duni Chand Puri with 14 surveyors completed the planetables and Mr. Jiya Lal Sahgal with 7 computers and levellers computed the heights and prepared the spot height charts. The sheets on the western limit of the Haveli Project were completed from reductions of 6-inch planetables surveyed by the Irrigation Department. It is hoped to send 106 sheets for publication by the end of September 1928.

Settlement Survey Detachment.

Officer in charge.—Rai Sahib Maya Das Puri.

87. General.—The detachment was employed for the North-West Frontier Government in the Dera Ismail Khān district on traversing and surveying boundaries of certain selected villages and plotting the results with a view to compare the same with those obtained from the previous settlement maps in degree sheets 38 L and 39 I, and on the survey of Malandri area recently annexed from Buner to the Mardān *tahsīl* of the Peshāwar district in degree sheet 43 B. The field headquarters were at Campbellpore and the Recess headquarters at Murree.

88. *Personnel.*—The detachment on the 1st October numbered 2 Upper and 42 Lower Subordinates mostly *purely temporary*. As the programme of the detachment was curtailed the strength was gradually reduced. One Upper and 11 Lower Subordinates were transferred to other units, 5 *purely temporary* were discharged, and 16 Lower Subordinates were sent on departmental leave.

89. Field work was organized as follows:—

Mr. Dalip Singh Gandhi (U.S.S.) with 1st Class Surveyor Ram Singh and 11 traversers, was employed in the Dera Ismail Khān district till the 11th December 1927, when he was transferred with one traverser to the Malandri area, at the special request of the Settlement Officer, Peshāwar, for triangulation and traverse in order to lay out stations for the 24-inch survey of boundaries, and fields in cultivation by *patwāris*. Surveyor

Ram Singh was left to look after the Dera Ismail Khān work till the end of January after which traverser Lorind Chand continued the work till its completion during March.

Mr. Mohabat Lal Kohli (U.S.S.) did 10 linear miles boundary survey in a portion of the Malandri area on the scale 24 inches to a mile as desired by the Settlement Officer, Peshāwar. The field work in this tract was finished on the 20th March.

90. *Area surveyed.*—270 square miles were traversed in the Dera Ismail Khān district in degree sheets 38 L and 39 I; and 17 square miles were triangulated and traversed in the Malandri tract in degree sheet 43 B.

91. *Triangulation, traversing and boundary survey.*—26 villages were traversed, and their boundaries surveyed by offsetting from traverse lines. In some cases fields in the interior of villages were also picked up. The work was generally connected with *pakka* trijunctions traversed by old No. 18 Party in seasons 1906—09. Where no connections could be made for want of traversed or triangulated points in the vicinity, the work was closed on the starting points.

In Malandri, the triangulation was started from *Hamza Kot h.s.* and *Paja h.s.*, and was connected with the Mardān and Swābi *tahsīls* traverse. No heights were observed either in Dera Ismail Khān or in Malandri, since they were not required.

In Dera Ismail Khān the ground under survey consisted partly of cultivated plains watered by inundation canals and desert country with scrub jungle, and partly of low barren hills and ravines with patches of cultivation. There was generally great scarcity of water in the district. The Malandri tract consisted of high hills with large fertile tracts of cultivation and densely wooded forests.

92. *Plotting, and compilation of boundaries etc.*—Mr. Mohabat Lal Kohli with 5 Lower Subordinates traced 43 four-inch indexes prepared by *patwāris* at the previous settlement, checked them with the original *musāvis* (settlement mapping sheets), and corrected them where necessary. All of them except two were found fairly accurately reduced, which showed that the discrepancies revealed by the 4-inch compilation of boundaries done last year, were mostly due to some other cause. Besides this he plotted the boundaries surveyed during the season in black, and compiled those obtained from the last settlement maps with the help of common *pakka* points in red, on scales 4 inches, 12 inches, or 24 inches to a mile. The discrepancies thus discovered were especially unusual in areas intersected by *nullāhs* and fluctuating irrigation, and in tracts covered with hills and ravines. They were shown and explained to the Duputy Commissioner, Dera Ismail Khān, and the Settlement Officer, Peshāwar.

In Malandri the work was plotted on the scales 4 inches and 24 inches to a mile and the plotted *musāvis* with surveyed boundaries marked on them supplied to the Settlement Officer, Peshāwar, for the detailed survey of cultivation and remaining boundaries.

The section also completed the plotting of traverse and triangulation charts on the ¼-inch scale, copied out co-ordinates of the *pakka* points (districts Peshawar and Attock) in degree sheets 38 N & O, and 43 B & C;

and traced and compiled a map on the ¼-inch scale of the Campbellpore Division for the Superintendent, Post Offices.

93. *Computations.*—First class computer Joti Sarup with 5 hands computed all the work done during the season, and completed the Peshāwar computation volumes.

94. Recess duties.—Mr. Dalip Singh Gandhi with three draftsmen and one traverser traced the Indus riverain sheets on the 4-inch scale, compiled the boundaries on the 4-inch scale and prepared *mujmilīs* (rough field charts showing boundaries) for traversers. Computer Joti Sarup with two more hands completed the computation volumes, converted the values of the Malandri survey *pakka* points from rectangular to spherical, and prepared necessary traverse data for next field season.

VI.—SURVEY REPORTS, CENTRAL CIRCLE.

DIRECTOR:—Lt.-Col. L. C. Thuillier, I.A.

95. Summary.—The units administered by the Central Circle were Nos. 1, 5 and 22 Parties, Rājputāna and Bhopāl Survey Detachments, and No. 3 Drawing Office.

No. 24 Party (Sind Rectangulation) was transferred from the Frontier to the Central Circle and No. 22 Party from the Central to the Frontier Circle on 1st April 1928. The Jhānsi Survey Detachment was renamed the Rājputāna Detachment with effect from 1st October 1927.

The officer in charge of No. 5 Party, in addition to his normal duties, continued to act as Assistant Director of Surveys, Central Provinces, and administered the revenue, town, and other surveys of that Province.

96. *Death.*—Mr. Nur Muhammad, Sub Assistant Superintendent, attached to No. 1 Party died at Mussoorie on 6th May 1928.

97. *Training.*—There were no pupils under training. The two soldier-surveyors transferred from the Frontier Circle in May 1927 completed their first period of training in March and April respectively and have been recommended for a second period of training. Two Class II probationers were also transferred from the Frontier Circle in October 1927.

98. *The field work* of parties and detachments was as follows:—

No. 1 Party.—Topography on 1-inch scale in degree sheets 72 D and 73 A. Triangulation in advance.

No. 5 Party.—Topography on 1-inch scale in sheets 55 P and 64 C. Triangulation in advance.

No. 24 Party.—Traversing and demarcation of rectangles for the Bombay Government in the area commanded by the Lloyd Barrage Project in Sind.

Rājputāna Detachment.—Topography on 1-inch scale in sheet 45 J; a 4-inch special survey in 45 B and F. Triangulation in advance.

No. 1 Party.

Officer in Charge.—Lt.-Col. R. Foster, I.A.

99. General.—The party having completed the special surveys for which it was required in Bihār and Orissa, took up normal topographical surveys on the 1-inch scale in degree sheets 72 D and 73 A. The field headquarters of the party were at Rānchi.

Personnel.—The field strength of the party was, apart from the O. C., 4 Class II officers, 1 Class II Probationer, 1 U. S. S. officer, 25 surveyors and 2 computers. The strength of the previous year was considerably reduced to provide for urgent needs in other circles. Mr. Nur Muhammad, U. S. S., died suddenly in May and is a great loss to the department.

Out-turn.—3,619 square miles of 1-inch re-survey in sheets 72 D and 73 A, in Hazāribāgh, Palāmau and Rānchi districts and Jashpur and Surgujā States, including 24 square miles of forest survey in Palāmau district and Sarguja State.

2,434 square miles triangulation in advance in sheets 63 P and 72 D in Gayā, Hazāribāgh, and Shāhābād districts.

100. Field work was organised as follows:—

Camp (1).—Mr. F. B. Kitchen, (Class II), with 9 surveyors, (reduced to 8 in February), surveyed 1,360 square miles on the 1-inch scale in sheets 72 D and 73 A in Hazāribāgh, Palāmau and Rānchī districts.

The area comprised an intricate system of low hills and spurs, covered with jungle, forming the low land under the Chotā Nāgpur plateau; it was difficult to survey.

Camp (2).—Mr. H. T. Hughes, (Class II), Mr. S. M. Murtaza, B.A., (Class II Probationer), with 8 surveyors, surveyed 1,318 square miles on the 1-inch scale in sheet 73 A in Palāmau and Rānchī districts and Jashpur and Surgujā States.

The greater part of the area consisted of elevated plateaus locally called "pāts" rising 1,000 feet above the plains with flat and partly cultivated tops, and steep densely wooded sides. To add to the difficulty of survey the area was unhealthy, several surveyors falling sick, two being invalided and their places filled from other camps; the north-eastern portion of the area was infested with man-eating tigers, whose depredations were so costly that large rewards were offered for their slaughter.

Camp (3).—Mr. M. N. A. Hashmi, B.A., (Class II), with 8 surveyors, (reduced to 7 in February), surveyed 941 square miles on the 1-inch scale in sheets 73 A/10 (part), 11, 15 and 16 in Rānchī district.

Except for a high range of hills in sheet 73 A/10 the area is an open undulating plateau highly cultivated, with occasional isolated small hills composed of large boulders or smooth slab rock. The country was easy to survey and the camp was therefore manned by the less skilled surveyors and pupils under training. Surveyor Gagan Singh, whilst returning to camp from work, killed a tiger at short range with buck shot.

Camp (4).—Mr. S. R. Gupta, B.A., (Class II), with one computer triangulated 1,084 square miles in sheet 72 D in Gayā and Hazāribāgh districts.

The country consisted mostly of intricate low hills covered with jungle in which it was difficult to select points which could be seen from any distance.

Camp (5).—Mr. Nur Muhammad, (U. S. S.), with one computer triangulated 1,350 square miles in sheets 63 P and 72 D, in Gayā and Shāhābād districts.

The area was mostly open cultivated plains where it was difficult to find sites for stations above the level of the plain.

101. Recess duties.—*Fair mapping* was divided into there Sections under Messrs. F. B. Kitchen, H. T. Hughes, and M. N. A. Hashmi. The mapping of all field work was completed during the year.

Mr. S. R. Gupta, B.A., aided by Mr. Nur Muhammad, (up to his death), and Mr. S. M. Murtaza, completed the computations of the triangulation.

Guide Map of Mussoorie and Landour.—The Guide Map of Mussoorie and Landour, on the 8-inch scale, and the Mussoorie City Map

on the 24-inch scale, both surveyed in 1919, were revised to date during June and July by 6 surveyors, and the materials handed over to No. 3 Drawing Office for preparation of new editions.

No. 5 Party.

Officer in Charge.— Mr. P. A. T. Kenny, O.B.E., from 1-10-27 to 2-11-27.
Lt. D. R. Crone, R.E., from 3-11-27 to 27-2-28.
Major L. H. Jackson, I.A., from 28-2-28.

102. *General.*—This party continued surveys on the 1-inch scale in the Central Provinces in sheets 55 P and 64 C. The field headquarters were again at Nāgpur in order to keep in touch with the Settlement Commissioner, Central Provinces, the officer in charge of the party being also Assistant Director of Surveys, Central Provinces.

103. *Personnel.*—The field strength, apart from the O. C., was 1 Class II, 3 U. S. S. officers, and 20 Surveyors.

Out-turn.—2,969 square miles of 1-inch survey (2,704 square miles original and the remainder supplementary) in sheets 55 P and 64 C, and 3,577 square miles of triangulation in sheets 64 B, 64 C and 64 J. The latter was connected with the Jubbulpore Meridional Series.

104. Field work was organized as follows:—

Camp (1).—Headquarters Dongargarh.—Mr. J. H. Johnson assisted by Mr. M. D. Nangia, with 13 surveyors completed 1,782 square miles of original and 74 square miles of supplementary survey in the Bālāghāt, Bhandāra and Drug districts, and in the Chhattīsgarh feudatory states. The country was sparsely inhabited and lacking in communications and consisted chiefly of heavily wooded low hills necessitating much planetable traversing. The work was further delayed in the early months of the field season by the prevalence of malaria and a local form of jungle fever, and later by lack of water.

Camp (2).—Headquarters Brahmapurī.—Mr. Shadi Lal Dube with 7 surveyors completed 922 square miles of original and 191 square miles of supplementary survey in the Bhandāra, Chānda and Nāgpur districts. With the exception of a few heavily wooded low hills, the country consisted of open and undulating plains under cultivation. Communications were, on the whole, fair. In the early part of the field season, the camp suffered to some extent from malaria and jungle fever, but was able to complete its area well up to time.

Camp (3).—Mr. N. D. Joshi triangulated 1,647 square miles in sheets 64 B and 64 J in the Bilāspur and Mandlā districts, and in the Chhattīsgarh feudatory states. This area is for the most part hilly, the hills being flat-topped and densely wooded, necessitating extensive clearing operations before observations can be commenced. Villages are small and few and far between, and communications are bad. Malaria was prevalent up to the end of January, and the work was further delayed by haze after the beginning of March.

Camp (4).—Mr. J. R. Chibbar triangulated 1,930 square miles in sheets 64 B and 64 C in the Bālāghāt, Drug and Mandlā districts, and in the Chhattīsgarh feudatory states. Of this area 829 square miles was triangulated by Traverser Raghubir Prasad in 1926-27, but the work was rejected, and had to be re-observed. The nature of the country is

very similar to that in which Camp (3) was working, although communications are slightly more numerous. Haze and malaria considerably delayed progress, and one khalasi died of fever.

105. *Recess duties.*—Fair mapping was divided into two sections under Messrs. J. H. Johnson and Shadi Lal Dube. The mapping of all field work was completed during the year. Messrs. N. D. Joshi and J. R. Chibbar were responsible for the computation of their triangulation.

No. 24 Party (Sind Rectangulation).

Officer in Charge.—{Major H. E. Roome, M.C., R.E., to 19-12-27. Major A. H. Gwyn, I.A., from 20-12-27.

106. General.—The work consists of laying out 320-acre rectangles over the whole area and fixing markstones at the corner of each rectangle. Field headquarters opened at Hyderābād (Sind) on 26th October 1927, and closed on 12th April 1928; the office then moved to Karāchi for recess.

Personnel.—The field strength, apart from the O. C., consisted of 2 Class II officers and 1 U. S. S. officer with 18 traversers and 31 rectangulators.

Out-turn.—4,680 square miles of traversing and demarcation of corners of main rectangles (of 4 square miles), for subdivision in 1928-29 to 320 acres; and 3,154 square miles of 320-acre rectangles.

Bonus System of Payment.—As an experiment, "Purely Temporary" Lower Subordinates and menials were paid according to out-turn. The increased out-turns enabled the party to execute a larger programme than it would have done otherwise while avoiding the dead weight expense of outfitting a larger establishment.

107. Field work was organized as follows:—

Camp (1).—Mr. O. N. Pushong (Class II), with 18 traversers carried out the traverse and stone-laying operations and in addition subdivided 157 square miles into 320-acre rectangles.

Camp (2).—Mr. Mohammad Najamuddin, B.A., (Class II), with 15 rectangulators subdivided 1,036 square miles into 320-acre rectangles.

Camp (3).—Mr. Amrit Ram (U. S. S.), with 16 rectangulators subdivided 1,961 square miles into 320-acre rectangles.

108. Recess duties.—Mr. Amrit Ram with 9 men completed the computations for the past field season, computed data for 1928-29, and prepared *Masavi* originals for reproduction for the Chief Engineer. The miscellaneous index mapping was directly under the Officer in charge.

Rājputāna Detachment.

Officer in Charge.—{Mr. J. C. C. Lears, from 1-10-27 to 31-4-28. Mr. L. Williams, M.B.E., from 1-5-28.

109. *General.*—This detachment, the name of which was changed from Jhānsi Survey Detachment to Rājputāna Detachment on the 1st October 1927, took up normal topographical surveys on the 1-inch scale in sheet 45 J, also a special survey on the 4-inch scale in sheets 45 B and F. The field headquarters were at Ajmer.

110. *Personnel.*—The field strength, apart from the O. C., was 1 Class II officer, 2 Upper Subordinate Service officers, 14 surveyors, 3 levellers and 2 computers. Surveyor Shabir Ali died on the 9th July 1928 while on sick leave.

111. *Out-turn.*—1,066 square miles 1-inch original survey in sheet 45 J in Ajmer district, Jaipur, Jodhpur and Kishangarh States. This includes an area of 28 miles of *Forest Surveys* in the Ajmer Division of the Western Forest Circle.

76 square miles of 4-inch original survey in sheets 45 B and F in Jodhpur State.

269 acres of 16-inch survey of the Mayo College grounds in Ajmer.

2,135 square miles of triangulation in sheet 45 J of which 1,066 miles were for the current season's survey.

The framework and levelling for a 16-inch survey of the Kailāna Tank proper to be undertaken next season, the cost of which will be met by the Jodhpur State, was also completed.

112 Field work was organized as follows:—

Camp (1).—Mr. H. H. P. Butterfield (Class II) from 1-10-27 to 5-3-28, and Mr. Jagan Nath (U. S. S.) from 6-3-28, with 10 surveyors (decreased to 7 in March), surveyed 1,066 square miles on the 1-inch scale in sheet 45 J in Ajmer district, Jaipur, Jodhpur and Kishangarh States. The area was open with scattered hills and ridges and easy to survey.

Camp (2).—Mr. Ram Narayan Hastir (U. S. S.) with 4 surveyors (increased to 7 in March), 3 levellers and 1 computer, surveyed 76 square miles on the 4-inch scale in sheets 45 B and 45 F in Jodhpur State. The area was undulating and sandy with rugged hills in the southern part. This camp also completed the triangulation, levelling and 4-inch survey of 76 square miles of the Kailāna Tank Catchment area in Jodhpur, with contour intervals at 5, 10, and 25 feet according to the steepness of the ground and the requirements of the State officials.

A special 16-inch survey of the Mayo College grounds in Ajmer, covering an area of 269 acres was undertaken, on payment, at the close of the season.

Camp (3).—Mr. Jagan Nath (U. S. S.) with 1 computer triangulated 2,135 square miles in sheet 45 J in Ajmer and Merwāra districts and Jaipur, Jodhpur and Kishangarh States. The area was open, with ranges of hills at convenient intervals for triangulation.

113. Recess duties.—Fair mapping was divided into two sections under Messrs. Ram Narayan Hastir and Jagan Nath. The mapping of all field work was completed during the year.

Mr. Jagan Nath completed the computation of the triangulation in addition to his other duties.

Bhopāl Survey Detachment.

Officer in Charge:—Mr. Chuni Lal Kapur, Rai Sahib.

114. The detachment continued and completed the Cadastral Survey on 16-inch scale in Bhopāl State in sheets 54 L and 55 E. It also demarcated with permanent mark-stones all traverse stations which had been laid down in previous years throughout the State.

Except for 3 traversers and 2 computers lent by the Survey of India all hands were entertained and trained by the State.

Mr. Chuni Lal Kapur, Rai Sahib, who has been on deputation to Bhopāl State for over 5 years now, and who has carried out and completed during this period, the traverse and Cadastral Survey of the whole State has made himself so necessary to the State that his services are still required for the survey on 4-inch scale of all the forest blocks in the State which cover an area of about 1,400 square miles. This survey will be taken up next field season.

Under arrangements originally made with the State the detachment was inspected by the Director, Central Circle once during the field season and once during recess season.

VII.—SURVEY REPORTS, SOUTHERN CIRCLE.

DIRECTOR:—{ Lt.-Colonel C. M. Browne, C.M.G., D.S.O., R.E., up to 7-11-27.
" L. G. Crosthwait, I.A., from 8-11-27.

115. Summary.—The units administered by the Southern Circle were Nos. 6, 7 and 8 Parties and No. 4 Drawing Office.

116. *Training.*—One Class II probationer continued his training in the field. Of the pupil surveyors and draftsmen under training in the Circle, 19 made satisfactory progress and 2 were discharged as unlikely to become efficient. Eight pupils, whose educational qualifications were above the previous standard, were entertained during the recess and attached to No. 7 Party for training in drawing and planetabling.

117. *Special surveys.*—There is a considerable increase in demands for, and enquiries regarding large-scale surveys of private estates.

118. *The field work* of parties, of which the outturn on the normal scale of 1 inch = 1 mile was 16,291 square miles covering 58 sheets, was as follows:—

No. 6 Party.—Topography in sheets 56 E, I, J, K and 66 A on the scale of 1 inch = 1 mile; forest surveys on the two-inch scale and a three-inch survey of part of Hyderābād City and Environs.

No. 7 Party.—Topography on the scale of 1 inch = 1 mile in sheets 57 A and B. Sixteen and eight-inch surveys of estates in sheets 48 O and P and four-inch survey of mining concessions in sheets 57 A and B.

No. 8 Party.—Topography on the scale of 1 inch = 1 mile in sheets 58 F and J. Sixteen-inch survey of estates in sheets 49 M and 58 A and B.

No. 6 Party.

Officer in Charge.—Major R. S. Wauchope, O.B.E., I.A.

119. General.—The party opened its field headquarters office at Secunderābād on the 16th November and continued topographical surveys in the Yeotmāl district of the Central Provinces and the Ādilābād, Karīmnagar, Nalgonda, Nānder, Medak and Nizāmābād districts of Hyderābād State. It also carried out survey on the Madras coast in the Guntūr and Kistna districts.

Personnel.—The field strength of the party was 1 Class I, 2 Class II, 3 Upper Subordinate and 45 Lower Subordinate Officers.

120. Areas surveyed.—A total area of 7,043 square miles was surveyed as follows:—

5,094 square miles original and 271 square miles supplementary survey on the one-inch scale in sheets 56 I and J and 66 A; 35 square miles in sheets 56 E and I and five sheets in 56 K covering 1,416 square miles, both of which areas had been previously surveyed on the half-inch scale, were revised on the one-inch scale, the latter at the request of the military department.

189 square miles of special survey of Hyderābād City and environs were surveyed on the three-inch scale for the Hyderābād Government and

38 square miles of the Kondapalli reserved forest were surveyed on the two-inch scale for the Madras Forest Department. 6 sheets of the sixteen-inch map of Bangalore Civil and Military Station were brought up to date during recess.

121. Field work was organized as follows.—

Topographical surveys.—Camp (1), under Mr. E. N. Natesan, B.A., (Class II), assisted by Mr. J. A. Cabral, (U. S. S.), and a staff of 19 surveyors completed 2,444 square miles original and 35 square miles revision survey on the 1-inch scale in sheets 56 E/15 and 56 I/South and a portion of 56 M/4 which had been left over from last year owing to scarcity of water. The country was chiefly low hills covered with jungle of varying thickness and flat cultivated plains.

Camp (2) under Mr. C. P. E. Davenport, (Class II), assisted by Mr. Muhammad Abdul Azim, I.D.S.M., (U. S. S.), and a staff of 16 surveyors, surveyed sheet 56 J/North on the one-inch scale comprising 2,253 square miles. The country varied considerably from flat open cultivated areas to undulating hills covered with thick jungle in which survey was difficult owing to the paucity of recognisable points.

It was arranged that outlying areas of each camp should be pushed ahead in order to relieve some surveyors early, the remainder being concentrated under one camp officer and an assistant; it was thus possible to send Mr. Natesan with Mr. Azim and the best draughtsmen to Bangalore by the 1st April, and open an advance drawing section to prepare blue prints and start work on the first batch of sheets. Other surveyors followed immediately they had completed their areas, with the result that drawing was well in hand and the first sheets were sent to the Drawing Office in July; congestion was thus avoided.

Camp (3) consisting of 4 surveyors directly under the supervision of the Officer in charge of the party revised 1,416 square miles on the 1-inch scale in sheets 56 K/5, 9, 13, 14 and 15, which had been previously surveyed on the half-inch scale; it carried out 397 square miles original survey in sheets 66 A/5 and 9, and 271 square miles supplementary survey in sheets 66 A/13 and 14, for which a sheet compiled by the Madras Survey from their revenue work was available. Four surveyors from other camps were transferred to this camp towards the end of the season, after completing their allotted areas.

Some minor corrections were made to the three-inch military map of Secunderābād and Bolārum and to the one-inch Secunderābād Training Area Map.

One surveyor working for 2½ months completed the Kondapalli reserved forest of the Kistna forest division, an area of 38 square miles in sheets 65 D/5, 6 and 10 on the scale of 2 inches = 1 mile for the Madras Forest Department.

Five surveyors working for varying periods of from two to four months completed an area of 189 square miles of Hyderābād City and environs on the three-inch scale at the expense of the Hyderābād State.

Triangulation.—An area of 2,266 square miles was triangulated by Mr. K. B. Muthanna, (U. S. S.) and Surveyor A. Narasingha Rao in part of the Agency Tracts of Madras falling in the Godāvari, Kistna and Vizagapatam districts. The triangulation both in 65 K and G has

been connected with the geodetic series Nos. 43 and 46. The country is very mountainous with thick jungle, and head-loads are the only means of transport in a large part of the country. Provisions are not available locally and had to be brought from towns some distance away.

122. Miscellaneous.—Owing to the shortage of transport obtainable locally in the north of the area under survey camels procured from the Hoshangābād district were employed as in previous years. This greatly assisted the progress of survey. The Godāvari river being in flood later than usual prevented the camel transport from crossing the river at the beginning of the field season and made it necessary for surveyors working north of the river to make a considerable detour, thus causing delay in getting to their work.

Owing to the Nizām's Government having completed most of the traverse work of *tālukas* to which reference was made in last year's report, there was insufficient work left for the party to take over and negotiations were, therefore, stopped.

Large areas of the Nirmal tāluk have remains of iron workings which probably date back to a considerable age, especially east of Nirmal itself where in many places large heaps of slag are found. There is probably a considerable amount of mineral deposits in the areas south of the Godāvari between Nizāmābād and Jagtial. Ancient stone circle burials have been located between Bālkonda and the Godāvari, but none have been found to the north of the river.

The country over which survey has been completed this year is being rapidly opened up. The area north of Nizāmābād will shortly be very considerably developed when the Nizām Sāgar irrigation project has been completed. Owing to the construction of new roads now in progress the Adilābād district is rapidly becoming more civilized and with the ubiquitous motor bus is not so cut off as formerly. It is probable that larger areas of this district will come under cultivation before very long.

123. Recess Duties.—25 fair sheets on the 1½-inch scale were completed during the recess, the work being divided into two sections under Messrs Natesan and Davenport. Three half-inch sheets *viz.*, 56 I/N.W., N.E. and 56 M/S.W. were completed.

The special three-inch map of Hyderābād City and environs consisting of four sheets was drawn on a scale of four inches to a mile and sent for publication. 25 two-inch special forest maps for H.E.H. the Nizām's Government have also been drawn, and the two-inch map of the Kondapalli reserved forest was completed and sent for publication.

The computation of the triangulation was completed satisfactorily under Mr. Muthanna.

During recess 6 sheets of the Bangalore Civil and Military Station were brought up to date by a few surveyors less expert as draughtsman under the supervision of the Officer in charge of the party with surveyor Mokhan Chand in charge.

124. Map Sales.—Quite a large business was done during the field season both with the military authorities and official departments of Hyderābād State. Sales to private individuals of all classes is greatly on the increase. This has been due partly to greater advertisement costing very little, by publication in Brigade and Regimental orders, occasional

paragraphs in the local papers and the display of lantern slides at cinemas. A large proportion of both official and private sales was also done by sending a man with samples to interview officials, business firms and private individuals.

No. 7 Party.

Officer in Charge.—{Mr. V. W. Morton, to 20-5-28.
{Captain G. W. Gemmell, I.A., from 21-5-28.

125. General.—The party continued survey in sheets 57 A and B on the scale 1 inch = 1 mile in the Anantapur and Bellary districts of Madras, in the Raichūr district of Hyderābād and the Chitaldrug district of Mysore States. It also undertook the survey of two private estates and one mining concession. The field headquarters were at Bellary.

126. *Personnel.*—The field strength was 2 Class II officers, 1 Class II officer probationer, 4 Upper Subordinate officers. 19 Lower Subordinate officers and 15 pupil surveyors. Mr. V. W. Morton handed over charge to Captain G. W. Gemmell and proceeded on leave on 21st May. Mr. F. C. Pilcher joined the party on 1st May.

127. Areas surveyed.—The topographical survey carried out consisted of 4,803 square miles of original survey. In addition 25 square miles of special surveys were completed.

128. Field work which commenced on the 21st November, was organized as follows.—

Topographical surveys.—Camp (1), Mr. N. S. Harihara Iyer (Class II) with 1 Class II probationer, 1 U. S. S. officer and 6 surveyors completed 1,728 square miles on the one-inch scale.

Camp (2), Mr. Shib Lal, R. S., (U. S. S.) assisted by Mr. Abdul Ghafur (U. S. S.) with 3 surveyors and 6 pupil surveyors completed 1,637 square miles on the one-inch scale.

Camp (3), Mr K. G. Mandanna (U. S S.) assisted by surveyor Ghulam Rasul Khan, I.D.S.M., C.H., 4 surveyors and 9 pupil surveyors completed 1,438 square miles on the one-inch scale. The country surveyed consisted of undulating cultivated plains, rocky outcrops and sparsely wooded hills. In some areas surveyors and khalasis experienced considerable hardship towards the end of the field season owing to scarcity of water.

129. *Special surveys.*—The survey on payment of 320 acres of coffee estates and 2,648 acres of tea gardens in the Kadūr and Hassan districts of Mysore State was completed on the scale 16 inches and 8 inches = 1 mile, respectively and 13.120 acres of mining concession areas were surveyed on the scale of 4 inches = 1 mile in the Sandūr State of Madras States. Triangulation and 23 linear miles of traversing were carried out for these surveys.

130. Miscellaneous.—At the foot and on the summits of the rocky hills west and north-west of Rāyadrug in sheet 57 B/14 there are several temples of archæological interest.

The health of the party was far from satisfactory during March and April when several surveyors and menials suffered from fever.

131. Recess duties.—The mapping of the 17 one-inch fair sheets which was completed during recess was divided into four sections under Messrs F. C. Pilcher, Harihara Iyer, Mandanna and Shib Lal. The drawing of half-inch sheet 57 A/S.W. was also undertaken. The maps of estates and mining concession areas were drawn and sent for printing to the Circle Office.

No. 8 Party.

Officer in Charge.—Mr. E. A. Meyer.

132. General.—Survey was continued in the Coimbatore, Madura, Rāmnād and Trichinopoly districts and Pudukkottai State of the Madras Presidency. The area around Coimbatore town was revised and surveys were made on payment of several private estates in the Coimbatore, Malabar and Nīlgiri districts and Cochin State. The field headquarters were at Coimbatore.

133. *Personnel.*—During the field season the average strength was 5 Class II, 3 Upper Subordinate and 56 Lower Subordinate Officers.

Thirteen young surveyors were received from other parties at the commencement of the field season. Mr. F. C. Pilcher (Class II) was transferred to No. 7 Party from 1st May.

134. Areas surveyed.—A total of 4,672 square miles was surveyed comprising 436 square miles of original and 4,236 square miles of supplementary survey on scale 1 inch = 1 mile in sheets 58 F and J. 65 square miles were revised on scale 1½ inches = 1 mile in the vicinity of Coimbatore town. In addition 16,129 acres (25 square miles) of estates were surveyed on scale 16 inches = 1 mile.

The alignment of the Pollāchi-Dindigul Railway now nearing completion was surveyed on published sheets 58 F/7, 11, 15.

135. Field work which commenced on 1st December and closed on 29th April was organized as follows :—

Topographical surveys.—Camp (1), Mr. F. C. Pilcher with 12 surveyors carried out 1,499 square miles of supplementary and 255 square miles of original survey on the scale of 1 inch = 1 mile.

Camp (3), Mr. M. S. Ganesa Iyer (Class II) with 12 surveyors completed 1,689 square miles of supplementary and 62 square miles of original survey on scale 1 inch = 1 mile and revised 65 square miles on the 1½-inch scale in sheets 58 A/16 and B/13.

Camp (4), Mr. P. S. Vengusvami (U. S. S.) with 8 surveyors completed 1,048 square miles supplementary and 119 square miles original survey on scale 1 inch = 1 mile.

The country varied from flat highly cultivated plains to hills attaining a height of 4,500 feet which were generally covered with dense low jungle. In the plains nearly every field and road was bounded by cactus hedges which impeded movement, and the banks of the main streams were thickly planted with cocoanut and palmyra palms, the area adjoining the Cauvery and Amarāvati Rivers being particularly congested.

The supplementary survey was carried out on blue prints of one-inch sheets prepared by the Director, Madras Survey, from the sixteen-inch

revenue survey sheets. The detail which appeared on these sheets, on being checked in the field, was found very accurate on the whole.

Special surveys.—Camp (2), under Mr. B. T. Wyatt (Class II) with 13 surveyors completed the survey of 16,129 acres of tea, coffee and rubber estates on the scale of 16 inches = 1 mile with contours at intervals of 25 feet. The camp carried out and computed 3,462 acres of triangulation and 22 miles of traversing for these surveys. Considerable trouble was experienced owing to managers not being able to point out the external boundaries of their estates. In such cases the party undertook to demarcate the boundaries at an extra charge after consulting the leases and the Madras revenue sheets. Matters were still further complicated by there having been a recent and fresh settlement survey, frequently the field numbers were changed, so that the numbers entered in the leases could not be reconciled with those on the new survey.

The estates were mostly situated in the Wynaad portion of the Malabar and Nilgiri districts which is notoriously unhealthy. Some estates were on the Anaimalai Hills of the Coimbatore district and the remainder in Cochin State. The country surveyed was hilly. The areas under tea were generally open and easy, coffee requiring heavy shade was thickly wooded, and the undeveloped areas consisted of heavy jungle with an almost impenetrable undergrowth of lantana.

Traversing.—Mr. S. R. Kelkar, B.Sc., with Messrs. H. Narasimhamurti Rao, B.A., and Saiyid Budhan (U. S. S.) and 9 Lower Suhordinates completed 1,556 linear miles of theodolite traversing covering an area of 3,462 square miles in sheets 58 N and 58 M 8 in the Tanjore and Trichinopoly districts and Pudukkottai State for detail survey on the scale of 1 inch = 1 mile next season. Traversing was resorted to as the country is flat and unsuitable for triangulation. The traverses are based on the stations and points of the S. E. and Coast series of the G. T. triangulation. In addition to the traverse stations about 1,500 intersected points were fixed.

136. Recess duties.—The fair mapping of the 16 one-inch fair sheets which was completed during recess was organized in four sections under Messrs Wyatt, Ganesa Aiyar, Kelkar and Vengusvami. The four half-inch sheets of 58 E which were begun last recess were completed and two more, 58 F/N.W. and N.E., put in hand. The maps of 15 estates were drawn and submitted for printing in the Circle Office.

Mr. H. Narasimhamurthi Rao was in charge of the Computing and Compiling section. This section completed the computations of the traversing and prepared the mosaics for the planetable section required during the coming winter from data supplied by the Director, Madras Survey.

VIII.—SURVEY REPORTS, EASTERN CIRCLE.

DIRECTOR:—{Lt.-Colonel R. H. Phillimore, D.S.O., R.E., up to 28-10-27. / Colonel A. A. McHarg, D.S.O., R.E., from 29-10-27.

137. Summary.—The units administered by the Eastern Circle were Nos. 4, 9 and 12 Parties, and No. 5 Drawing Office.

The Director, Eastern Circle also acts as Director of Surveys, Assam, under the local government. This entails the administration of the Assam *Traverse Party*, the Assam *Drawing and Reproducing Offices* at Shillong, and the Assam *Survey School* at Jhālukbāri.

In addition, as technical adviser to the Government of Bengal, the Director, Eastern Circle visited the Bengal Survey Office at Alipore, the field work of the Garden Reach survey, the Survey School at Mainamāti near Comilla, the Settlement Survey Drawing Office at Chittagong and the Air Survey field headquarters at Mathrapur in the Mālda district as well as their drawing office in Calcutta.

The Bihār and Orissa Government has now also agreed to employ the Director as technical adviser on survey matters and to contribute a part of his pay accordingly.

138. *The field work* of parties coverd e50 one-inch sheets partly or wholly surveyed, as follows:

No. 4 Party.—Topography 3,803 square miles on the 1-inch and 6-inch scales in sheets 73 E, 73 I and 78 P.

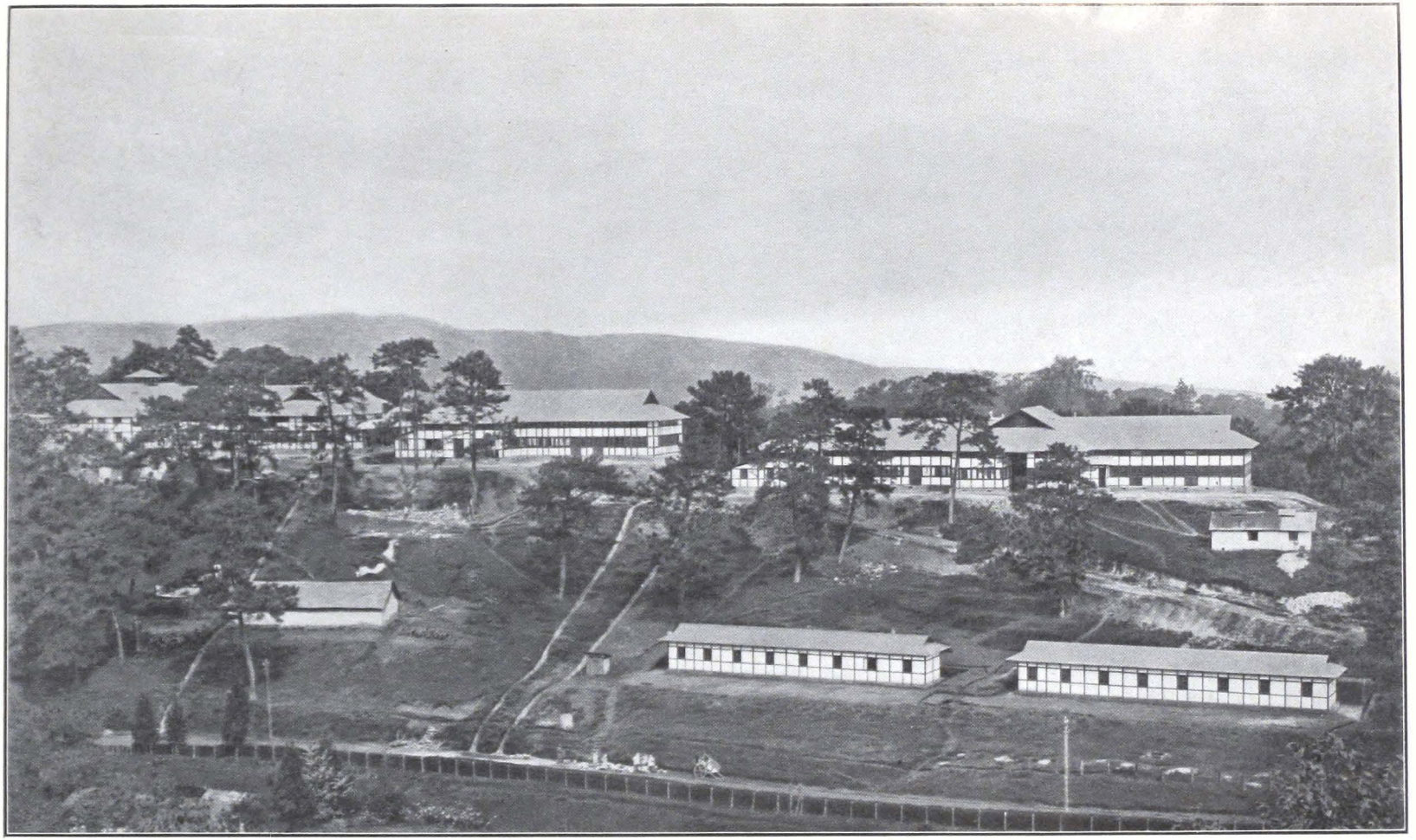
No. 9 Party.—Topography 2,859 square miles on the 1-inch scale in sheet 73 K.

No. 12 Party.—Topography 3,910 square miles on the ½-inch, 1-inch and 4-inch scales in sheets 78 A, B, F, I, J, K and P, and 83 B, D, F, I and J.

Training.—Most of the pupils attached for training to parties in the field, appear to be promising and likely to become useful surveyors. Only one pupil was discharged during the year.

139. The New Office buildings for all units of the Eastern Circle were completed on the "Bonnie Brae" estate, which was purchased by the Government of India for the purpose in 1926. The buildings are well-designed and well-lit, and should expedite all branches of the work. It is very fortunate that they have been completed just before an extra regiment is to be posted to Shillong, which will add seriously to the congestion of the place. The Director's Office, the Drawing Office and No. 12 Party moved into the new buildings in July 1928, and Nos. 4 and 9 Parties in August. Colonel McHarg and all concerned are to be congratulated on this excellent result and the promptitude with which it has been completed. A photograph of the new offices (back view) will be found on the opposite page.

140. *Air Survey of Mālda district.*—The Bengal Goverment on the advice of Mr. A. K. Jameson, I.C.S., Director of Land Records and Surveys, has set a lead to all India by having the new cadastral maps of Mālda district, on the scale of 16 inches to one mile, prepared from air photographs. The contract was placed with the Air Survey Co., Ltd., who are taking air photographs of the whole area of 1,700 square miles



EASTERN CIRCLE OFFICES, SHILLONG.
Built in 1928.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1928.

and have improvised a large drawing office in Calcutta for the preparation of the maps, which will be ready for settlement operations next field season.

This method is particularly suitable for the flat plains of India and greatly reduces the harassment of the villagers by chainmen, etc. There is also every hope that the method will prove better, cheaper, and quicker than ordinary methods; though the results cannot be fully judged until tested in the field next season during the settlement operations.

Lieut. D. R. Crone, R.E., and Mr. B. B. Kuttappa, (U. S. S.) were transferred to this work from 28th February and 1st April respectively, with the object of gaining experience in air-survey methods and of assisting the Company in technical questions, the former until he proceeded on furlough in June and the latter for the remainder of the year. Mr. Muhammad Husain (U. S. S.) was lent by the Geodetic Branch for about 2 months to the Director of Land Records and Surveys, Bengal, to assist in the rapid completion of the traverse programme in time for the Air Survey.

Procedure.—The work is based on traverse points placed approximately at one-mile intervals; these control points as eventually devised consisted of four trenches, (10 feet long by 2½ wide by 1½ deep, with the excavated earth built up like a wall on the east and south sides) dug at right angles in the form of a cross, with the centre at the junction of field aisles, and 15 feet distant from the near ends of the trenches; as seen from the air about 11 a.m. early in February they showed up quite clearly. Experience seems to show that much of the above procedure may be simplified and cheapened in future work.

Photography was carried out with the Eagle Automatic Film Camera taking exposures 7 by 7 inches with a 10-inch lens at altitudes of about 6,600 feet, resulting in approximate scales of 8 inches=1 mile. Longitudinal and lateral overlaps were not less than 55 and 20 per cent respectively.

Lieut. Crone carried out the field calibration of the camera and organized the computations for the scaling of the photographs and for the adjustment of the sub-control obtained from the radial line plots to the traverse control.

Mr. Kuttappa was employed in the several sections of the drawing office and later took over the computation section from Lieut. Crone. The computations indicate that the standard of accuracy of one in two hundred required should be maintained, but the actual accuracy is dependent partly on the control and can only be determined when the final sheets on the sixteen-inch scale are examined in the field during the course of the settlement operations in the seasons 1928-29 and 1929-30. These final sheets will be blue vandyked copies of the rectified traces, by villages, prepared from sixteen-inch photographed enlargements.

One of the air-photographs is reproduced in the frontispiece of this report and a fuller account of the work is given in Appendix I.

141. Air Survey, Orissa coast.—The Air Survey Co., Ltd., photographed on the scale of approximately 3 inches=1 mile, about 164 linear miles by 4 miles in width of the Orissa coast from the northern mouth of the Dhāmra river to the southern end of the Chilka Lake as well as approximate areas of 24, 39 and 20 square miles at the mouth of the

Dhāmra river, in the vicinity of False Point and the mouth of the Devi river respectively, for the Committee investigating the causes of Orissa floods.

Mosaics of the long coastal strip and the three areas have been made, and outline traces, not tied down to fixed points, have been supplied to the Committee. Copies of these traces as well as copies of the mosaics have also been supplied to Eastern Circle Office and will be made use of by No. 9 Party when the fair mapping of the areas in question is taken up next season.

No. 4 Party.

Officer in Charge.—Major F. B. Scott, I.A.

142. General.—Supplementary survey on the 1-inch scale was carried out in sheets 73 E and 73 I, in Bihār and Orissa, and original survey on the 6-inch scale of tea gardens in Assam.

Personnel.—The field strength of the party was 2 Class II officers, 1 Class II probationer, 4 Upper Subordinate Service officers and about 36 Lower Subordinates.

Areas surveyed.—

1-inch supplementary survey 3,785 square miles.

6-inch tea-garden survey 18 square miles.

Triangulation—3,797 square miles.

143. Field work was organized as follows:—

Camp (1).—Mr. P. N. Sur (Class II) assisted by Messrs Sajawal Khan, C.H., and Abdul Aziz Khan (U. S. S.), with 8 surveyors and 8 pupils; supplementary survey on the 1-inch scale of 1,230 square miles in the Chotā Nāgpur plateau around Rānchī, consisting of open cultivated ground with isolated rocky hills and small areas of jungle.

Camp (2).—Lieut. C. S. McInnes (Class II) with one Class II probationer and 12 surveyors; supplementary survey on the 1-inch scale of 1,602 square miles in the Chotā Nāgpur plateau east of Rānchī and the scarps and adjoining plains, including large areas of jungle.

Camp (3).—Mr. A. C. Maulick (U. S. S.) with 6 surveyors: supplementary survey on the 1-inch scale of 953 square miles in the Chotā Nāgpur plateau between Rānchī and Hazāribāgh, consisting of wooded hills and valleys interspersed with cultivation. Bear and tiger were fairly common in parts of the jungle, but caused no casualties. All wooded areas are being steadily denuded and wild life destroyed.

Triangulation.—Mr. N. C. Roy (U. S. S.), surveyor Hari Singh and traverser Raghubir Prasad were employed on triangulation in sheets 72 H and 73 E, comprising the northern portion of the Chotā Nāgpur plateau and adjoining plains of Gayā.

144. *Forest Surveys.*—The 1-inch survey included supplementary survey on the 1-inch scale of 20 square miles in the Mudāli and Kālīmāti reserved forests and the Mātha protected forest of the Chaibāsa forest division and in the Horhāp reserved forest of the Porāhāt forest division, by *Camp (2).*

145. *Tea Garden Surveys.*—At the request of Messrs Duncan Brothers & Co., Calcutta, Managing agents, Mr. S. C. Chatterjee (U. S. S.),

An Oraon Hunter of the Chota Nagpur Plateau.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1928.

of No. 12 Party, with 6 surveyors of this party, surveyed an area of about 18 square miles on the 6-inch scale with contours at 20-foot intervals in the Alinagar, Chatlapur, Daurachara and Madhabpur tea gardens. The work was begun in April and completed in May. The maps are required for the preparation of anti-malarial schemes and will be fair drawn at the firm's request on the 16-inch scale; the whole cost amounting to Rs. 11,000 will be borne by the Agents.

146. *Recess duties.*—The fair mapping was divided into three sections under Messrs Sur, Creed and Maulick and was duly completed before the end of recess, excluding the partially surveyed sheets 73 E/10 and E/14.

Triangulation computation was in charge of Mr. Roy.

No. 9 Party.

Officer in Charge.—Mr. P. A. T. Kenny, O.B.E.

147. General.—Original surveys on the 1-inch scale were carried out in sheet 73 K in Bihār and Orissa.

Personnel.—The average field strength of the party was 2 Class II officers, 5 Upper Subordinate Service officers and about 37 Lower Subordinates.

Areas surveyed.—One-inch original survey 2,859 square miles.

Triangulation.—556 square miles.

Traversing.—2,810 square miles.

148. Field work was organized as follows:—

Camp (1).—Mr. Bhupendra Nath Saha, M.Sc. (Class II), with one Upper Subordinate officer and 11 surveyors, carried out original surveys on the 1-inch scale of 1,105 square miles in the Balasore district and Mayūrbhanj and Nilgiri Feudatory States of Orissa. This area consisted partly of densely forested and steep hills reaching 3,200 feet in height above sea level, without villages or communications and presenting great difficulties to the surveyors; these were occasionally compelled to build platforms on tree tops for the purpose of resection. The rest of the area was undulating country, mainly wooded, but with numerous clearings.

Camp (2).—Mr. Satish Chandra Mukerjee (U. S. S.), with 5 surveyors and 2 pupils, carried out original surveys on the 1-inch scale of 554 square miles in the Balasore district, and Keonjhar, Mayūrbhanj and Nilgiri Feudatory States of Orissa, consisting of much the same type of country as that of No. 1 Camp.

Camp (3).—Mr. Rohini Kumar Talapatra, B.A., (U. S. S.), with 6 surveyors and one pupil, carried out original surveys on the 1-inch scale of 784 square miles in the Balasore district and the Nilgiri Feudatory States of Orissa, consisting for the most part of a flat cultivated plain stretching from the Nilgiri hills to the coast of the Bay of Bengal. It was noticed that the sea had receded about one third of a mile since the last survey in 1894.

Triangulation.—Mr. Bidhu Bhusan Shome (U. S. S.), triangulated in sheet 73 L/1 and 2 in the Cuttack district. He was transferred to the Central Circle on completion of his work in January 1928.

Traversing.—Mr. John McCraken, M.B.E., (Class II), with 1 U. S. S. officer, 8 traversers and 6 computers, traversed the whole of next field season's area in 73 L and 74 I, in the Balasore, Cuttack and Puri districts of Orissa. Towards the end of the field season Mr. McCraken, with surveyors from the other three camps completed the 1-inch original survey of sheet 73 K/8, additional to the original programme.

Forest surveys.—The 1-inch survey included the Simlipāl reserved forest of the Mayūrbhanj Feudatory State, and a special edition of the 1-inch sheets affected will show forest boundary pillars, bungalows and offices in a special colour.

City surveys.—Two surveyors were attached to the Map Publication Office and employed on revision of the 6-inch guide map of Calcutta and Howrah.

Recess duties.—The fair mapping was divided into two sections under Messrs McCraken, and Saha, assisted by 4 U. S. S. officers. The former also supervised the triangulation and traverse computation section. The whole was duly completed by the end of recess.

No. 12 Party.

Officer in Charge.—Major H. R. C. Meade, I.A.

149. General.—The following programme was carried out:—supplementary survey on the 1-inch scale in sheet 78 F in Assam and Bengal; original survey on the ½-inch and 1-inch scales in sheets 78 F, I, J and K in Assam and Bhutān; original and supplementary surveys on the 4-inch scale in sheets 78 A and B in Bengal; and supplementary survey on the 1-inch scale of railway extensions in Assam.

Personnel.—The field strength of the party was 2 Class II officers, 3 Upper Subordinate Service officers and about 41 Lower Subordinates.

Areas surveyed.—

½-inch original survey 1,018 square miles.
1-inch original survey 2,547 square miles.
1-inch supplementary survey 295 square miles.
4-inch original survey 30 square miles.
4-inch supplementary survey 20 square miles.
1-inch railway survey 179 linear miles.

Triangulation 1,888 square miles.

Traversing 3,458 square miles.

150. Field work was organized as follows:—

Camp (1).—Mr. E. M. Kenny (Class II) with 9 surveyors; original and supplementary surveys on the 1-inch scale of 1,359 square miles in the Jalpaiguri district of Bengal, Goālpāra district of Assam, and Bhutān.

The Bhutānese *Durbār* very kindly lent one surveyor and permitted our surveyors to cross the frontier for the first time. This resulted in 476 square miles of incidental survey of previously unexplored country, and in triangulation which will improve traverse adjustment in the adjoining Bengal *Duārs*.

Camp (2).—Mr. R. C. Hanson (Class II) with 7 surveyors; original and supplementary surveys on the 1-inch scale of 806 square miles in the Goālpāra district south of Camp (1).

Camp (3).—Mr. S. C. Chatterjee (U. S. S.) with 3 surveyors, 2 pupils and 5 traversers; original and supplementary surveys on the 1-inch scale of 477 square miles on both banks of the Brahmaputra river, south of Camp (2).

Camp (4).—Mr. M. L. Roy (U. S. S.) with 4 surveyors and 3 pupils; original survey on the ½-inch and 1-inch scales of 1,218 square miles in the Gāro Hills and Goālpāra districts of Assam south of the Brahmaputra river.

The country surveyed by Camps (1) to (4), which was last surveyed about 1870, comprised part of the basin of the Brahmaputra river as far west as Dhubri, where the river turns south round the Gāro Hills.

In the south of this area planetabling was by resection from triangulated control; the Gāro foot-hills however, where numerous mineral deposits are found, are so low and wooded that recourse was necessary to height traverses and fixings made on *machāns* built above the surrounding jungle.

In the north lie valuable Government reserved forests, chiefly *Sāl*, with considerable areas of high elephant grass which are burnt down yearly in March and April. Here and in the Bhutān Hills theodolite traverses were the only control.

The three party elephants were utilised in the Goālpāra reserved forests area, where other transport was scarce.

In November the Brahmaputra valley was still flooded, and malaria was prevalent, accounting for the death of five *khalāsis*. On the Bhutān border however most streams dry up in the cold weather, and the scarcity of water is so great that the forest authorities run daily water trains for the supply of their employees. The whole country teems with game.

Camp (5).—Mr. Muhammad Siddik (U. S. S.) with one surveyor; original and supplementary survey on the 4-inch scale of 50 square miles of chinchona plantations in the Darjeeling district of Bengal. These plantations were steep and scantily wooded, and lay between altitudes of 2,000 and 9,000 feet above sea level.

Surveyor Ali Ahmad surveyed 179 linear miles of railway extensions in Assam on the existing 1-inch sheets.

Triangulation.—Surveyors Hari Datta and Abdus Salam triangulated in sheets 78 F and K, comprising portions of the Bhutān foot-hills and Gāro Hills respectively. The former failed to connect his triangulation with his G. T. base in Cooch Behār State, 40 miles distant. This will be completed next season.

Traversing.—Mr. S. C. Chatterjee (U. S. S.) with 5 traversers traversed about one and a half years' detail survey area in sheets 78 B, F, G, K and L in the Jalpaiguri and Mymensingh districts and Cooch Behār State of Bengal, and the Sylhet district of Assam.

Forest surveys.—In addition to 50 square miles of special chinchona plantations surveyed on the 4-inch scale already mentioned, the ½-inch and 1-inch survey included 719 square miles of reserved forests in the districts of Goālpāra and Gāro Hills (Assam) and Jalpaiguri (Bengal).

Recess duties.—The fair mapping was divided into four sections under Messrs Kenny, Hanson, Moti Lal Roy and Muhammad Siddik, and was duly completed before the end of recess. Mr. S. C. Chatterjee was in charge of the computing section.

IX.—SURVEY REPORTS, BURMA CIRCLE.

DIRECTOR:—Colonel E. T. Rich, C.I.E., R.E.

151. Summary.—The units administered by the Burma Circle were the same as last year, *viz.*, Nos. 10, 11 and 21 Parties and No. 7 Drawing Office.

152. *Training.*—Nineteen pupil surveyors and draftsmen were under training in the Circle, and all of them made satisfactory progress.

In addition 8 new pupils were enlisted during recess and were attached to No. 7 Drawing Office for instruction in drawing.

153. *The field work* of parties was as follows:—

No. 10 Party.—Topography on ½-inch, 1-inch and 4-inch scales in sheets 83 N, 83 O, 85 L, 85 P, 86 I, 86 M and 94 D.

No. 11 Party.—Topography on 1-inch, 1½-inch, and 4-inch scales in sheets 94 C and 94 G.

No. 21 Party.—Survey of reserved forests on 2-inch and 4-inch scales in the Northern and Chindwin Forest Circles and three Forest Divisions.

No. 10 Party.

Officer in Charge:—Major F. J. M. King, R.E.

154. General.—The party surveyed a total area of 4,539 square miles in the unadministered tribal area and Upper Chindwin district, and in the Hanthawaddy, Myaungmya and Pyapon districts of the Irrawaddy Delta,—completing the survey of the Burma coast line and adjoining country as far as the mouth of the Rangoon River,—in sheets 83 N and O, 85 L and P, 86 I and M, and 94 D. The field headquarters were at Rangoon.

The area surveyed comprised 3,520 square miles of original and supplementary survey on the scale of 1 inch = 1 mile, 1,001 square miles of original survey on the scale of ½ inch = 1 mile and 18 square miles of reserved forest on the scale of 4 inches = 1 mile.

595 linear miles of traverse were run in the vicinity of the Myanaung Plain in sheets 85 N and O, and 1,350 square miles were triangulated in the Prome, Sandoway and Thayetmyo districts in sheets 85 I and J.

155. Field Work.—The field strength of the party was 3 Class II, 6 Upper Subordinate and 22 Lower Subordinate officers. The work was distributed as under:—

Camp (1), Mr. D. K. Rennick, M.B.E., (Class II), with one U. S. S. Officer and 9 surveyors carried out original and supplementary survey of 1,860 square miles on the scale of 1 inch = 1 mile.

Camp (2), Mr. G. A. Norman, M.B.E., (Class II), with one U. S. S. Officer and 8 surveyors carried out original and supplementary survey of 1,660 square miles on the scale of 1 inch = 1 mile, and 18 square miles of reserved forest on the scale of 4 inches = 1 mile.

Mr. Ram Prasad, R.S., (U. S. S.), and one U. S. S. officer (under instruction) were employed on triangulation for the first half of the season, after which they were transferred to No. 11 Party.

U. Pe, A.T.M., (U. S. S.) with one surveyor carried out original survey of 1,001 square miles on the scale of $\frac{1}{2}$ inch = 1 mile while attached to a civil expedition in unadministered Nāgā tribal territory and in the Upper Chindwin district.

Except in the north-west of the Delta the area was easy and, but for the Delta forests in the south, consisted of open paddy land cut up by innumerable creeks and rivers. The Delta forests had been surveyed in 1923-24 by air photography and the present work therein consisted for the most part in surveying boundaries, which do not follow natural features, and the fixing of high and low water marks. Except for the above deficiencies and in certain places, where the air-photos fell outside the controlling traverse and triangulation, the air-survey was found extremely accurate. The country surveyed in the unadministered tribal territory consisted of deep valleys and a mass of rugged hills of heights varying from 5,000 to 8,000 feet.

156. *Traversing.*—The Traverse Camp under Captain F. E. R. Calvert with one U. S. S. officer and four traversers carried out 511 linear miles of traverse in the Myanaung plain for the Irrigation Branch, P. W. D. and this area will be surveyed on the scale of 4 inches = 1 mile next field season. 84 linear miles were also traversed for 1-inch topographical survey.

157. *Special surveys.*—In the Insein Forest Division 18 square miles were surveyed on the scale of 4 inches = 1 mile, comprising the Kanbe, Kyundaw, Kawhmu, Peinnegon, Thamo, Wamyetsangyi and Mingalun reserved forests.

Captain Calvert was employed for two short periods in verifying and rectifying the positions of certain boundary pillars in the Burma oilfields at the request of the Burma Government.

158. *Miscellaneous.*—Cholera was very prevalent in the Delta during the latter part of the field season, and, in spite of preventive inoculation, five deaths occurred among the khalasis: in addition, one khalasi died of heart-failure following pneumonia.

For inspection work in the Delta, one camp officer was supplied with a motor launch and the other with a motor boat: the officer in charge was also provided with a motor launch. Transport in this area was entirely by means of sampans, with which as many surveyors as possible were supplied, or by the creek steamers of the Irrawaddy Flotilla and other companies.

The gallant act of Inter Class Surveyor Riaz Bahadur Khan of No. 10 Party in risking his life to save a Kachin khalasi of his squad from drowning is deserving of high commendation. While his squad was crossing a tidal creek near the Pyamalaw River in Burma, one of his khalasis fell into the river. Riaz Bahadur Khan immediately plunged after him and was with the khalasi fortunately swept by the spring tide to the bridge pole where the two men were rescued by the remainder of the squad. Neither Riaz Bahadur Khan nor the Khalasi could swim.

159. Recess duties.—The fair mapping was divided into two sections under Messrs Rennick and Norman. The whole area surveyed in the Delta, comprising 15 sheets, was fair-mapped on the scale of 1½ inches = 1 mile; in addition, the 7 forest reserves mentioned in para. 157, above, were drawn on the scale of 4 inches = 1 mile.

A computing section under Captain Calvert completed the traverse and triangulation computations.

No. 11 Party.

Officer in Charge:— Major J. H. Williams, to 1-11-27.
Mr. D. K. Rennick, M.B.E., from 2-11-27 to 6-12-27.
Major O. Slater, M.C., R.E., from 7-12-27.

160. General.—Topographical surveys mostly on the 1 inch = 1 mile scale were continued at the head of the Gulf of Martaban in sheet 94 C and G. The field headquarters of the party were at Rangoon.

This is the first season for many years that the party has worked in an area with reasonably good communications. In consequence mules were not hired and surveyors were able to move about by bullock carts, motors and rail.

161. *Areas surveyed.*—The party surveyed a total area of 3,037 square miles comprising 2,961 square miles of original and supplementary survey on the scale of 1 inch = 1 mile, 67 square miles on the scale of 1½ inches = 1 mile, and 9 square miles on the scale of 4 inches = 1 mile. This area forms part of the Insein, Pegu and Thaton districts of Burma and falls in sheets 94 C and G.

An area of 1,700 square miles was triangulated in sheet 94 D in the Hanthawaddy and Insein districts, and an area of 280 square miles was traversed in sheet 94 C in the Pegu district. In addition 113 linear miles were traversed for forest surveys.

162. Field Work.—The field strength of the Party was 2 Class II, 1 Class II Probationer, 6 Upper Subordinate and 21 Lower Subordinate officers. The field work was distributed as under:—

Camp (1), Mr. G. E. R. Cooper, (Class II), with 1 U. S. S. officer and 10 surveyors, surveyed on the 1 inch = 1 mile scale 1,640 square miles of supplementary and 78 square miles of original survey in the Pegu and Thaton districts in sheets 94 C and G.

The country varied from hills, rising to 3,600 feet, to the flat alluvial plain at sea level at the mouth of the Sittang river. This river is dangerous to navigate owing to a considerable bore at spring tides. At the present time its estuary is in a very unstable condition and considerable scouring is occurring on the eastern side which will shortly necessitate the re-alignment of part of the railway. Deposit is occurring on the western side and after building banks and washing out the salt, considerable areas of valuable rice land will be added to the Pegu district.

The foothill area necessitated a good deal of planetable traverse but the major part of the area was easy to survey. The survey of the accretions, mentioned above, had to be postponed, as the haze in the

late part of the season made points invisible and special boat arrangements, which had not been anticipated, could not be made in time.

Mr. A. F. Murphy (Class II), with Mr. M. R. Nair, B.A., (Class II probationer), 10 surveyors and one pupil comprised *Camp (2)*. They surveyed on the 1 inch = 1 mile scale 1,243 square miles; on the 1½ inches = 1 mile scale 67 square miles; and on the 4 inches = 1 mile scale 9 square miles of reserved forest. This area forms part of the Insein and Pegu districts of Burma and falls in sheet 94 C.

The country varied from the southern spurs of the Pegu Yomas, rising to 600 feet, to the alluvial Pegu plain. The broken foothill area presented considerable difficulties to the surveyor as *in situ* fixings were generally impossible and long planetable traverses had to be made. Some *machans* were built, but as a general rule the trees were not high enough to enable a view to be obtained over the surrounding jungle. Many of the minor hill and valley features have been located by offset lines and if ever the area is cleared of jungle it is possible that the maps will shew discrepancies with the ground.

Both of the above camps utilised old one-inch surveys based on large-scale revenue surveys and forest surveys on the 2 inches = 1 mile and 4 inches = 1 mile scales. These maps were not contoured and, though in places they gave a very good representation of the ground, their general use could not be relied upon.

Mr. Hayat Muhammad, K.S., in *Camp (3)*, was responsible for the instruction of eight pupils. The area selected was particularly suitable for training and consisted of a main ridge rising to 1,700 feet with long spurs and minor features standing over the sugar-cane plantations on the Bilin river opposite Bilin itself. Numerous *taungya* clearings exist, so jungle cutting was unnecessary.

163. *Triangulation and Traversing.*—An area of 1,700 square miles in the Hanthawaddy and Insein districts of Burma, in sheet 94 D. was triangulated by Messrs Ram Prasad, R.S., Khan Muhammad, and L. M. Ganguli. This area is mostly alluvial plain and the stations were only 2 to 4 miles apart. It is debatable whether traverse would not have been cheaper, but the closing and adjusting of the traverse would have been difficult towards the coast.

An area of 280 square miles was traversed by Mr. A. K. Sengupta in the Pegu district in sheet 94 C, the nature of the ground making triangulation impossible. In addition 113 linear miles of forest traverses were run by Messrs M. R. Nair, L. M. Ganguli and surveyor Bishan Dutt, and 500 square miles of triangulation reconnaissance was completed by Mr. Ram Prasad, R.S., in the Insein, Pegu and Tharrawaddy districts in sheet 94 C.

164. *Special Surveys.*—Kalitaw Reserve of the Insein Forest Division consisting of an area of 9 square miles was surveyed on the 4 inches = 1 mile scale.

A rubber estate of 1,380 acres was surveyed on payment. The scale adopted was 8 inches = 1 mile with contours at 10-foot intervals. This survey was based on a careful theodolite traverse round the estate. adjusted by numerous azimuth observations and one cross line, the traverse being also connected to two triangulated points. The particular

features required were the corner pillars of the ten-acre blocks, water stand-pipes, and the drains. These latter are dug about two feet deep at intervals of one or two chains practically all over the estate.

165. *Miscellaneous.*—In the rice plain, particularly towards the mouth of the Sittang river, good water is extremely difficult to obtain. All surveyors were issued with bottles of chlorogen and on the whole the party was remarkably free from bowel complaints. The whole party was inoculated against cholera and no cases occurred. In the broken country at the foot of the Pegu Yomas a particularly virulent type of fever seems to be very common. Esanophile was issued to some surveyors and the party Sub-Assistant Surgeon visited and inoculated nearly all the bad cases. In consequence there were fewer days lost through sickness than might have been expected.

Throughout the area, there are several interesting pagodas, the most important of which are those situated either in or near the town of Pegu, and the Kyaiktigo pagoda situated on a range of hills in the Thaton district near Kyaikto. This latter is built on a huge rounded egg-shaped boulder balanced on the summit and overhanging a cliff. Other features of historic interest are the gigantic recumbent image of Buddha, called the Shinbinthalyaung, situated in the town of Pegu, and the site of Taikkala which was the earliest Talaing capital. Little now remains of the latter. If the fretting of the eastern bank of the Sittang estuary continues the site will once more connect with the sea as was the case in the days of its greatness.

166. Recess duties.—The mapping of the 10 fair sheets on the 1½ inches = 1 mile scale, which was completed during the recess, was divided into two sections under Messrs Cooper and Murphy.

The Kalitaw Reserve was incorporated with the original fair sheets of the adjoining reserves.

Mr. Hayat Muhammad, assisted by Messrs Khan Muhammad and Ganguli completed the triangulation and traverse computations.

Mr. Nair assisted by Mr. Talapatra prepared mozaics and data for the 4 inches = 1 mile survey of Rangoon and Environs to be surveyed next year. The basis of the town portion is a 12 inches = 1 mile air-photo compilation prepared by the Rangoon Development Trust.

No. 21 (Burma Forest) Party.

Officer in Charge—{Mr. J. O. Greiff, up to 1-11-27.
Major J. H. Williams, from 2-11-27.

167. General.—The *raison d'être* of the party is the survey of reserved forest areas in Burma, on scales larger than one-inch. The total cost of the party is debitable to the Government of Burma.

The party surveyed reserved forests in degree sheets 83 P, 84 M and 92 D. The field headquarters of the party were at Shwebo.

168. Area surveyed.—The party surveyed a total area of 321 square miles on the scale of 4-inches = 1 mile, in two Forest Circles and three Forest Divisions.

Northern Forest Circle.—In the *Kathā Forest Division* an area of 130 square miles was surveyed in the Mankat reserve.

In the *Mansi Forest Division* an area of 119 square miles was surveyed in the Nankut, Nansi, Nankadin and Nantagun reserves.

Chindwin Forest Circle.—In the *Mu Forest Division* an area of 71 square miles was surveyed in the Nandaw, Tagyaing-Tamaw, Kalawpa, Wabo, Nabe and Kwethe reserves.

169. Field Work.—The field strength of the party was 3 Class II Officers, 3 Upper Subordinate Service officers and 35 Lower Subordinate Service officers. The work was distributed as follows:—

Mr. L. B. Fitz-Gibbon (Class II), *Camp (1)*, with 1 U. S. S. officer, 8 traversers and 2 computers, worked in the Kathā and Mansi Forest Divisions.

Mr. A. V. Dickson (Class II), *Camp (2)*, with 2 U. S. S. officers, 10 surveyors and 4 pupils, worked in the Mu and Kathā Forest Divisions, and was assisted during the last month of the field season by *Camp (1)*.

Mr. H. M. Critchell (Class II), *Camp (3)*, with 11 surveyors, worked in the Kathā and Mansi Forest Divisions.

The area surveyed by the party lay in the Chindwin and Kathā districts, and varied in height from 300 feet in the lower portion of the Kathā district, to 3,000 feet in the high hills on the Chindwin-Kathā border.

The whole area surveyed was covered with dense forests. These forests were opened out by unmetalled cart tracks and paths, except in the Mankat Reserve, where the forest was particularly dense and no paths had been cut by the Forest Department.

170. *Triangulation.*—500 square miles were triangulated by Mr. G. S. Bagchi, in sheets 83 O and 83 P. The work was connected with the Mandalay Meridional and Manipur Longitudinal Series, and with a number of stations of minor triangulation.

171. *Traversing.*—374 linear miles of forest boundary theodolite traversing, and 25 linear miles of interior and connection traversing was carried out by Camp (1) to provide data for the ensuing field season. This falls in sheets 83 O and 83 P and in two Forest Divisions of one Forest Circle. The traverses were connected in each case with triangulated stations.

Recess duties.—The fair mapping was divided between two sections under Messrs Dickson and Critchell. The computation work was under the charge of Mr. L. B. Fitz-Gibbon. The fair mapping and computations of all the field work were completed during the year.

X.—MISCELLANEOUS SURVEY REPORTS.

172. This section includes all reports of surveys not administered by the Directors of the five survey circles, such as miscellaneous surveys and industrial levelling administered by the Director, Geodetic Branch, or extra-departmental explorations, etc., in which members of the Department have taken part.

No. 20 Party (Cantonment Surveys).

Officer in Charge.—{ Mr. M. C. Petters, up to 17-4-28.
{ ,, C. E. C. French, from 18-4-28.

173. General.—The party carries out original and revision surveys of cantonments and military lands, as required by the Engineer-in-chief and the Army Department, and other large-scale surveys when required. This year it was decided to stop correcting existing maps from material sent in from extra-departmental sources. The annual corrections used to involve a great deal of labour, and the results were unsatisfactory; the new material was not always accurate and could not be distinguished on the published maps from the original accurate survey. The resulting map was a mixture of doubtful material with good, and therefore altogether untrustworthy.

The permanent headquarters of the party are at Dehra Dūn, under the administration of the Director, Geodetic Branch.

174. Field work.—The field section of the party, consisting of 12 surveyors and 2 computers, was under the supervision of Mr. J. M. Mukerji up to 15th March and then under Mr. Muhammad Husain; and between October 1927 and August 1928 it completed the survey of the following cantonments on the 16-inch scale of:—

Razmak	700	acres	original survey
Peshāwar	4,850	,,	revision ,,
Nowshera	4,460	,,	,, ,,
Poona	4,400	,,	,, ,,
Kirkee	5,100	,,	,, ,,
Belgaum	3,560	,,	,, ,,

Traversing.—270 linear miles of theodolite traversing were carried out in advance of the detail survey.

Levelling.—115 linear miles of levelling were run at suitable intervals in the cantonments as control for 5-foot contouring.

Special Surveys.—The party also surveyed 2,112 acres on the 12-inch scale of New Delhi (Pahārganj).

175. Recess duties.—The fair maps of Quetta, Amritsar, Multān, Lahore, Chak Bhaikewāl, Razmak, New Delhi (Pahārganj) and parts of Peshāwar and Nowshera, a total of 30 sheets, on the 16 and 12-inch scales, were completed for publication. This work was supervised by Mr. A. B. Hunter (Class II) up to 20-10-27 and then by Mr. O. D. Jackson (Class II). In addition, the annual corrections, supplied by Commanding Royal Engineers of districts, affecting 58 sheets and falling in 19 cantonments, were entered on the office copies and originals of the plans concerned.

No. 17 Party (Levelling).

Officer in Charge.—{Captain G Bomford, R.E., from 7-11-27 to 26-2-28.
{Mr. N. R. Mazumdar, from commencement to 6-11-27 and from 27-2-28.

176. General.—Formerly this party was concerned only with geodetic levelling, but latterly took up tertiary levelling for large irrigation projects. Thus during 1922—26, over 100,000 miles of tertiary levelling was accomplished for the Sutlej Valley project of the Punjab Irrigation Department. A reversion to the old practice is now decided on, where possible, and tertiary levelling of the Haveli irrigation project for the Punjab Government was transferred to No. 23 Party, Frontier Circle. Further, the tertiary levelling of the Lloyd Barrage area can be adequately controlled by the newly devised tertiary double levelling method and this work will accordingly be transferred to No. 24 Party, Central Circle. In this method two levellers work more economically, side by side, instead of following each other as in secondary levelling. In future all tertiary levelling will ordinarily be carried out by the Circle in whose area it lies.

No. 17 Party still undertakes secondary levelling for control of tertiary work and other purposes when this is necessary. An abstract of high precision levelling is given on page 17, and full accounts are given in Geodetic Report, Volume IV (1927-28).

177. Field work.—*Secondary Levelling.*—Three detachments took the field under the charge of Messrs Lalbir Singh, J. N. Kohli and B. P. Rundev all of the Upper Subordinate Service with Mohd. Faizul Hasan, P. John and Mohammed Ishak Khan as assistants. The out-turn was:—

For the Bombay Government.—Lloyd Barrage project 1,085 miles.
For the Punjab Government.—Haveli project (extension) 14 miles.

Training School, Dehra Dūn.

178. *Class II probationers (First year).* Seven joined the training school on the 15th November 1927 on first appointment. Each probationer completed 4 square miles of planetabling on the 4-inch scale and 16 square miles on the 2-inch scale during the field season. Instruction was given them in all branches of survey, the class being inspected monthly by a senior Class I officer.

179. *U.S.S. probationers (Second year).*—Of the fourteen appointed in November 1926, four were discharged as unsuitable during the year, and the remaining ten joined "E" Survey Company at Quetta on the 19th November 1927, after completing a year's training at Dehra Dūn. One of these, Mr. M. M. Ganapathy, was successful at the Class II entrance examination and was appointed to that service in November 1927.

Miscellaneous.—Three surveyors were instructed in large-scale cantonment surveys on the 16 and 64-inch scales and underwent a course of traversing and levelling before joining No. 20 Party in May 1927. One Upper Subordinate Officer and 2 computers of 17 Party completed courses of training during the year.

APPENDIX I.

THE AIR SURVEY OF MĀLDA, 1928.

1. The replacement of terrestrial methods for cadastral survey by air photography is a definite step forward in the science of survey. Hitherto accurate air methods have been confined to topographical and city surveys on smaller scales. It will be remembered that the first of these surveys, with the exception of the early trial at Agra in 1920, was carried out by Mr. R. C. Kemp assisted by officers of the Survey of India in 1923-24, when the forests of the Irrawaddy Delta were surveyed and mapped on the scale 3 inches to 1 mile.* It was the success of this survey which brought about the formation of the Air Survey Company Ltd., in 1924, with Colonel C. H. D. Ryder, C.B., C.I.E., D.S.O., and Mr. R. C. Kemp as Directors. Since then topographical air surveys have been carried out in Burma, Borneo, Federated Malay States and Bengal.

The Air Survey Company during the past four years has thus gained considerable experience in the new science, and has devoted a large amount of time and money to research and experimental work, which has resulted in many improvements in air photography, survey flying, and production of maps from air photographs.

In the Spring of 1927, on the completion of the air survey of the Chittagong Forests,† the company carried out a test for the Director of Land Records and Surveys, Bengal, to demonstrate that the same method would be suitable for cadastral survey in Bengal. The air photographs of the test area were despatched to No. 18 Party, Survey of India, which completed a cadastral map from them on a scale of 16 inches to a mile, by a modification of the radial line method.

As a result of this test the Air Survey Company Ltd., negotiated with the Director of Land Records and Surveys, Bengal, for a settlement survey of 1,700 square miles in the Mālda District. The proposals were provisionally approved in the autumn of 1927, but the agreement was not finally sanctioned and signed until the 21st December. In spite of the short time thus allowed for preparation, the Air Survey Company started work in February 1928.

2. *The Mālda District* is flat and intersected with numerous water-courses. It is closely cultivated and densely populated, but except round the villages, sparsely wooded. The existing maps of the area (4-inch Revenue maps) were made in 1860 and on them village boundaries are only very approximately shown. This district was an excellent choice for the commencement of cadastral air survey, for complete re-survey by ground methods would have been very expensive and would have entailed considerable harassment of the people by survey

* For a report on this survey see *Records of the Survey of India, Vol. XXI.*

† See General Report 1926-27, pages 42–44, and the body of this General Report, page 47.

subordinates chaining across growing crops. The Director of Land Records and Surveys, Bengal, therefore intended to regard this air survey as a test prior to the adoption of the method in the more difficult, larger and unhealthier districts of Rangpur and Dinajpur.

3. *Ground Control.* The Director of Land Records and Surveys, Bengal, sent out three parties which in four months traversed lines at 1-mile intervals, at the same time fixing points every mile throughout the area. The air party commenced their operations early in February 1928 while this work was still in progress.

The stations and points fixed by the traverse party were marked by digging trenches in the form of a cross. Experience has since proved that this type of mark occasionally fails to show up distinctly on the photograph and is therefore somewhat unreliable.

4. *The Air Photography* was carried out with a long-focus lens in order that a scale of about 8 inches to the mile might be maintained, the photographs then requiring enlargement to double size only. The L B Camera was unsuitable owing to the tremendous number of exposures that would have been necessary on account of the small plate and the consequent unwieldy organization in the field dark-rooms. It was decided therefore to employ the Eagle Camera with a 7″ × 7″ picture and 10¼-inch lens. This Camera, similar in every way to the F 8 now being employed in the Royal Air Force, is made to take a film and not plates, and has been purchased by the Survey of India for use on the North-West Frontier in co-operation with the Royal Air Force. Unfortunately the first batch of panchromatic films sent out to Mālda was too slow and not very successful. Two months were therefore wasted in experimenting with these films and it was not until another make of film was introduced that the work went ahead; continuous flying was then impossible on account of the approaching Monsoon. These very serious delays, of 3 months in closing the contract and 2 months on account of films, forced the Company to use every possible expedient to hasten the rectification and fair-drawing in order to deliver the maps by the due dates, after which, they will be tested, and completed where necessary, on the ground.

5. *Mapping.* Before the mapping commenced it was believed that it would be impossible to train enough Indian draftsmen in Major Bagley's Radial Line Method or in the recent adaptation of this brought into use by Lieut. Hotine. It was decided therefore that a small party should be trained in the Ray Plot system and taught to lay out a grid over the whole area from strips of photographs positioned by this method. This grid was then to be enlarged to the 16-inch scale and plotted on celluloid; and the photographs being placed beneath in mosaic form, the tracers would line in all detail.

The training of draftsmen was undertaken in April 1928 and it was decided to employ the full Ray Plot method. The results were however somewhat inconsistent in accuracy and the plotting section could not keep pace. To meet these difficulties without delaying the work, an ingenious modification of the application of radial line principles was evolved by Mr. Lloyd and Lt. Crone, R.E. (Survey of India), and has been applied to the whole work.

6. *Instruments.* The Mathematical Instrument Office of the Survey of India has been able to afford the Company much assistance in the design and construction of special instruments. Among the most important of these may be mentioned the Co-ordinatograph, the large Glass Protractor, and the Roller Ink Rulers. These have been manufactured under the personal supervision of Mr. S. Woodhouse, the Superintendent.

7. *Field work.* The Company is providing the Director of Land Records and Surveys, Bengal, with maps printed in blue which will be sent out with the record-writing Party, who will line up in black such of the field boundaries as are required to show the limits of property holdings. The plots will be numbered, and all additional detail in the immediate neighbourhood of village sites, which has not been shown in the air map on account of congestion, trees, etc., will also be put in by this party. The sheets will then be sent to the Bengal Drawing Office and re-vandyked.

8. *Conclusion.* The Air Survey Company are to be congratulated on the spirit and skill with which they have faced most serious difficulties in connection with this contract. The Survey of India has gained considerably by working in the closest touch with the Company throughout; and the Company has benefitted by the survey and technical experience of officers from the Department. The Surveyor General, the Director, Eastern Circle, and Survey of India officers stationed in Calcutta, have visited the Company's Drawing Office in Hungerford Street, and watched with interest the progress of the work.

Further contracts have now been obtained by the Company, among which perhaps the most important is that concluded with the Government of the United Provinces whereby 2,500 square miles of settlement survey will be undertaken by the Company in the winter of 1928-29. The Director of Central Circle, Survey of India, will undertake the traverse for this work, *after* the photography has been completed, the position of the stations being marked on the photographs by the traverse party.

APPENDIX II.

The Height of Mount Everest.

1. Mount Everest is nearly 1,000 feet higher than any other known peak, and recent researches show that its true geoidal height is probably about 70 or 80 feet higher than the accepted value, 29,002, which was computed in 1852 from observations taken in 1849-50. The terminal figure 2 has never been taken very seriously, but was retained because the round figure 29,000 might have given the impression that the height was only roughly known to the nearest thousand feet whereas it is almost certainly correct within one hundred feet.

2. Further observations were made in 1880-83 and in 1902, but, like the original observations of 1849-50, they were all taken at great distances, varying from 85 to 119 miles, and these are still the best data we possess. In 1907 Colonel Sir Sidney Burrard deduced a height of 29,141*. This value, so far as it goes, has been closely confirmed by recent research (*vide* para. 6 below), but we are now able to apply approximate *geoidal* corrections which considerably reduce these computed heights. In view of such possibilities, Sir Sidney Burrard did not consider his value sufficiently certain for general adoption.

3. The effective height of a point, which controls the flow of water, is that above the geoid or surface of equilibrium. This is known as the *geoidal* height and can only be directly obtained by running a line of spirit-levelling to the point. Since this is impossible for inaccessible peaks we have to deduce their heights from vertical angles, which in the case of Everest have been taken from very great distances.

4. Such distant observations require large corrections for refraction, which is an uncertain quantity, and in order to get geoidal heights further corrections have to be applied on account of the difference between the geoid, which is an irregular figure, and the assumed figure of the earth on which the computations are based. In the Survey of India this spheroid of reference is that adopted by Sir George Everest in 1830; but the geoid deviates considerably from any possible spheroid of reference in and near the Himalayas, owing to the attraction of this great mass of mountains.

5. Dr. de Graaff Hunter's researches have added greatly to our knowledge of refraction, and he has also applied geoidal corrections to all these distant observations to Everest and to some other Himalayan peaks. He recorded the results in an evening lecture before the Indian Science Congress at Madras in February 1922, which was recently re-published in Geodetic Volume I of the Survey of India, where full particulars will be found.

6. Dr. Hunter's improved refraction corrections have greatly increased the accordance of the results derived from the different stations of observation, so that he gets a height for Everest which has a probable

* *A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet.*—Burrard and Hayden.

error of less than 5 feet and a possible error of less than 15 feet. This height is 29,149 feet, and we may say that it almost certainly lies between 29,140 and 29,160. This figure however only gives the height above the adopted spheroid of reference, which must diverge greatly from the geoid, or surface of equilibrium, in any area like the Himalayas.

7. In order to get the true *geoidal height*, such as would be obtained from spirit levelling, we have to reduce the above figure by the difference of height between the geoid and the adopted spheroid of reference under the peak itself. This difference cannot be accurately computed until we know a great deal more about the geoid and the distribution of density in the earth's crust; but in 1922 Dr. Hunter took it to be 70 feet, while Capt. Bomford R.E. has recently computed it to be 80 feet on the basis of Hayford's compensation theory. If we put it at 74 feet we get the effective height of Mount Everest above the geoid to be **29,075 feet,** but this is subject to uncertainties which may possibly exceed 25 feet. This height may be put at 8,862 metres, with possible errors which might approach 10 metres either way.

8. Thus the best we can do at present is to say that when the geoidal height of Mount Everest comes to be better known it will probably lie between 29,050 and 29,100 feet. Until we can make a closer estimate it seems hardly worth while to disturb the original figure of 1852, namely 29,002. Dr. Hunter's paper (*vide* para. 5) gives similar estimates of the height of another important peak, Kinchinjunga, in the same neighbourhood, with an interesting discussion of all the varied problems involved.

9. The recent survey of Nepāl has confirmed the Survey of India view that there is no native name for Mount Everest and that the name Gauri Shankar certainly applies to a twin peak about 30 miles distant from Everest. This point is more fully discussed at the end of Appendix II of last year's General Report.

E. A. TANDY, *Brigadier,*

Surveyor General of India.

Survey & Compilation

4" to 1 mile to $\frac{1}{8}$" to 1 mile scales

SURVEY OF INDIA

MODERN TOPOGRAPHICAL SURVEYS AND COMPILATION

on scales ranging from 4 inches to 1 mile to $\frac{1}{8}$ inch to 1 mile.

SURVEY CIRCLES
(boundaries shown in blue)

Director Frontier Circle, Simla
" Central " Mussoorie
" Southern " Bangalore
" Eastern " Shillong
" Burma " Maymyo
Also Director Geodetic Branch, Dehra Dun
" " Map Publication, Calcutta
" Assistant Surveyor General, Calcutta

N. B. The index shows all topographical work brought on to the true longitude since 1905. Previous topographical work, in the blank areas was about two miles out of position, being based on the old longitude of 1815.

SYSTEM OF NUMBERING SHEETS.

THE $\frac{1}{M}$ SERIES forms the basis of numbering for sheets on all scales. It consists of sheets 4° × 4° on the scale of 1:1,000,000, whose numbers are shown on the Index thus:— 55

QUARTER-INCH SHEETS—Each $\frac{1}{M}$ sheet is divided into 16 sheets of scale quarter-inch to one mile, lettered A–P as shown on the Index ma

MODERN TOPOGRAPHY
up to 30th September 1928.

REFERENCES.

MODERN SURVEYS (since 1905).
Scale 1 inch to 1 mile, and over
" about $\frac{1}{2}$ inch to 1 mile
" $\frac{1}{4}$ inch to 1 mile, and less