SURVEY OF INDIA

TECHNICAL REPORT 1950

(From 1st April 1949 to 31st March 1950)

PART I—TOPOGRAPHICAL AND OTHER SURVEYS
PART II—MAP PUBLICATION AND OFFICE WORK

PUBLISHED BY ORDER OF
BRIGADIER I. H. R. WILSON, F.R.I.C.S., M.I.S. (INDIA)
SURVEYOR GENERAL OF INDIA

PRINTED AT THE OFFICE OF THE GEODETIC & TRAINING CIRCLE
SURVEY OF INDIA, DEHRA DUN, 1952.

Price Eight Rupees, or Twelve Shillings and Nine Pence

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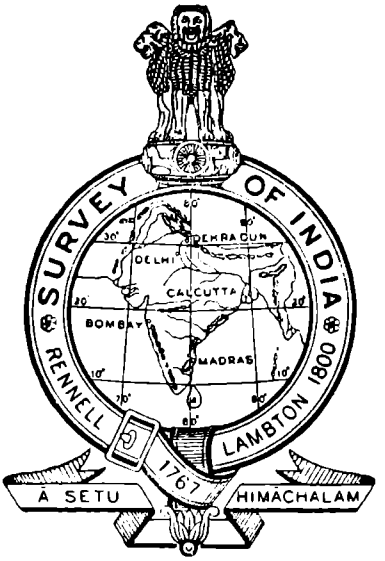

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FOREWORD

Part I of this Technical Report is prepared by Directors and Officers in charge of Survey Circles and Units respectively. The author of any particular report is normally the Officer holding office at the end of the period covered by the report.

2. Part II is prepared by the Director, Map Publication.

3. The Report, as a whole, is edited in the office of the Surveyor General, but expresses the personal views of the authors of the various sections.

G. F. HEANEY,
Brigadier,
Surveyor General of India.

MUSSOORIE :
May 1951.

SURVEY OF INDIA

TECHNICAL REPORT 1950

From 1st April 1949
To 31st March 1950

I. INTRODUCTION AND SUMMARY

1. **Annual Reports.**—The publication of the two Annual Reports of the Survey of India namely, the General Report and the Geodetic Report was suspended in 1942 for the duration of the war. The resumption of publication of these reports was made from the year 1947 in two separate volumes namely :—

(*a*) *The General Report.*
(*b*) *The Technical Report.*

The General Report is a brief narrative covering all work of the department and is intended for the information of the Government of India and non-technical readers.

The Technical Report which has superseded the Geodetic Report not only deals in detail with the geodetic and geophysical activities of the department, but also covers technicalities of survey work, drawing and map reproduction not included in the scope of the Geodetic Report.

The Technical Report for 1947 covered the period from 1st October 1946 to 14th August 1947, after which date India was partitioned. The present report covers the period from 1st April 1949 to 31st March 1950 and is the second report relating only to the Union of India. Future reports will cover approximately the period of the financial year which begins on 1st April and ends on 31st March.

The Technical Report is arranged as follows :—

Part I contains Table C (previously published in the General Report) giving a detailed statement of areas, out-turns and costs rates of surveys. It also contains technical notes on topographical and other surveys, descriptions of country surveyed, notes as to weather, communication, availability of food and on other subjects likely to be of interest to surveyors. It may also have appendices describing new technical methods and equipment.

Part II deals with the technicalities of map drawing and reproduction and allied matters.

Part III deals with geodetic and geophysical operations with special reference to the technical aspects of the work, and to an analysis of the results. This part is being published as a separate volume this year.

The report is self-contained with indexes, charts, samples of finished work, photographs and illustrations, etc.

A Supplement to the Technical Report containing some of the information previously published in the Technical Supplement to the General Report will continue to be prepared in typescript for departmental use.

PART I.—TOPOGRAPHICAL AND OTHER SURVEYS

II. ABSTRACT OF TOPOGRAPHICAL WORK

2. In issues of the annual General Report of the Survey of India published before the World War II, the abstract of topographical work was explained by three Tables namely, **Tables** A, B and C.

Table A showed the area of survey completed on various scales since 1905 as well as the approximate balance which remained to complete the contoured topographical survey of India.

Corrigendum

Page 3, para 2, line 24—

After 'field' *enter* 'and Departmental overhead charges'.

G. & T.C.—P.O.—J.S. 584—1-11-50—250.

PART I.—TOPOGRAPHICAL AND OTHER SURVEYS

II. ABSTRACT OF TOPOGRAPHICAL WORK

2. In issues of the annual General Report of the Survey of India published before the World War II, the abstract of topographical work was explained by three Tables namely, Tables A, B and C.

Table A showed the area of survey completed on various scales since 1905 as well as the approximate balance which remained to complete the contoured topographical survey of India.

Table B showed the survey of the area revised during the period under review.

Table C showed in detail the figures for areas surveyed, outturns and cost-rates of surveys, compilation and mapping by the various survey parties of the department.

Tables A and B will continue to be published in the General Report although they were omitted in the General Report, 1947.

Table C is now published in the Technical Report.

In Table C, although every endeavour has been made to calculate the cost-rates accurately, it is extremely difficult to allocate overhead charges fairly to the various classes of work. The cost-rates shown in the Table C must, therefore, be considered to be approximate. The net cost represents the expenditure actually incurred on the work plus Party overhead charges, but excludes expenditure incurred on moving the party to the field and Departmental overhead charges. The overall cost is the net cost plus the cost incurred on moving the party to the field. The information contained in this Table is intended to be useful to those familiar with survey organization, in estimating costs in subsequent years.

The cost shown for mapping and computation are those incurred in the party, etc., offices only, except where otherwise stated. Publication charges, if required, may be ascertained from the Director, Map Publication, at Dehra Dūn.

Indexes A and *C* published in the General Report also appear at the end of the Technical Report. The progress of modern (i.e., since 1905) topographical surveys made by the department and of compilations made from our own or other material is illustrated in *Index A*. The surveys in hand in connection with the various irrigation and development projects are shown in *Index C*.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	
No. 1 Party.—	**New Delhi Development—Scale 100 feet to 1 inch, contours at 5-foot interval.**					**NORTHERN CIRCLE**
40% area undulating and broken. 60% area flat, built up and covered with fruit gardens	Incorporation on fair originals of verification corrections and ground surveyed contours and completion of drawing	26·4	0·34	692·3	865·4	
	Rewa and Satna Towns—Scale 16 inches to 1 mile, contours at 10-foot interval.					
City area, undulating at places	Incorporation and drawing on fair originals of verification corrections and contours	9	0·58	448·6	560·8	
	Agra Central Railway Station—Scale 32 inches to 1 mile and contours at 5-foot interval.					
City area, mostly built up, uneven where open with mounds generally of 20 to 50 feet heights	Incorporation and drawing on fair originals of verification corrections and contours	2·1	0·31	782·4	978·0	
	Bargi Dam—Scale 32 inches to 1 mile, contours at 5-foot interval.					
Low hills, 300 feet average height covered with open jungle	Complete air survey	1·2	0·14	2080·0	2600·0	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	**NORTHERN CIRCLE.—*Contd.***
No. 1 Party.—*Contd.*						
	Bargi Reservoir—Scale 4 inches to 1 mile, contours at 10 and 20-foot intervals.					
Low hills, 300 feet average height covered with fairly dense jungle	Complete air survey and contouring on photo-mosaic	173	2·82	120·7	150·9	
	Patiala Development—Scale 16 inches to 1 mile, contours at 20-foot interval.					
Mountainous area, 5,000 to 6,000 feet ..	Complete air survey	9·5	0·34	845·8	1057·3	
	Ramganga Reservoir—Scale 4 inches to 1 mile, contours at 20-foot interval.					
Low foothills, covered with fairly dense forest	Complete air survey	99·5	7·42	37·6	47·0	
	Tawa Reservoir—Scale 4 inches to 1 mile, contours at 20-foot interval.					
Hills covered with dense forests. Average height 600 feet	1. Supplementary triangulation and re-heighting of trigonometrical stations and points	300	48·7	43·8	58·3	Air survey in hand.
	2. Height control for 4-inch air survey.	220	13·8	136·5	188·5	Air survey in hand.

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 1 Party.—*Contd.*		sq. m.	sq. m.	Rs.	Rs.	**NORTHERN CIRCLE.—*Contd.***
	Jumna Hydro-electric Power Scheme—Scale 32 inches to 1 mile, contours at 5-foot interval.					
Sub-mountainous forest area	Plane-tabling	2·1	·14	4389·5	5486·9	Triangulation done for 4″ = 1 mile scale accepted. Done by 4 Plane-tabler trainees.
	Jumna Hydro-electric Power Scheme—Scale 4 inches to 1 mile, contours at 20-foot interval.					
Sub-mountainous dense forest area ..	1. Triangulation	20	5·4	250·9	313·6	
	2. Plane-tabling	4·5	3·9	637·8	797·2	In hand with trainees.
	Sambhar Salt Lake—Scale 2 inches to 1 mile, contours at 1-foot interval in the bed of the lake and 50-foot interval elsewhere.					
80% sandy bed area. 20% desert area with villages, etc.	1. Triangulation	225	97·8	19·7	26·1	
	2. Levelling	184 linear miles	62·0 linear miles	15·3 per linear mile	19·8 per linear mile	
	3. Plane-tabling	125	12·2	101·1	129·7	Incomplete.

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 1 Party.—*Contd.*		sq. m.	sq. m.	Rs.	Rs.	**NORTHERN CIRCLE.—*Contd.***
	Didwana Salt Lake—Scale 8 inches to 1 mile, contours at 1-foot interval in the bed of lake and 10-foot interval elsewhere.					
80% sandy bed area. 20% desert area with villages, etc.	1. Triangulation	15	17·3	155·9	212·4	
	2. Levelling	29 linear miles	36·3 linear miles	17·2 per linear mile	22·8 per linear mile	
	3. Plane-tabling	9·1	2·6	394·7	508·3	
	Korea–Rewa Boundary					
Hills with forests	1. Triangulation	60	50	25·2	33·0	
	2. Traverse of Boundary ..	16 linear miles	13·7 linear miles	73·4 per linear mile	97·3 per linear mile	
	3. Plane-tabling 4-inch scale ..	1·8	1·1	795·9	1042·4	
	4. Fair mapping and supply of data	1·8	0·20	..	..	Cost is burdened with various charges not truly applicable to fair mapping.

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per acre (or mile)		Remarks
				*Net	*Overall	
No. 1 Party.—*Contd.*	**Palam Airport (Landing Chart)—Scale 2 inches to 1 mile, contours at 50-foot interval.**	acres	acres	Rs.	Rs.	**NORTHERN CIRCLE.—*Contd.***
Area fairly congested and country undulating and broken	1. Levelling and fixation of reference mark	14	90	44·5	60·1	
	2. Plane-tabling	32	7·5	155·6	200·4	
	Palam (Airport Approach Chart)—Scale 1 inch to 4 miles.					
Area flat and fairly congested and country undulating and broken	Verification of ¼-inch maps	1000	682	2·0	2·6	
	Bhākra Reservoir —Scale 4 inches to 1 mile, contours at 20-foot interval.					
Partly hilly and partly undulating ground; cultivated along river beds; covered with jungle and scattered trees	1. Planimetric control ..	50	50	70·7	94·1	Incomplete.
	2. Levelling	19 linear miles	27·1 linear miles	36·0 per linear mile	50·6 per linear mile	
	3. Plane-tabling and supplementary framework	25	2·8	756·8	986·1	
	4. Control lay-out on ground ..	59 linear miles	1·6	29·6	36·8	
	Punāsa Reservoir—Scale 4 inches to 1 mile, contours at 20-foot interval.					

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 1 Party.—*Concld.*		sq. m.	sq. m.	Rs.	Rs.	**NORTHERN CIRCLE.—*Contd.***
Hilly ground with open jungle	Supplementary planimetric control	120	92·3	31·8	41·9	
	Delhi and Locality					
Built-up areas, open and flat cultivated plains	Rapid verification of 1-inch maps ..	500	652	4·4	5·9	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 13 Party.—	**Bhākra Dam Project—Scale 4 inches to 1 mile, contours at 1-foot vertical interval.**	sq. m.	sq. m.	Rs.	Rs.	**NORTHERN CIRCLE.—Concld.**
70% of area is affected by floods from the Ghaggar and the Saraswati Rivers and is thickly wooded and covered with high grass. Small patches of cultivation occur here and there. Remaining 30% area consists of flat, generally open and cultivated plains	Triangulation	1100·0	234·0	8·2	11·1	
	100 Acre Rectangulation ..	1894	10·7	86·7	164·1	
	Levelling, tertiary; and levelling computations	2044	14·6	80·1	122·3	
	Mapping of contours at 1-foot vertical interval on 4-inch scale outline sheets	2012	7·1	50·7	69·8	
	Complete Job ..	2012	..	218·2‡	354·6‡	‡ Averages. Include also expenditure incurred on field work only in an area of 2044 sq. miles during season 1949–50, mapping work of which was not started during the period under report.

*For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Net	*Overall	
No. 5 Party.—	**Dihāng Reservoir—4-inch scale with contours at 50-foot vertical interval.**	sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE**
Heavily wooded steep hills	Triangulation	168	15·2	203·1	273·0	
	Traverse	144 linear miles	15·1 linear miles	145·2 per linear mile	195·3 per linear mile	
	Tertiary simultaneous double levelling in the plains	100·0 linear miles	32·9 linear miles	65·0 per linear mile	87·4 per linear mile	
	Do. do. in hilly area ..	29·8 linear miles	6·4 linear miles	154·2 per linear mile	207·4 per linear mile	
	Height control by clinometer ..	71	12·1	89·1	119·9	
	Dihāng Dam—16-inch scale with contours at 10-foot vertical interval.					
Heavily wooded steep hills	Triangulation	4·5	2·0	994·3	1274·5	High cost due to difficulties in procuring labour and bad weather.
	Tea Estate in Assam—16-inch scale without contours.					
Open and flat country	Traverse (without heights) ..	40 linear miles	15 linear miles	65 per linear mile	85 per linear mile	Low out-turn due to inexperienced officer carrying out this job.
	Ground verification of photographs	7	19	44	62·5	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Net	*Overall	
No. 5 Party.—*Concld.*		sq. m.	sq. m.	Rs.	Rs	**EASTERN CIRCLE.—*Contd.***
	Jamshedpur Town Extension—16-inch scale with contours at 5-foot vertical interval.					
Undulating ground with sāl jungle; cultivated plains interspersed with low hills covered with dense jungle	Fair mapping	11·7	0·63	670·9	838·6	
	Ganga Bridge Project—1-inch scale without contours.					
Flat country with sandy river beds ..	Correction of one-inch maps from air photographs	775·0	59·1	8·3	10·4	The corrections were carried out on 2-inch film positives of the old 1-inch sheets.
	Kopili Flood Control—4-inch scale with contours at 1-foot vertical interval.					
Low lying plains interspersed with swamps and high grass	Outline air survey including combination	150	9·3	44·9	56·1	
	Preparation of spot height charts, compilation of contours and fair-mapping	200	4·1	105·2	131·5	Contours were interpolated from a mesh of spirit levelled heights.

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 9 Party.—		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—** ***Contd.***
	Kosi Irrigation—4-inch scale with contours at 1-foot vertical interval.					
Generally flat ground interspersed with water channels, patches of jungle and high grass, cultivated areas interspersed with scattered trees, mango groves, bamboos, tanks and groups of small villages	Traverse	8·2 linear miles	11·1 linear miles	188·0 per linear mile	297·5 per linear mile	Field work carried out at the end of season 1948–49, but not included in the previous report, and all work done in recess 1949.
	Tertiary levelling	10·1 linear miles	10·7 linear miles	134·5 per linear mile	213·4* per linear mile	*Cost rates very high as they are based on unrealistic figures for out-turn.
	Ground survey	13·0	6·3	262·4	420·1†	†Heavily wooded area.
	Photo marking	189·0	75·0	3·9	6·3	
	Outline air survey	337·5	20·2	17·6	27·9	
	Fair mapping	581·5	3·2	76·9	123·5	
	Computations	581·5	..	10·0	16·1	
	Combined project	581·5	1·5	482·3	753·1	For *all* work carried out in field season 1948–49 and recess 1949.

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 9 Party.—*Concld.*	**Kosi Irrigation—4-inch scale with contours at 1-foot vertical interval.**	sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
	Traverse	250·5 linear miles	34·5 linear miles	40·8 per linear mile	81·0 per linear mile	
	Double tertiary levelling ..	332·8 linear miles	15·3 linear miles	49·4 per linear mile	98·1 per linear mile	For all work carried out in field season 1949–50.
	Tertiary levelling	2808 linear miles	36·6 linear miles	22·6 per linear mile	44·8* per linear mile	*Includes taking abreast levels at 10-chain intervals.
	Stone-laying	1039·2	21·7	43·5	86·3	
	Ground verification	1051·5	33·7	28·9	57·3	
	Ground survey	1·5	7·5	124·8	247·8†	†Photo gap area filled by ground survey.
	Photo marking	864·0	118·6	4·2	8·3	
	Outline air survey	432·0	25·0	17·1	34·0	
	Kosi River Survey—2-inch scale without contours.					
	Correction air survey	1400·0	9·0	4·4	8·6	Corrections carried out on film positives for reproduction on 1-inch scale.

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 11 Party.—		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—** ***Contd.***
	Air Field (Landing Charts)—1½-inch scale					
Open, flat area	Tertiary levelling	91·1 linear miles	7·59 linear miles	8·68 per linear mile	32·4 per linear mile	
	Double tertiary levelling ..	163·8 linear miles	13·65 linear miles	13·42 per linear mile	38·5 per linear mile	
	Triangulation	58·8	58·8	1·23	2·3	
	Traversing	26·5 linear miles	26·5 linear miles	5·77 per linear mile	12·6 per linear mile	
	Plane-table revision survey ..	152·2	15·2	2·82	7·4	
	Air Field (Approach Charts)—¼-inch scale					
	Plane-table correction survey ..	3806·0	126·8	1·39	3·8	

* For explanation of 'net and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 11 Party.—*Contd.*		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
	Mahanadi Irrigation—4-inch scale with contours at 5-foot vertical interval.					
Undulating country with scattered trees and scrub	Outline air survey	782·2	9·31	6·14	9·9	For work carried out in field season 1948–49 but not included in the previous report and that done in recess 1949.
	Fair mapping	782·2	2·04	244·29	322·9	
	Computation	443·6	9·25	21·56	33·9	
	Combined project	782·2	1·71	282·27	446·1	For *all* work carried out in field season 1948–49 and recess 1949. Arrears of pay and dearness allowance of Class IV men have also been included in the expenditure.
	Tertiary levelling	1827·3 linear miles	30·455 linear miles	14·55 per linear mile	28·9* per linear mile	*Includes abreast heights at ten chain intervals
	Stone-laying	181·4	10·07	19·35	81·5	For all work carried out in field season 1949–50.
	Computation	221·4	18·45	14·09	25·4	
	Outline air survey	30	7·5	10·76	16·6	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 11 Party.—*Contd.*		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
	Gandak Barrage Project—4-inch mapping from air photo mosaics with contours at 1-foot vertical interval.					
Flat open cultivated area with scattered trees all over and numerous sugar-cane plantations	Tertiary levelling	5562·34 linear miles	40·37 linear miles	5·16 per linear mile	16·8 per linear mile	
	Double tertiary levelling ..	313·36 linear miles	19·58 linear miles	12·49 per linear mile	35·8 per linear mile	
	Secondary Levelling	112·40 linear miles	14·05 linear miles	18·47 per linear mile	41·0 per linear mile	
	Computations	1500	62·5	4·53	12·1	
	Konār Dam Site—To establish a B.M. at the Dam Site.					
Hilly country covered with fairly dense jungle	Secondary levelling	31 linear miles	15·5 linear miles	20·903 per linear mile	68·1 per linear mile	
	Kalaikunda Air Field—16-inch scale with contours at 1-foot vertical interval.					
Flat and open area	Ground survey	780 Acres	260 Acres	0·58 per acre	1·9 per acre	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Area, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 11 Party.—*Concld.*		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
	Upper Mahanadi Dam and Reservoir—Ground control for complete air survey of the reservoir area on 4-inch scale with 10-foot contours and out-line air survey only of the dam area on the 32-inch scale.					
Open cultivated valley on banks of Mahānadi with isolated hillocks all round	Triangulation	80	6·66	59·96	112·0	
	Tertiary levelling	51·2 linear miles	12·8 linear miles	8·10 per linear mile	15·3 per linear mile	
	Traversing	35·4 linear miles	8·85 linear miles	37·43 per linear mile	73·1 per linear mile	
	Height control	80	5·33	36·33	72·9	Observation by theodolite and distance from plane-table fixings.

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Net	*Overall	
No. 12 Party.—		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—** ***Contd.***
	Calcutta Urban Drainage Scheme—6-inch scale.					
Heavily congested area with innumerable buildings, roads, tanks, etc.	Outline air survey	67·8	0·8	400·3	500·4	
	Konār Pipe Line Applique Slip—6-inch scale with contours at 10-foot vertical interval.					
Undulating ground with jungle of medium density and some cultivation	Air survey of contours only ..	2·0	0·4	1047·5	1309·4	High cost due to the work having to be revised a second time owing to discrepancies in the adjoining sheets.
	Konār Pipe Line—6-inch scale with contours at 10-foot vertical interval.					
Undulating ground with jungle of medium density and some cultivation	Air survey of contours only ..	9·0	0·8	455·5	569·4	
	Konār Reservoir—6-inch scale with contours at 10-foot vertical interval.					
Undulating ground with jungle of medium density and some cultivation	Air survey of contours only ..	18·0	7·2	39·2	49·0	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Net	*Overall	
No. 12 Party.—*Concld.*		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Concld.***
	Bokāro Coalfield—4-inch scale with contours at 10-foot & 50-foot vertical interval.					
Hilly ground with medium jungle ..	Complete air survey	171·0	1·0	148·8	186·0	
	Bokāro Dam—16-inch scale with contours at 5-foot vertical interval.					
Spurs with fairly dense jungle	Fair mapping of outline and contours	1·1	0·22	1907·2	2384·0	High cost due to a Class II Officer being wholly employed on supervision of the work.
	Dungri Limestone Deposit—4-inch scale with contours at 10-foot vertical interval.					
Hilly ground with medium jungle ..	Complete air survey	11·0	2·0	198·9	248·6	Partly form-lined.
	Dihāng Reservoir—2-inch scale with contours at 50-foot vertical interval.					
Densely wooded steep hills with deep gorges	Form-lining on photo mosaic ..	37·0	10·1	28·5	35·6	
	Kāziranga Game Sanctuary—1-inch scale.					
Open plains with scattered trees	Correction air survey of outline only	86·0	72·1	5·8	7·3	

*For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
Headquarters Section.—	**Morvi Town and Environs (Saurāshtra)—Scale 32 inches to 1 mile, contours at 4-foot interval.**	sq. m.	sq. m.	Rs.	Rs.	**SOUTHERN CIRCLE**
Congested town with open suburbs ..	Planimetric control and computations	4·00	0·89	116·3	116·3	
	Outline air survey	4·00	0·27	731·0	731·0	
	Ground verification and contouring	4·00	0·17	1147·0	1522·1	Cost rates exclude charges incurred by men under training.
	Fair drawing	4·00	·21	1391·8	1391·8	
	Combined project	4·00	0·39	3386·1	3761·2	
	Pennār Dam (Kistna–Pennār Project)—Scale 16 inches to 1 mile, contours at 5-foot interval up to 250 feet, at 10-foot interval between 250 and 500 feet and at 50-foot interval above 500 feet.					
Fairly steep wooded hills with cultivation ..	Planimetric and height control and computations	4·5	0·7	785·6	979·6	
	Air survey compilation of details and contours including fair drawing on Kodatrace air survey section	4·2	0·2	842·1	842·1	
	Combined project	4·2	0·5	1627·7	1821·7	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per acre		Remarks
				*Net	*Overall	
Headquarters Section.—*Concld.*		acres	acres	Rs.	Rs.	**SOUTHERN CIRCLE.—*Contd.***
	Pennār Reservoir (Kistna–Pennār Project)—Scale 4 inches to 1 mile, contours at 10-foot interval.					
Hilly, undulating ground with low jungle and open cultivated areas	Height control by tertiary levelling	360	9·2	29·2	34·0	Cost rates exclude charges incurred by men under training.
	Contouring on photo-mosaics ..	360	6·7	13·9	13·9	
	Combined project	360	8·0	43·1	47·9	
	Airfields (Landing Charts)—Scale 1 : 50,000, contours at 50-foot interval.					
Varies from jungle covered hills to the flat coastal belt, alternating with undulating and cultivated plains with scrub and scattered trees	Supplementary triangulation, height control and computations	160	14·2	44·7	47·7	Surveyors with no proper previous experience of plane-tabling were employed. Excludes fair drawing.
	Revision survey for landing charts	160	15·2	58·3	61·4	
	Combined project	160	14·7	103·0	109·1	
	Airfields (Approach Charts)—Scale 1 inch to 4 miles, contours at 250-foot interval.					
	Verification survey for approach chart	3360	704·4	1·4	1·6	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 6 Party.—	**Ukāi Dam Site—Scale 32 inches to 1 mile, contours at 5-foot interval.**	sq. m.	sq. m.	Rs.	Rs.	**SOUTHERN CIRCLE.—** *Contd.*
Cultivation and low densely wooded hills ..	Ground control by triangulation ..	2·5	1·5	1,425·3	1,904·8	
	Air survey compilation ..	2·3	0·4	1,684·2	2,103·2	
	Ground verification and contouring	2·3	0·2	4,387·1	5,480·3	
	Fair drawing	2·3	0·3	55·9	69·9	
	Combined project	2·3	0·6	7,552·5	9,558·2	
	Moj Commanded Area—Scale 4 inches to 1 mile, contours at 1-foot interval.					
Open plains	Ground control (Triangulation and Traverse)	60·0	21·8	70·4	91·8	
	Air survey compilation ..	60·0	17·1	17·3	21·5	
	Ground verification and contouring	60·0	8·9	190·3	247·4	
	Tertiary levelling	484·0 linear miles	69·1 linear miles	17·1 per linear mile	22·8 per linear mile	
	Fair drawing	60·0	3·0	47·0	58·8	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 6 Party.—*Concld.*		sq. m.	sq. m.	Rs.	Rs.	**SOUTHERN CIRCLE.—*Contd.***
	Combined project	60·0	12·7 69·1 linear miles	342·1	442·3	
	Kandla Port Development Reclamation Area—Scale 1 inch to 400 feet, contours at 6-inch interval.					
Open flat marsh	Ground survey	6·6	1·3	1,070·9	1,338·7	No fair drawing required.
	Quarry Area—Scale 1 inch to 200 feet, contours at 1-foot interval.					
Open flat plains	Ground survey	1·5	0·9	1,216·3	1,520·2	No fair drawing required.
	Topographical survey—Scale 1 inch to 1 mile, contours at 50-foot interval.					
Barren hills with cultivated valleys and scrub-covered plains	Triangulation for air survey compilation in Kutch State	2,040	190	10·2	13·2	
Hilly, medium jungle	Triangulation for ground survey in sheet 46 G	819	81·9	23·1	30·7	

* For explanation of 'net' and 'overall' rates see page 3.

TABLE C.—Areas, out-turns and cost rates of Surveys, Computations and Mapping

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Net	*Overall	
No. 8 Party.—	**Kistna Dam (Kistna–Pennār Project)—Scale 16 inches to 1 mile, contours at 5-foot interval.**	sq. m.	sq. m.	Rs.	Rs.	**SOUTHERN CIRCLE.—** *Concld.*
50% jungle covered hills and 50% open undulating cultivated plains	Supplementary triangulation and computations	8·0	12·0	115·0	150·0	
	Height control by resection and tertiary levelling and computations	18·0 linear miles	66·8 linear miles	63·0	83·0	
	Air survey compilation and fair drawing	8·0	0·7	730·0	912·0	
	Combined project	8·0	{ 6·4 / 66·8 linear miles	908·0	1,145·3	

* For explanation of 'net' and 'overall' rates see page 3.

III. TECHNICAL NOTES, NORTHERN CIRCLE

DIRECTOR :—{Mr. B. N. Saha, M.Sc., to 3-9-49 and from 21-11-49.
Lt.-Col. J. S. Paintal, R.I.E., from 4-9-49 to 20-11-49.

3. **Summary.**—During the period under report, the following survey units were under the administrative control of the Director, Northern Circle :—

No. 1 Party
No. 13 Party
No. 14 Party (up to 14-6-49)
No. 15 Party (up to 31-7-49)
No. 20 (Cantt.) Party
No. 2 Drawing Office
Stores Office, Surveys (up to 31-8-49).

Brief reports on the various survey operations carried out by the above mentioned units have been given in the General Report, 1950. As this report deals only with work of technical interest, no reference is made here to the activities of parties employed on work of a purely routine nature.

No. 1 PARTY

Officer in charge :—{Mr. N. L. Gupta, O.E., to 12-7-49.
Mr. P. S. Shinghal, O.E., from 13-7-49.

4. **General.**—Field strength of nearly the entire party remained employed on extra-departmental air and ground survey jobs, sponsored by the Central and State Governments in connection with their development projects. The main departmental task carried out was the survey of Palam Airport for preparation of the Landing and Approach charts in accordance with the specifications laid down by the International Civil Aviation Organization.

A brief description of the methods used in various project surveys is given in the following paragraphs.

5. **Surveys with brief description of country, etc.**—(*i*) *Tawa Reservoir.*—Air survey on the scale of 4 inches to 1 mile with contours at 20-foot vertical interval, was required for an area of 220 square miles by the Central Waterpower, Irrigation and Navigation Commission in connection with its multi-purpose development scheme in the Narbada valley. The area, which comprises the forest-covered catchments of the Tawa and Denwa rivers, falls in Hoshangābād and Betūl districts of Madhya Pradesh in sheets 55 F and J.

Air photography of the area was carried out in 1948 and planimetric and height control was completed in field season 1949–50.

The existing trigonometrical data of 1910–11 was plotted on 2 inches to 1 mile scale on projected plane-table sections and checked rigorously on the ground by plane-tabling. This data was

supplemented by observation of subsidiary stations or resection stations in areas where control was deficient. In the central area a triangulation scheme, based on a Hunter Short Base measurement and an astro-azimuth observation, was carried out to determine the accuracy of the existing triangulation. A difference of only 7 feet equivalent in the log side established by Hunter Short Base measurement and the largest log side of the existing triangulation was revealed. This being unplottable on 4 inches to 1 mile scale, existing triangulation data was considered satisfactory for planimetric control.

Vertical angles, using a theodolite, were observed to all trigonometrical stations and points found intact on the ground. This was done for two reasons ; (i) to bring all heights in terms of spirit-levelled heights and (ii) to check the heights of old stations and points. Connections to bench-marks were established at three places in the area.

Both clinometers and Paulin barometers were used to supplement heights to the required density for controlling 4 inches to 1 mile scale air survey in areas covered with dense forest. The method of using these barometers had been fully described under No. 1 Party, in Technical Report, 1948–49.

The area of work was extremely malarious and survey operations were badly handicapped by sickness among the staff.

(*ii*) *Punāsa Reservoir.*—Air survey of 600 square miles on 4 inches to 1 mile scale with contours at 20-foot vertical interval in sheets 55 B, C and F was asked for by the Central Waterpower, Irrigation and Navigation Commission in connection with its preliminary investigations for a storage scheme in the Narbada valley in Madhya Pradesh. A portion of this area near the dam site was taken in hand for reconnaissance towards the end of February.

(*iii*) *Bhākra Reservoir.*—The Chief Engineer, P.W.D. (Irrigation), Government of Punjab, initially required 4 inches to 1 mile scale original ground survey of 10 square miles in sheet 53 A and determination of co-ordinates of three points at the dam site. His demand increased subsequently to surveys over the entire reservoir area. The final requirements for survey were :—(i) to provide a contoured map of Bhākra Reservoir on 4 inches to 1 mile scale up to the limit of the 1700 feet contour involving a survey of 77 square miles, (ii) fixation of co-ordinates with levelled heights of certain strategic points at and near the dam site and (iii) laying out on the ground the 1280 and 1693 feet contours. Parts of jobs (i) and (iii) had to be left over for completion in the next field season.

Supplementary triangulation was carried out at the dam site to fix the position of seven points and to augment existing trigonometrical data in areas, where it was considered inadequate for 4-inch survey. A Hunter Short Base measurement and an astro-azimuth were observed as usual for checking the accuracy of existing data.

All heights were refixed by observations of vertical angles by theodolite; distances being taken from 4-inch survey plane-table sections.

The 1280 feet contour was located on the ground as described in the Appendix. One Surveyor with a squad of 8 men, working in close liaison with the local revenue staff, executed this task which presented unusual problems.

(*iv*) *Jumna Hydro-electric Scheme.*—The Chief Engineer, Uttar Pradesh, P.W.D. (Irrigation), required surveys on 32 inches to 1 mile and 4 inches to 1 mile scales for areas in the vicinity of Kālsi on the Dehra Dūn–Chakrāta Road, in sheet 53 F. The work was carried out by plane-table surveying. Framework was fixed by triangulation based on a Hunter Short Base extension and an astro-azimuth observation.

(*v*) *Sāmbhar and Didwāna Salt Lakes.*—The Salt Controller, Government of India, Ministry of Industry and Supply, placed a demand for a 2 inches to 1 mile survey of Sāmbhar Lake and an 8 inches to 1 mile survey of Didwāna Lake in sheets 45 I, J, M and N to enable the Rājasthān Salt Sources Division to formulate its plans for extracting salt from both these lakes to their utmost capacity.

The existing triangulation, being old and inaccurate was not accepted. Triangulation based on Hunter Short Base measurements and astro-azimuth observations, and tied to a G.T. station, was carried out separately in both the areas. Several double tertiary levelling lines to fix a number of bench-mark heights, were run around the periphery and across the bed of the lakes and contours at 1-foot vertical interval were surveyed by supplementary levelling and with the help of the *clinopole method*, described in Appendix I of Technical Report, 1947.

Detail on 2 inches to 1 mile and 8 inches to 1 mile scales was surveyed by methods of plane-tabling using the framework fixed by fresh triangulation. In the case of Sāmbhar Lake the survey of Sāmbhar town proper was carried out on the 4-inch scale and its reduction incorporated in the 2-inch survey of the area.

Survey of Didwāna Lake was completed at the beginning of February but contouring in the wet and slushy portion of the Sāmbhar Lake remained to be completed after the month of March 1950.

The final maps of both the lakes will carry a table of capacities.

(*vi*) *Pālam Airport.*—Survey on scale of 2 inches to 1 mile and rapid verification survey on $\frac{1}{4}$ inch to 1 mile scale were carried out for Pālam (Delhi) Airport in sheets 53 D and H in accordance with the specifications laid down by the International Civil Aviation Organization for production of Landing and Approach charts on 1 : 50,000 and 1 : 250,000 scales respectively.

Landing Chart (*1 : 50,000*).—Existing data found on the ground was quite adequate for the survey on the 2 inches to 1 mile scale, which was the scale on which fair drawn originals of the 1-inch

topographical map existed. Details of aeronautical and radio facilities were surveyed with particular care. A reference point, observed as a subsidiary station from two existing stations and connected to a bench-mark by double tertiary levelling, was fixed near the crossing of the two runways of the aerodrome, at a site selected by the Director-General of Civil Aviation. Objects, such as spires of temples, tall trees, etc., which constitute obstacles for air navigation and are known as "hazards", were heighted by observation of vertical angles using a theodolite.

Approach Chart (1 : 250,000).—An area of about 1,000 square miles on the ½-inch scale, centered on the main radio station of the aerodrome, was verified on the ground for main detail like roads, railways, rivers and main streams. All important obstructions and "hazards" were surveyed and heighted by theodolite observation of vertical angles. The plane-tabler took 32 days to finish the work which was done on a print of the ½-inch map of the area with all the office copy corrections incorporated thereon. New detail was surveyed with respect to existing detail and the trigonometrical stations and points appearing on the map.

(*vii*) *Korea–Rewa Boundary*.—The task was to demarcate in sheet 64 I, a boundary extending for 16 miles between Rewa and Korea States, in accordance with Captain W. Samuel's decision of 1870, which appeared on the old style one-inch maps. A conference of representatives of both the States and the Officer in charge, No. 1 Party was convened at Rewa before undertaking this job ; and the representatives of both the States agreed that the demarcation of the boundary by the Survey of India would be accepted as final.

Actual demarcation of the boundary accurately in terms of Captain Samuel's decision presented difficulties as the line offered very few identifiable points of detail. The entire boundary was transferred from maps on to plane-table sections with reference to existing identifiable trigonometrical data. After this the alignment of the boundary was fixed and demarcated on the ground by making plane-table fixings or by plane-table traverse, and pillars were constructed at salient points along the boundary.

The co-ordinates of all the pillars thus erected were fixed by a theodolite traverse connected by triangulation to a reliable trigonometrical station. Triangulation was itself based on Hunter Short Base measurement at both ends of the boundary.

A 200-yard wide strip was surveyed along the demarcated boundary on 4 inches to 1 mile scale with contours at 20-foot vertical interval. Finally both the States of Rewa and Korea were supplied with a map on 4 inches to 1 mile scale of the boundary and co-ordinates of all pillars.

A considerable amount of time was spent in clearing the boundary line which passed through forest-covered hills.

(*viii*) *Verification Survey.—Harsi Reservoir*.—Consequent on a report made by a pilot that a large lake (in sheet 54 G) had not been shown on the map, the office copy corrections in the vicinity of

Harsi Reservoir were verified on a published copy of the half-inch sheet 54 G/NE and the water-line of the reservoir and the dam with its works, etc., were inserted with respect to existing identifiable detail on the map.

Delhi and Locality Map.—A rapid verification in sheet 53 H of all the major roads falling in the Delhi and Surrounding Country map on 1-inch scale was carried out on prints of the component 1-inch sheets for the revised edition of the Delhi and Locality map, scale 1 inch to 1 mile.

6. **Fair Mapping and Air Survey.**—The undermentioned surveys, details of which are given in the Technical Reports of previous years, were completed for final printing.

(*i*) *Bargi Reservoir and Dam site.*—Air survey on 4 inches to 1 mile and 32 inches to 1 mile scales was carried out by the principal point radial line method on kodatrace, using planimetric and height control provided during the previous field season. Names, footnotes, headings, etc., were pasted on the originals, which were used for final printing.

(*ii*) *Patiāla Development.*—The survey on 16 inches to 1 mile scale was completed in 5 sheets, compiled as above.

(*iii*) *Rāmganga Reservoir.*—The air survey was carried out on 4 inches to 1 mile scale, in four sheets, using the old triangulation data for planimetric control and the height control, carried out in 1945 in connection with contoured photo-mosaics of Rāmganga Reservoir.

(*iv*) *New Delhi Development.*—54 sheets on the scale of 100 feet to 1 inch with contours at 5-foot vertical interval were fair drawn and submitted for publication.

(*v*) *Āgra Central Railway Station.*—3 sheets on 32 inches to 1 mile scale with contours at 10-foot vertical interval were fair drawn for publication on the same scale.

(*vi*) *Rewa and Satna Towns.*—3 sheets on 16 inches to 1 mile scale with contours at 10-foot vertical interval were fair drawn.

7. **Density and accuracy of control.**—The following table shows the density of control used and the accuracy achieved.

Scale of air survey	Planimetric Control		Height Control *		Remarks
	Density (yards apart)	Accuracy	Density (yards apart)	Accuracy	
2-inch (Karnali)	3,500	1 in 6,000	800	12 feet	New triangulation.
4-inch (Tawa)	4,000	1 in 6,000	400	10 feet	Old triangulation accepted.

* Paulin Barometers were employed for heights in wooded areas and deep streams.

8. **Training in air-cum-ground surveys.**—A training camp was opened in January 1950 to train junior draftsmen and plane-tablers

in air survey and plane-tabling. A short syllabus of training in air survey was drawn up and worked through.

The object of this course was to complete the training in air survey and plane-tabling of personnel of other units in the Circle.

No. 13 PARTY

Officer in charge :—{Mr. F. M. Hawley, to 2-4-49.
Mr. T. M. C. Alexander, from 3-4-49.

9. **General.**—The unit continued to be employed on surveys for canalization of the commanded area of the Bhākra Dam project for the Punjab Government.

The project involves construction of a dam, across the Sutlej River at Bhākra, which will increase the supply of water to existing canals in the State, and also provide water for additional canals. The work is being speeded up and the construction of main canals has already started.

10. **Description of country.**—The country surveyed during the year consists, for the most part, of flat and thickly wooded plains with occasional patches of cultivation. The area particularly in the north and east is affected by floods from the Ghaggar and the Saraswati rivers. This greatly impeded the progress of work.

11. **Field work.**—The methods of survey involved have already been fully described in previous reports. Rectangulation was continued to 100 acres only, though levelling was carried out as usual, to 25-acre rectangles, with the approval of the Punjab Government.

12. **Accuracy required.**—Permissible closing errors of different types of work carried out are given below :—

(*a*) *Position*

(i) Triangulation .. 1 in 4,000
(ii) Rectangulation .. 1 in 1,000

(*b*) *Heights*

(i) Double tertiary circuits....$0 \cdot 05\sqrt{M}$ feet,
where M is the length of the circuit in miles.
(ii) Single tertiary.....0·3 feet in 4 miles.

13. **Recess work.**—During recess the levelled heights were reduced to mean sea-level and plotted on the 4-inch sheets. Contours at 1-foot vertical interval were interpolated and drawn for the area surveyed during the previous field season.

No. 20 (CANTONMENT) PARTY

Officer in charge :—Mr. M. D. Nangia, B.A.

14. **Purpose of survey.**—The party surveyed cantonment and other military lands in the Western, Eastern and Southern Commands on different scales in accordance with the programme approved by the Engineer-in-Chief in India and the Ministry of Defence.

The work done may be divided into two main categories based on the purpose for which required :—

(*a*) Record purposes.

(*b*) Planning purposes.

15. **Accuracy.**—

(*a*) *Survey and mapping for record purposes.*—These surveys were to fix accurately the boundaries and detail of military lands. The framework consisted of theodolite traverse and the height control was from secondary and tertiary levelling. For bāzār areas the scale of survey was usually 64 inches to a mile and an accuracy of 1 link in position was aimed at. For cantonment areas, the scale of survey was usually 16 inches to a mile and an accuracy of 5 links in position was obtained.

The mapping was done by normal methods on the scale of survey and the maps were printed in black and brown with a red tint for sites.

(*b*) *Survey and mapping for planning purposes.*—These surveys were usually of sites that were to be developed, and were based on theodolite and plane-table traverses, as a high standard of accuracy was not required. As the maps were urgently required, normal fair drawing was not done. The maps of these sheets were produced in some cases by merely photographing the plane-table sections completed for names, heights, etc. In other cases traces were supplied to the Chief Engineers for preparation of ferro-prints.

16. **Methods of survey.**—In brief, the normal method of detail survey for record purposes was traversing with the chain and optical square between fixed points. Interpolations and intersections were used only in open areas.

For surveys for planning purposes usually interpolations and intersections were used.

IV. TECHNICAL NOTES, EASTERN CIRCLE

DIRECTOR:—Colonel R. T. L. Rogers, M.A. (Cantab.).

DY. DIRECTOR:— (Mr. M. M. Ganapathy, B.A., to 31-8-49 and again from 29-10-49.
(Mr. J. C. Ross, from 1-9-49 to 28-10-49. (Current duties).

17. **Summary.**—This report deals with the technical work of the following parties :—

No. 5 Party.
No. 9 Party.
No. 11 Party.
No. 12 (Air Survey) Party.

The technical reports of the following Calcutta units are incorporated in Part II of this report which deals with map publication and drawing office work :—

No. 5 Drawing Office.
Photo-Litho Office.
Engraving Office.

During the year under report, no normal departmental topographical survey work was taken up. Surveys were carried out for development projects such as hydro-electric, irrigation, town planning, river control and railway construction ; for a private firm in connection with land holdings of tea gardens, and for geological investigations.

18. **Technical Methods.**—There was very little departure from the standard methods for the types of project surveys which have been going on since the war. These methods have been described in past Technical Reports and any modifications worthy of note have been described in the parties' reports, which follow.

Mention was made in the 1948–49 Technical Report of the possibility of irrigation engineers accepting a more simplified and rapid type of 4-inch mapping for the planning of canal systems in "commanded" areas. The acceptance of a less rigorous type of air survey than was previously carried out for the Kosi and Māhānadi (Hirākud) irrigation projects was confirmed and a start was made on the surveys for the Gandak irrigation project using the simplified methods. The new method, which has the great advantage of rapidity of out-turn and cheapness (the cost being less than one-third that of previous surveys carried out for similar areas), is described in No. 11 Party's report.

The new principle involved is that the requirements of the irrigation engineers will be met, in fairly flat areas, by 4-inch "picture" maps on which the detail has not been rigorously air-surveyed. It is traced from "controlled" air photo mosaics and,

although relatively accurate within limited areas, the scale is liable to errors between distant points. Such maps will meet the engineers' planning requirements provided the 1-foot contours are correct with respect to nearby detail and provided a network of bench-marks are left all over the "commanded" area which can subsequently be used as close control for level lines along proposed canal alignments. The new method has been designed to meet the above requirements and it is hoped that it can be widely adopted, with consequent great saving in expenditure, for future irrigation surveys in areas to which the method is suited.

In revision surveys from air photographs on both the 1-inch and larger scales, use has been made of a film positive of the previous survey, enlarged to the scale of the photographs, as a suitable medium on which to carry out the air photo revision. Certain qualities of film have little distortion, the line work is easily erased, and the revised detail can be very adequately drawn in a mixture of photopake and ink. Use of the reddish coloured photopake is an advantage both from the point of view of line density for future reproduction and because the difference in colour makes it easily apparent as to what has been revised. This is valuable for examination purposes.

No. 5 PARTY

Officer in charge :—Mr. K. C. Gosain, B.A.

19. **General.**—The party was employed on the following special jobs :—

(*a*) Ground control for 4-inch air survey of Dihāng Reservoir and 16-inch air survey of Dihāng Dam for the Central Waterpower, Irrigation and Navigation Commission.

(*b*) Ground control of Tezpur and Gogra Tea Estates in Assam for Messrs. Jardine Henderson, Limited, Calcutta.

(*c*) Rapid revision of existing one-inch maps covering the Mokamehghāt area on the Ganges River from air photographs for the Engineer-in-Chief, Ganga Bridge Project, Mokameh.

(*d*) 4-inch revision air survey and fair mapping of Kopili Flood Control area for the Chief Engineer, Public Works Department, Assam.

20. **Personnel.**—The average technical strength which could be utilized for air survey and fair mapping was 1 Officer Surveyor, 4 Surveyors, 2 Survey Assistants, 1 Division I Draftsman, 20 Planetablers and Draftsmen ; for field work the average strength was 3 Officer Surveyors, 5 Surveyors, 2 Planetablers and 1 Computer ; and for computations the average strength was 1 Surveyor and 6 Computers.

21. **Area Surveyed.**—Area for which planimetric and/or height control was provided—either by triangulation, traverse, theodolite levelling or clinometer—totalled approximately 181 square miles.

Area surveyed by air and/or ground methods on 1-inch, 4-inch and 16-inch scales totalled 932 square miles.

22. **Field Work.**—(*a*) *Dihāng Reservoir, Dam and Commanded Area* falling in sheets 82 L, 82 P, 83 I and 83 M in North-East Frontier Agency and Lakhimpur district of Assam.

Requirements.—The indentor required

(1) 4-inch air survey maps with contours at 50-foot intervals on either side of the gorge up to the 1,050-foot contour and, with form-lines thereafter, up to available height control.

(2) 16-inch air survey maps of Dam site with contours at 10-foot intervals up to the limit of 1,100 feet above Mean Sea-Level.

(3) Fixing of tertiary bench-marks—one at the Dam site, four on the left bank of the Dihāng River and four on the main road between Pasighāt and Kobo.

Planimetric control.—Fixation of plan control by triangulation, below the limit of the 1,050-foot contour on either side of the river bed was found impracticable in the first 50 miles of the Dihāng valley and the first 20 miles of the Siyom valley. Theodolite traverse, mostly with Substense Bar and Hunter Short Base, was, therefore, resorted to. For controlling these traverses, a series of minor triangulation, based on measured base and observed azimuth, was extended from Pasighāt, north and westwards and connected, for geographical position, to an existing minor triangulation station. In the upper reaches of the Dihāng and Yamne valleys and in the Dam area, triangulation with independent bases and azimuths was carried out, with connections to the foregoing triangulation series for geographical positions.

Height control.—(i) *Dihāng Reservoir.*—A bench-mark was established at Pasighāt, by running a line of double simultaneous tertiary levelling from the nearest available Primary Protected Bench-mark at Dibrugarh. This line is about 100 miles long and was taken across the Brahmaputra river at a point near Kobo, the crossing having been effected by means of simultaneous reciprocal theodolite observations. The requirement of absolute accuracy of the height of the bench-mark was not very high and so the departmental method of observing vertical angles during the hours of minimum refraction over a period of 2–3 days was not strictly adhered to; the crossing being carried out in a single day's observation. Nor was it considered necessary to check the accuracy of the line by back levelling.

The establishment of several other bench-marks, as required by the indentor, across the Dihāng river in the Commanded Area, was

also effected in a similar manner. But in this case, observation was restricted to the hours of minimum refraction and was spread over a period of two days.

The Reservoir triangulation series was connected to the bench-mark so established at Pasighāt for height above Mean Sea-Level. For providing the requisite number of height control points, triangulation and traverse framework was supplemented by taking clinometer readings and theodolite vertical angles to objects which were identified on air photographs. Heights obtained by clinometer were computed in the field by measuring distances from the field charts on the 2-inch scale and those fixed by theodolite will be computed in recess by taking distances from the air photo combination sheets on the scale of 4 inches to a mile.

(ii) *Dihāng Dam.*—Contouring is to be done on the ground during the next field season.

Effects of terrain on out-turn of work.—The height of Pasighāt is about 500 feet above Mean Sea-Level, the area of work extending from Pasighāt to Bomdo (nearly 110 miles) in the Dihāng (Siang) valley, from Yekshing to Pakshing (nearly 50 miles) in the Siyom valley and 12 to 14 miles in the Yamne and Shimang valleys.

The terrain is extremely difficult for survey and is fully described in the General Report, 1950. The out-turn for this job was very low and the cost was, therefore, high, owing to the difficulties of the terrain, bad weather conditions, the necessity for carrying supplies over long distances and the scarcity of porters for this purpose, the very poor communications including difficulties in crossing the river gorges, and the fact that part of the operations were carried out in unexplored tribal areas where military escorts were necessary.

(*b*) *Tezpur and Gorgra Tea Estate in Assam* falling in Sheet 83 B, in Darrang district.

The 16-inch tea garden surveys were described in the Technical Report, 1948–49.

23. **Air Survey and mapping at headquarters.**—(*a*) *Kopili Flood Control ; Sheets Nos. 78 N and 83 B.*—The combination of air photos, on 4-inch to 1 mile scale, enlarged from 2-inch contact prints was carried out by the graphical radial line method and the detail was air-surveyed. The spot level heights were plotted and their positions adjusted between control points on drawing paper sheets projected on the drawing scale ; they were later traced on to kodatrace, which, with the roads which had been surveyed on it, served as the Red Original. Contours were not surveyed on the ground but were interpolated with the help of level heights. Originals were prepared for printing in 5 colours : grey for outline and names, red for level heights and roads, brown for contours, solid yellow for cultivated areas and solid blue for perennial water.

(*b*) *Ganga Bridge Project ; sheet Nos. 72 G and K.*—Existing 1-inch maps were revised rapidly from air photos for detail only. One film positive and two strong purple prints, on the reverse of kodatrace, of existing 1-inch maps were used. Corrections were first carried out on the purple prints direct from inked-up photos, using the existing detail as control, and later these corrections were incorporated on the film positives. These corrected film positives were mosaiced on drawing paper completed for headings and footnotes and served as fair originals. The maps were published in two colours : black for detail and names and light blue tint for perennial water.

No. 9 PARTY

Officer in charge :—Mr. H. H. Phillips, B.SC. (Hons.).

24. **General.**—The party was employed on surveys in connection with the Kosi irrigation project to meet the requirements of the Central Waterpower, Irrigation and Navigation Commission by producing suitable maps for the planning of an extensive system of irrigation canals covering the area.

Some triangulation was also carried out to connect the North-East Longitudinal G.T. series running through north Bihār and a new series in the hills to the north.

25. **Personnel.**—The average technical strength of the party was :—

Gazetted officers	..	5
Other technical personnel	..	71

26. **Areas surveyed.**—

1,053 square miles of 4-inch survey in the "Commanded" area of the Kosi project.

1,400 square miles of correction survey, from air photographs of 1-inch maps for the course of the Kosi river.

27. **Technical methods.**—(*a*) *Kosi Irrigation.*—The standard method for irrigation surveys, which has been fully described in previous Technical Reports, was followed except for the changes in the "stonelaying" procedure described below :—

The out-turn was appreciably increased by the employment of levellers instead of plane-tablers on stonelaying, the number of irrigation sheets done this season being 39 as compared to only 20½ sheets in the previous season. Whereas in the past a plane-tabler did the stonelaying and ground verification for air survey and the leveller had to wait till a sufficient number of stone pillars had been embedded, under the new plan the plane-tabler confines himself to ground verification for air survey, thereby completing many more sheets in a given time. As there are almost

three times as many levellers as plane-tablers in the party, the former can quickly carry out stonelaying a fairly large area thus providing themselves with a good number of embedded stones along the lines of which they are to carry out tertiary levelling.

An added advantage to the levellers carrying out the stonelaying is that the former are familiar with the positions of the embedded stones and do not waste time searching for them when they come to level the stone lines.

Some time was spent at the beginning of the field season in training the levellers to use air photographs for the stonelaying work, but this was amply compensated for by the increased out-turn as stated above.

(*b*) *Use of Bilby Towers.*—Bilby Towers were used for the first time in the Department for the triangulation carried out to connect the North-East Longitudinal G.T. series and previous triangulation in the hills to the north.

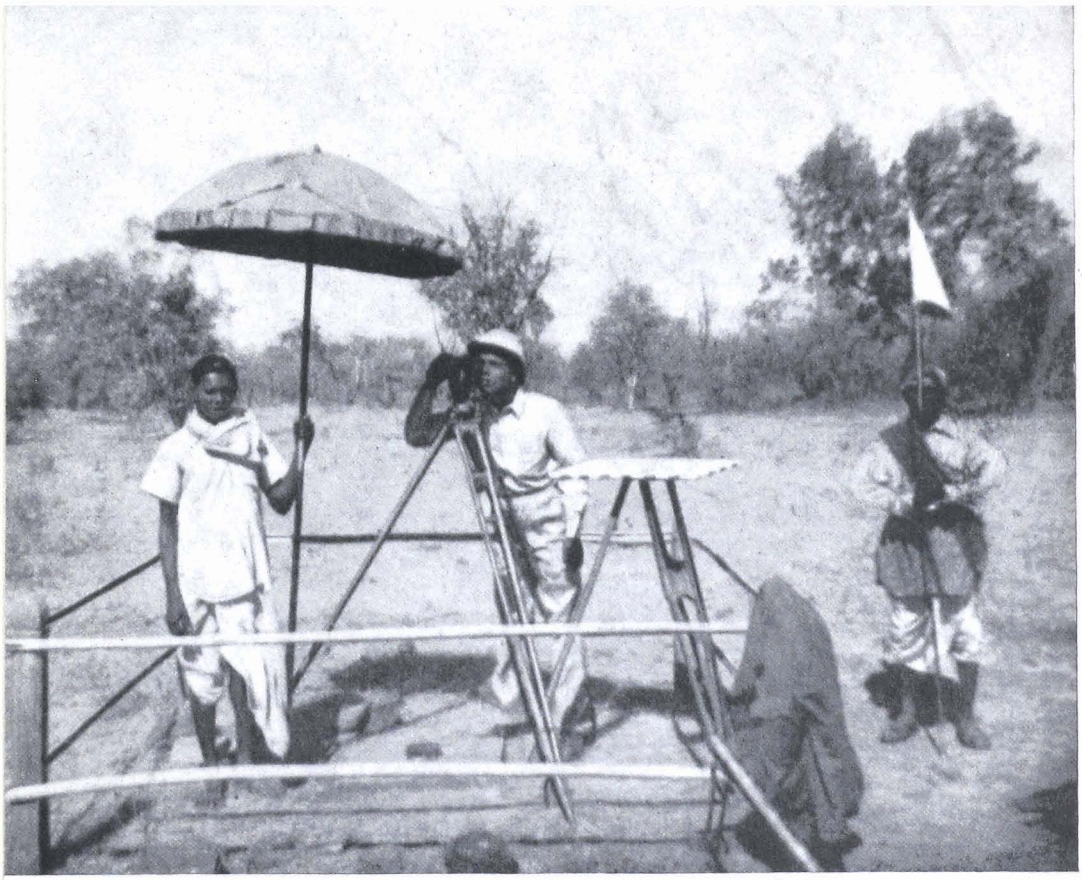
The Bilby Towers were erected to a height of 50 feet each over the lower undisturbed mark-stones of two adjacent G.T. stations in the Bihār plains. The erection was done by a team of trained erectors.

These Bilby Towers consist of steel latticed double structures on equilateral triangular bases, each structure being completely independent of the other, and each being securely anchored in the ground. The inner structure supports the instrument or signal and the outer structure supports the observer, his recorder and the observation tent or shelter.

The instrument, supported on the inner tower, was centered over the station mark in the following manner :—

Another observer positions a second theodolite, from which collimation errors have been previously removed, about 100 feet away from the base of the tower and after levelling this instrument he intersects the station mark. He then swings the telescope up, and directs the observer at the top of the tower to move the 'tower' theodolite in a direction at right-angles to the 'ground' instrument's line of sight until the vertical wire of the 'ground' instrument falls on the centre of the plumb-bob's suspension hook of the 'tower' theodolite. The 'tower' instrument is then lightly clamped. The 'ground' instrument is then moved to a new position at 90° to the first position and the above procedure is repeated. The 'tower' instrument is again lightly clamped and the setting checked from a third position of the 'ground' instrument. The 'tower' instrument is firmly clamped when the final correct setting has been checked from two ground positions.

(*c*) *Correction survey.*—As the course of the Kosi river had changed considerably since the original 1-inch survey was carried out



Top.—Traverser at work on the Upper Mahanadi Reservoir survey.

Bottom.—Secondary leveller at work on the Kosi Project survey.

and as the Central Waterpower, Irrigation and Navigation Commission desired to have up-to-date maps showing the present course of the Kosi, it was decided to revise the 1-inch maps from the latest available information without actually going on the ground. This information consisted of the air photography taken in 1946–47 in connection with the Kosi project.

The corrections to the 1-inch maps concerned were carried out as follows :—

As the photography was at the 2-inch scale, film positives of the 1-inch outline originals were obtained on the 2-inch scale.

In the area affected the photo-centres were resected from unchanged detail well away from the banks of the river. Using these resected positions and bases the new course of the Kosi river was surveyed.

No. 11 PARTY

Officer in charge :—Mr. S. C. Chatterjee, B.SC. (Hons.).

28. **General.**—No. 11 Party was employed on the following work :—

(*a*) 4-inch irrigation survey of the Mahānadi (Hirākud) Commanded area.

(*b*) Planimetric and height control for the Upper Mahānadi Reservoir area for air survey on the 4-inch scale and planimetric control for the Dam site area for air survey of the detail only on the 32-inch scale, the contouring to be carried out on the ground.

(*c*) Height control for Gandak Barrage area for a "picture" map traced from mosaics on about the 4-inch scale.

(*d*) Landing and approach chart surveys on $1\frac{1}{2}$-inch and $\frac{1}{4}$-inch scales respectively, of Gaya, Bhubaneswar, Dum Dum and Mohanbari airfields, according to the specifications laid down by the International Civil Aviation Organization.

(*e*) Airfield survey on the 16-inch scale.

29. **Personnel.**—The average technical strength of the party was :—

Gazetted officers	5
Other technical personnel ..	63

30. **Areas surveyed.**—

236·2 square miles of 4-inch survey of the commanded area of the Mahānadi (Hirākud) project.

80 square miles of planimetric and height control for 4-inch air survey of the Upper Mahānadi Reservoir and 32-inch air survey (detail only) of the Dam site.

2,401·6 square miles in which height control was provided by secondary, double tertiary and tertiary levelling for the 4-inch mapping of the Gandak commanded area.

152·2 square miles of 1½-inch revision survey and 3,806 square miles of ¼-inch verification survey for Landing and Approach charts for the International Civil Aviation Organization.

1·1 square miles of 16-inch ground survey of an airfield for the Ministry of Defence.

31. **Technical methods.**—(*a*) *Mahānadi (Hirākud) commanded area.*—The surveys carried out during the period under report completed the total area of 2,038 square miles required by the indentor. The methods used remained unchanged and are fully described in previous Technical Reports.

(*b*) *Upper Mahānadi Dam and Reservoir.*—The planimetric control for the 4-inch reservoir air survey was provided by minor triangulation which was based, for position, on previous topographical triangulation in the area. New bases and azimuths were measured and observed. The height control for 10-foot contouring was provided by clinometer observations, using tachymetric distances, to points easily identifiable on the photographs.

The planimetric control for the 32-inch Dam site air survey was provided by traverse of a more precise nature than ordinary topographical traverse. The 5-foot contouring will be carried out on the ground on plane-table sections of the 32-inch outline, compiled by air survey methods.

(*c*) *Gandak Irrigation Project.*—The terrain in the commanded area being very flat, a novel method of rapid 4-inch mapping with 1-foot contours was decided on for this project. It was decided that from enlargements of the 2-inch air photography, 4-inch controlled mosaics would be prepared. The topographical detail was then to be traced directly from the mosaics and the 1-foot contours were to be interpolated from a mesh of levelled heights, pricked on the photographs in the field and subsequently marked on the mosaics. The final maps were to be printed in two colours —black for detail and names and brown for contours.

The control for the 4-inch mosaics was taken from the 1-inch maps of the area ; points which were easily identified on the photographs and which would have been accurately surveyed originally, were chosen.

The control for the 1-foot contouring was provided by a uniform mesh of levelled heights covering the whole area. The levelling was controlled by secondary circuits, connected to the precision network, around the periphery of the area which was broken down into blocks by double tertiary level lines run between secondary bench-marks. These blocks were of such a size that the final tertiary level lines, between double tertiary bench-marks, were

never longer than ten miles. The tertiary lines were at half mile intervals and semi-permanent bench-marks were made along them at distances not greater than half a mile apart. These semi-permanent bench-marks were made on existing features such as rock outcrops, bases of large trees, culverts, bridge abutments, "pucca" wells and plinths. The positions of bench-marks, and all other staff positions which were easily identifiable on the photographs, were pricked by the levellers. In addition, important level heights of prominent tops and river beds were obtained and pricked on the photographs. In designing the lay-out of the level network, the tertiary level lines were made to run in the direction of the general slope of the terrain.

(*d*) *Landing Chart.*—The surveys, for the final production of charts on 1/50,000 scale, were carried out according to the specifications laid down by the International Civil Aviation Organization. As the four airfields surveyed were covered by modern 1-inch maps prints on the 1½-inch scale of the maps were used for revision on the ground. The geographical position of the aerodrome reference mark was fixed by traverse and its height by a double tertiary levelling connection to the nearest precision bench-mark. The height control required for establishing ground and obstacle heights in the Landing chart area was fixed by tertiary levelling.

(*e*) *Approach Chart.*—These surveys, for the final production of charts on the 1/250,000 scale, were also carried out according to the specifications laid down by the International Civil Aviation Organization. The existing ¼-inch maps were revised on the ground and the heights of important obstacles were obtained by observations of vertical angles using a theodolite from positions whose ground heights were known.

No. 12 (Air Survey) PARTY

Officer in charge:— Mr. J. C. Ross, to 30–8–49.
Mr. N. C. Sen. B. Com., from 31–8–49 to 12–12–49.
Mr. J. C. Berry, from 13–12–49.

32. **General.**—The party carried out extra-departmental air surveys on different scales and for various purposes for Central and State Government departments.

33. **Personnel.**—The average strength of the party was 4 gazetted officers and 32 non-gazetted personnel including 4 clerks.

34. **Areas surveyed.**—The total area surveyed from vertical air photographs, on various scales was 402 square miles.

35. **Air Survey.**—Air survey was carried out as detailed below :—

(*a*) *Dihāng Reservoir ; sheets 82 L and 82 P.*—Air survey of contours only on a photo-mosaic, at a vertical interval of 50 feet, on the 2-inch scale, for the Central Water-

power, Irrigation and Navigation Commission. Control for the contouring was taken from the existing 1-inch maps of the area.

(*b*) *Bokāro Coal-field ; sheet 73 E.*—Complete air survey on 4-inch scale, with contours at vertical intervals of 10 and 50 feet. The interval of 50 feet covers the area of high hills and was agreed to by the Geological Survey of India, for whom the work was being carried out.

(*c*) *Dungri Limestone Deposit ; sheet 60 O.*—Air survey on 4-inch scale, with contours and form-lines at a vertical interval of 10 feet, for geological investigations in connection with the Mahānadi (Hirākud) Project being carried out by the Central Waterpower, Irrigation and Navigation Commission. For the area in which hill features were shown by form-lines, the height control was obtained from the existing 1-inch map. A portion of the area was compiled from the Hirākud Reservoir sheets, which are on the same scale.

(*d*) *Calcutta Urban Drainage Scheme ; sheet 79 B.*—Revision air survey on 6-inch scale of detail only, for the Irrigation and Waterways Directorate, Government of West Bengal. Revision was carried out on film positives of the 6-inch Calcutta and Howrah Guide Map. The contouring is being undertaken by the Executive Engineer, Urban Drainage Division at 6-inch vertical interval from levelling carried out by his personnel.

(*e*) *Konār Reservoir ; sheet 73 E.*—Air survey revision of contours only, on 6-inch scale, at a vertical interval of 10 feet, for the Dāmodar Valley Corporation. The contours had to be revised because height discrepancies were discovered, during field season 1948–49, in an adjacent surveyed area which affected the contours in the reservoir sheets. The detail as previously surveyed, except for a few minor changes, was accepted. A separate name original was prepared.

(*f*) *Appliqué slips to Konār Pipe Line and Pipe Line Extension ; sheet 73 E.*—The revision of the 10-foot contours in these sheets was carried over from the previous year. The necessity for the revision was the same as given above for the reservoir sheets. This work was reported in the 1948–49 Technical Report.

36. **Technical Notes on air survey.**—(i) Combination in all cases was carried out by the principal point radial line method.

(ii) Detail which could not be identified on photographs, road and track classification, names, relative heights, etc., were picked up in the field at the time of fixing control, or, failing that, were taken from the existing largest scale published maps of the area.

37. **Control.**—Ground control for the above surveys was carried out in previous years and has already been referred to in the reports for those years.

V. TECHNICAL NOTES, SOUTHERN CIRCLE

DIRECTOR :—Mr. H. M. Critchell.

DY. DIRECTOR :— { Mr. J. C. Berry, to 13-11-49.
Mr. P. A. Thomas, from 14-11-49.

38. **Summary.**—At the end of the period under report, the following survey parties were under the administrative control of the Director, Southern Circle :—

No. 6 Party
No. 8 Party
No. 10 Party
No. 17 Party.

Besides the above, the Headquarters Section under the direct control of the Director, Southern Circle, had also to carry out several project surveys. No reference has been made to Nos. 10 and 17 Parties' work in these notes, as these parties still continued as training parties. No. 17 Party was disbanded on 20th March 1950.

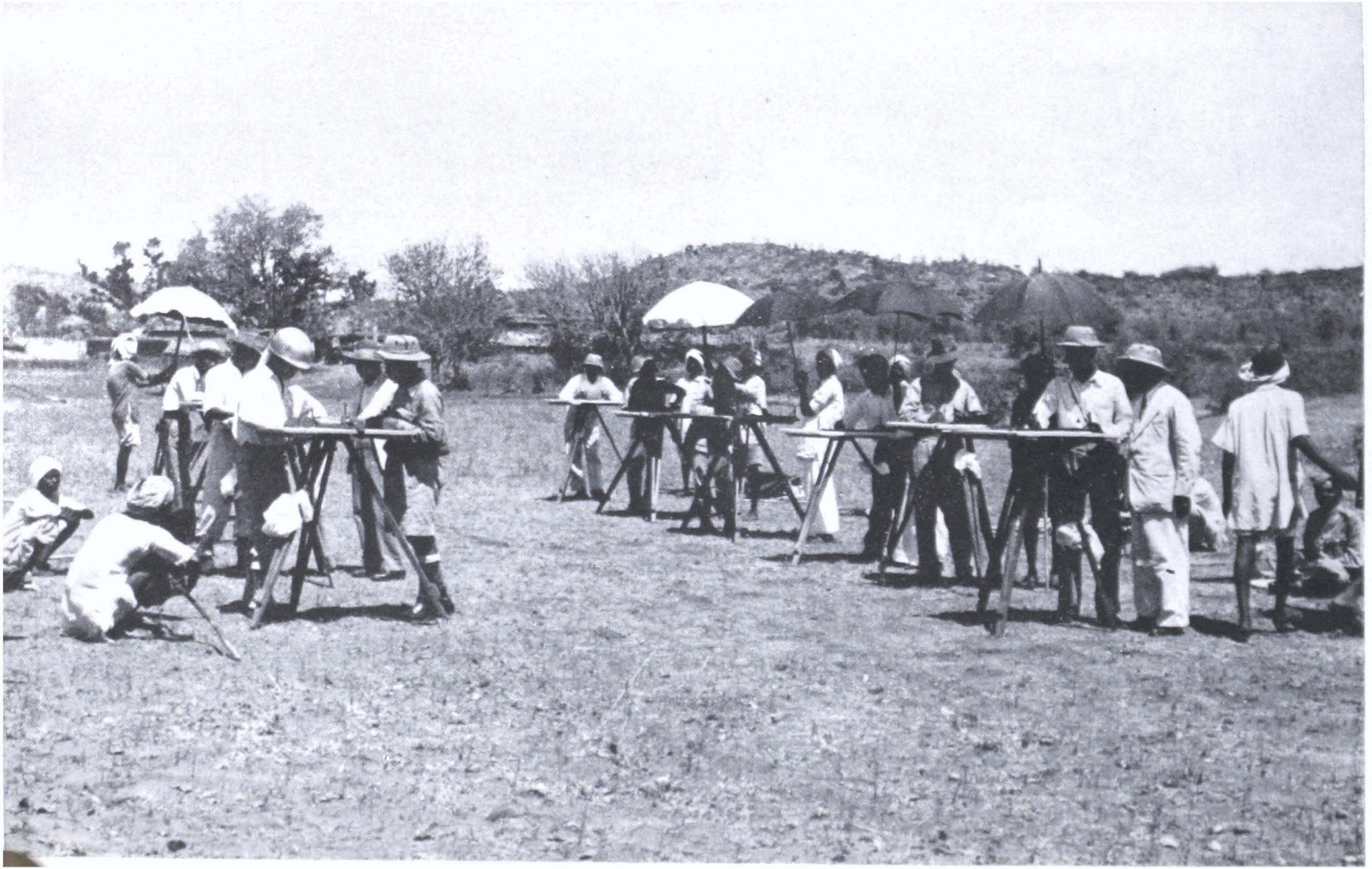
HEADQUARTERS SECTION

39. **General.**—The Headquarters Section under the charge of Mr. M. W. Kalappa (Class I) was employed on the following air survey and mapping of minor projects and topographical surveys for Landing and Approach charts :—

(*a*) Pennār Reservoir
(*b*) Pennār Dam
(*c*) Morvi Town and Environs
(*d*) Pej-Ulhās Irrigation Project
(*e*) Airfield Surveys.—Landing and Approach charts of Bangalore (HAL), Belgaum, Bombay (Juhu and Santa Cruz), Madras (St. Thomas Mount) and Trichinopoly Airfields.

The scales of survey and specifications varied for the different projects, which are briefly described below.

40. **Pennār Reservoir.**—The object of the preparation of the contoured mosaics for this project and the method employed for fixing the height control in the area has already been reported in the Technical Report, 1948-49. Contours at 10-foot vertical interval were first drawn on the loose 4-inch photo enlargements with the help of heights fixed and marked on photographs on the ground. These contours were subsequently transferred on to the 4-inch photo-mosaics under stereoscopic fusion.



Trainees under instruction in No. 10 Party.

The majority of the personnel employed on this job were Topographical Trainees, Type 'B'.

41. **Pennār Dam.**—The survey of an area of 4·2 square miles, on scale 16 inches to 1 mile, with contours at 5-foot vertical interval up to 250 feet, 10-foot vertical interval between 250 and 500 feet and 50-foot vertical interval above 500 feet was required by the Chief Engineer for Irrigation, Madras, for dam construction purposes.

The planimetric control was carried out by triangulation. A dense network of heights was fixed by observing vertical angles with a theodolite from known positions and heights, to the required points, marking them on photographs on the ground, intersecting their positions on the air survey plot sheet and computing their heights from the distances scaled off from the plot sheet. All the heights were in terms of a spirit-levelled bench-mark, fixed in the area by the P.W.D., Madras, which itself was based on the G.T. Levelling main-line No. 14, in sheet No. 57 N.

The air survey compilation was carried out by the normal radial line method in the recess. Detail not clear on the photographs and place names were verified on the 16-inch photo enlargements on the ground by the officer who carried out the ground control.

42. **Morvi Town and Environs.**—The survey of an area of 4 square miles, on scale 32 inches to 1 mile, with contours at 5-foot vertical interval was originally required by the Dewan, Morvi State, in 1947, for town development purposes.

The normal method of ground control and radial line method of air survey compilation for detail were used for this survey. The compiled detail was verified and contoured with the help of clino-poles on the ground, partly on foil-mounted blue prints for open suburbs of the town and partly on foil-mounted black prints for congested town areas. The black prints were found better than the blue prints, as they obviated the need of inking in black the limits of buildings, roads, etc., found correct during verification. They also avoided misinterpretation of detail, which is common with blue prints, in the hands of inexperienced plane-tablers. Personnel under training were employed for the ground verification and contouring.

43. **Pej-Ulhās Irrigation Project.**—The survey of an area of 27 square miles, on scale 4 inches to 1 mile, with contours at 5-foot vertical interval was required by the Superintending Engineer, P.W.D. (Irrigation), Bombay Circle, Bombay. This project is part of a scheme of the 'grow more food' campaign of the Bombay Government, to utilize the tail waters of the various hydro-electric power stations in their State for irrigation purposes. In this project, they propose to utilize the tail water of the Bhivpuri Power House, now running waste into the sea, for irrigation on either side of the Pej-Ulhās River.

During the year, only the planimetric control was carried out by the normal method for project surveys. The air survey compilation

of detail will be done during recess 1950 and the ground verification and contouring will be carried out in the field season 1950–51.

44. **Airfield Surveys.**—Surveys were required by the Director-General of Civil Aviation for the preparation of Landing and Approach charts of the various airfields indicated in para 31 (e) above. The surveys were carried out in accordance with the specifications laid down by the International Civil Aviation Organization.

Blue prints of modern 1-inch sheets were obtained on foil-mounted plane-table sections, on scale 1 : 50,000, and a revision survey of an area of 30 square miles, centered on the airfield, was carried out for the Landing chart by ground survey methods.

Cloth-mounted prints of the latest ¼-inch maps were used for verification survey in the field for the Approach charts.

On both the charts, special attention was paid to the survey of positions and heights of conspicuous obstructions and hazards, likely to endanger the safety of a plane in flight.

45. **Miscellaneous.**—All the airfield surveys, except one (which was completed by a Survey Assistant, assisted by a Temporary Computer) were carried out by Surveyors who had very little previous plane-tabling experience. This work provided them with good training and experience in topographical surveys. It was found economical to employ one Surveyor on both the Landing and Approach chart surveys for each airfield.

No. 6 PARTY

Officer in charge :— { Mr. M. R. Nair, B.A., to 23–11–49.
{ Mr. P. A. Thomas, from 24–11–49.

46. **General.**—The party was employed almost exclusively on surveys other than normal departmental topographical surveys. The programme was framed in response to heavy demands from the Development Commissioner, Kandla Port, the Central Waterpower, Irrigation and Navigation Commission and the Director General of Civil Aviation and comprised surveys for port development, land reclamation, town planning, water-supply, geological investigation, road and railway alignment, dam sites, reservoirs, airfields and Landing and Approach charts.

Scales of survey and specifications varied for the different projects which are briefly described below :—

47. **Kandla Port Development.**—Surveys for this purpose formed the biggest and most important item of the party programme. Due to the loss to Pakistān of the port of Karachi on the partition of India and the consequent over-congestion in other ports on the West Coast, a Commission was set up to investigate other suitable sites. The availability of deep water even at low tide in the Kandla Creek and the comparative shelter of the Gulf of Kutch influenced the

Taking readings at the tide pole at KANDLA. The recorder reads the water level every five minutes. It is hoped soon to instal an automatic tide gauge in place of this tide pole.

Commission in their decision that the small existing port of Kandla could be suitably developed.

(i) Surveys were mainly required for

(*a*) Port site planning and development on 4-inch scale with 10-foot contours in sheet 41 I.

(*b*) Port environs for town planning, water-supply and geological investigation on 1/25,000 scale with 25-foot contours in sheet 41 I.

(*c*) Geological investigations further afield on 1-inch scale with 25-foot contours in sheets 41 E, F, I and J.

The method employed for (a) above was the normal one for air surveys, i.e., firstly, the plan and height control and postpointing on photographs, secondly, the combination by slotted template and compilation, thirdly, the ground verification and contouring on blue prints obtained from the compilation. In flat areas it was necessary to follow contours by levelling.

A variation of the above method, used in previous seasons with success, was necessitated in the case of (b) and (c) above by the late arrival of the photographs. Since there was not sufficient time to complete the combination and compilation, the ground verification was done on the photographs themselves. The photographs were chalked for detail difficult to interpret and colour traces were maintained for individual photos. In hilly and undulating areas, heights were fixed on a plane-table section and their positions identified on the photographs for eventual contouring on the photographs themselves. In flat areas the contours were followed out on the ground by clinometer and plane-table and then drawn in on the photographs in the field.

(ii) Two small additional large scale jobs, one on the scale of 1 inch to 400 feet with contours at 6-inch intervals, and the other on the scale of 1 inch to 200 feet with 1 foot contours, were urgently required at short notice during the course of the field season and were complied with. The surveys were required in connection with land reclamation, *bunding*, volume calculations and quarrying.

The method employed was a combination of plane-tabling, levelling and tacheometry. After a small amount of additional trigonometrical control had been provided, a network of tertiary levelling was done. Plane-table fixings for the survey of detail were made at suitable levelling stations and at these fixings tacheometry readings were taken and plotted. Contours were interpolated from all the heights thus obtained.

(iii) Advantage was taken of the presence of the aircraft in the area to provide photographic cover for the large unsurveyed areas in Kutch adjoining the area of survey for Kandla Port development. The triangulation being done for Kandla Port development was, therefore, extended and the 15 surrounding one-inch sheets were completed to edge for control for future air surveys.

48. Dharoi Dam and Reservoir.—Surveys required by the Central Waterpower, Irrigation and Navigation Commission were,

(*a*) Survey on 32-inch scale with 5-foot contours of the Dharoi Dam site on the Sabarmati River in sheet 45 D.

(*b*) Survey on 4-inch scale with 5-foot contours of the Dharoi Reservoir in sheet 45 D.

(*c*) Levelling to establish a height datum for the above surveys in sheet 45 D.

(i) The method employed for (a) above was as follows:—

Two triangulation stations were established in the area by breaking down from neighbouring G.T. framework and on these two stations a framework of triangulation was based. The triangulation was computed in the field and plotted zinc mounted plane-table sections were issued to plane-tablers for ground survey and contouring by clinopole. Though air photographs on the 16-inch scale were available, it was decided to carry out the survey by ground methods, as experience in the past had shown the extreme difficulty of producing a satisfactory combination from air photography on this large scale, particularly when the photographs required enlarging to 32-inch scale. Heights were based on the values of two bench-marks fixed by a line of double tertiary levelling run from the nearest G.T. bench-mark.

(ii) For the reservoir area only the plan and height control and photo verification could be done during the field season. The triangulation done in connection with the dam site survey was extended to cover the area for the reservoir and plan control provided for the combination and air compilation. Heights were provided by lines of tertiary levelling at 10-chain intervals approximately, with additional spot heights on elevations and in streams. All trigonometrical points and heighted points were identified and marked on the photographs. Ground verification was done on the photographs, which were chalked for detail, difficult of interpretation, and colour traces were maintained for individual photographs.

(iii) To establish a height datum for the surveys of the dam site and reservoir, a line of double tertiary levelling was run up to the area of the dam site from the nearest G.T. bench-mark at Mehsāna, 55 miles away. Two bench-marks were established, one on either side of the Sabarmati River at opposite ends of the proposed dam site. The standard of levelling asked for was secondary but on account of the lack of secondary levelling equipment it was finally agreed that double tertiary would be acceptable.

49. Ahmadābād Airfield.—Surveys were required by the Director General of Civil Aviation for the Landing and Approach charts of Ahmadābād Airfield in sheets 46 A and B. Sufficient plan and height control was provided for the air survey compilation of the Landing chart. After the air survey compilation was carried out, the blue print of the same was obtained and verified and contoured on the ground.

50. **Bhuj Airfield.**—Landing and Approach charts were also required for Bhuj Airfield. The areas of these charts were covered by the 1/25,000 surveys being done for Kandla Port development and these surveys will be utilized for the preparation of the charts. The necessary additional work of fixing and heighting of obstructions and hazards to flying was carried out.

51. **Kakarpāra Reservoir.**—Survey required for this purpose was an extension of the work done for the Ukāi Reservoir on the Tapti River during the previous season in sheet 46 G. Plan and height control were required for an area of about 300 square miles on the 4-inch scale with 10-foot contours. As the maps were required as expeditiously as possible and as all available resources of the Southern Circle Directorate were already fully committed, it was not possible to undertake both the control work and the mapping. It was agreed, therefore, that the mapping would be done by Messrs. Air Survey Company Ltd., London with Multiplex equipment. To meet the requirements of mapping by Multiplex, control points were required in certain positions on the photographs as follows :—

(*a*) Plan control points on every fourth photograph in each strip.

(*b*) Height control points, four in number, on each photograph.

The obtaining of these plan and height control points in certain definite previously selected positions was not very easily achieved, particularly when some points were required in deep valleys or in flat wooded areas. It was also found that the positioning of trigonometrical stations or traverse lines was restricted rather than allowed the freedom presented by the topography. There is no question, however, that the contouring of a whole photograph from only 4 heights on it represents an immense saving in time and labour.

The country was somewhat difficult, consisting partly of flat wooded areas and partly of teak-covered hills, with trees 50–60 feet high. Visibility during the work was also very poor, restricting the length of rays of observation and this was worsened by smoke from forest fires.

As this is the first time that control work for mapping by Multiplex has been carried out, the above observations are made with some reserve.

The control was provided by a combination of triangulation, traversing and levelling depending on the nature of the country. Triangulation was based on neighbouring G.T. framework and traversing was based on the stations of this triangulation. Heights were based on a line of G.T. levelling running south of the area.

52. **Triangulation.**—In order to provide control in advance for future 1-inch topographical surveys the triangulation of three

1-inch in sheets 46 G and H was carried out. The triangulation was based on neighbouring G.T. framework.

53. **Description of Country.**—As must be expected from a field programme so varied and scattered, camps and detachments had to work in several completely different types of country. The bulk of the party programme, however, lay in Kutch State, which is, on the whole, treeless, barren and rocky but varied by ranges of hills and isolated peaks, with a few well-tilled valleys in the south-west and salt waste, tidal creeks and mangrove swamps in the east and south.

No. 8 PARTY

Officer in charge :— Mr. P. S. Shinghal, O.B.E., to 26-6-49.
Mr. B. B. Kuttappa (current duties), from 27-6-49 to 29-7-49.
Mr. F. M. Hawley, from 30-7-49.

54. **General.**—This party was mainly engaged on project surveys. These projects, given in decreasing magnitude, are :—

(*a*) Tungabhadra Project

(*b*) Kistna Reservoir

(*c*) Kistna Dam.

Both (b) and (c) form part of the Kistna Pennār Project.

The party was also engaged on the survey of the Approach and Landing charts of the Begumpet Airfield.

55. **Tungabhadra Project.**—The object of the Tungabhadra Project has already been described in the Technical Report, 1947. Further developments have been mentioned in Technical Report, 1948–49. It was later decided by the Hyderābād Government, for whom the survey is being carried out, that the commanded area of this project could usefully be extended by 320 square miles to the west and it was mainly the survey of this extension which gave employment to the technical staff of this party during the field season under report. The method of resection, stone-laying and levelling was the same as previously described.

56. **Kistna Pennār Project.**—The survey of the Kistna Reservoir area and the Kistna Dam site was taken up on behalf of the Madras Government in connection with the Kistna Pennār Project. The survey was carried out to obtain adequate height control to contour, at 5-foot vertical interval, a 4-inch photo-mosaic of the reservoir area. The method of survey was by resection on air photographs followed by a network of tertiary levelling.

The survey of the Kistna Dam site has already been reported in Technical Report, 1948–49. The 16-inch mapping of the site was completed.

57. **Airfield surveys.**—The survey of the Approach and Landing charts of the Hyderābād (Begumpet) Airfield was completed subject to revision subsequently as the airfield was found to be under

re-construction at the time of survey. The object of these charts is fully described in para 44 under Headquarters Section's report.

58. **Description of country.**—The country consists to a great extent of open undulating plains mostly of black cotton soil under cotton and *jowār* cultivation. Numerous isolated rocky outcrops and hillocks rising up to 300 feet exist. Both the Kistna and Tungabhadra Rivers flow between high banks of red loam. The greater part of the Kistna Reservoir area south of the Kistna River is open and very flat mostly under paddy cultivation.

59. **Mapping.**—The method of mapping employed for the Tungabhadra Project has already been described in Technical Report, 1947. With the decision of the Hyderābād Government to extend the commanded area by an average of 4 miles along the west edge of this project, the total number of 4-inch maps which will cover the whole area will now be 95 and not 91 as reported in 1947. 12 of the maps along the previous western limit already published will have to be revised and republished as new editions as a result of this decision.

VI. APPENDIX TO TECHNICAL NOTES

NOTE ON LAYING OUT A CONTOUR ON THE GROUND

60. Introductory.—In the Bhākra Reservoir area (sheet 53 A) the exploration sub-division of the Bhākra Dam Division was required to assess the cost of land to be submerged. For this purpose a surveyor marked out a contour on the ground by laying stones at 300 to 500 feet apart along the 1280 feet contour. In terms of the indentor's specification, the permissible error at any stone could be $\pm$ 2·5 feet.

The method employed is detailed below in general terms :—

61. Equipment used.—

(i) Microptic level with a pair of levelling staves,
(ii) Four 10 feet poles with targets (referred to as ' target-on-pole ') at the centre,
(iii) Red and white cloth signals,
(iv) 2 ordinary mirrors,
(v) Steel tape,
(vi) Plane-table with sight rule,
(vii) Magnetic compass and,
(viii) Clinometer.

The target is made of a wooden frame, size 12 inches $\times$ 12 inches, painted with horizontal strips of red, white and black. It is fixed at the centre of the pole which is marked in feet painted alternately in black and white.

62. Method of work.—

(*a*) A rigid network of double tertiary levelling lines is first established along the main river across which the coffer dam is to be built as an ancillary to the main dam, and along all the principal tributaries joining the river up stream of the coffer dam. (In this particular case, however, the levelling network had already been completed by the Irrigation Department in previous years, and heights of the P.W.D. canal bench-marks found intact along the river and streams were accepted after applying an initial check against G.T. data).

(*b*) A single tertiary levelling line is then run from a bench-mark established on the above line till the height of the required contour is reached and a peg is driven flush with the ground. The level is placed over the peg so that the height of the instrument over it is 5 feet. The *khalasi* holding the pole is directed to keep the

'target-on-pole' as far as possible at distinct features such as spurs and streams. He is then moved up and down by means of accepted signals. For example, waving the white cloth signal means a shift of the pole to a lower level, and waving the red cloth signal means a shift to a higher level. By repeating this a number of times the pole is brought to the place where the instrument reads to the centre of the target. A mirror flash is then given to indicate to the *khalasi* the correctness of his position. On receiving the flash, he drives a peg in the ground to indicate the position for erecting the contour cairn and moves on to another position. Another *khalasi* then replaces the peg with a suitable stone buried to half its depth in the ground. Around this embedded stone he generally builds a cairn of stones which is white washed and later numbered. From any of the positions thus fixed, work is carried forward.

The required contour belt of the reservoir may be all covered with vegetation, its nature varying from low bushes to thick jungle. In such cases the 'target-on-pole' is generally set up at two or three fixed positions of the contour cairns on the bank opposite to the one on which the observer is working. From these the surveyor determines the height at which to set up his level.

To accord with the requirement that the contour cairns are to be placed at every 300 feet or so, additional cairns are inserted by the surveyor at convenient spots during his return visit. Some of these additional cairn positions are fixed by actual levelling.

Cairn positions are fixed on a large scale chart either by plane-table fixings, intersections, or using distances deduced from the stadia wires of the level. The river, its main tributaries and important villages are sketched in to facilitate identification of the positions of the contour cairns.

63. **Precautions.**—(*a*) After proceeding with the work for 5 miles or so a check for cumulative error is made by connecting the last contour position with the nearest double tertiary bench-mark in the river bed by actual levelling to it. After determining the discrepancy the contour position is adjusted for the desired height.

(*b*) Curvature and refraction correction is applied wherever the distance between the level and the target exceeds 500 yards from the formula $C = 4/7 \times (\text{distance in miles})^2$, where C is the correction in feet.

64. **Speed and accuracy.**—The above methods can yield an average out-turn of 25 cairns or 1·5 to 2 miles per working day. Contour positions as fixed by the target method can be fixed to an accuracy of $\pm$ 1-foot in height, if proper care is taken.

65. **Cost.**—In this particular case the overall cost of laying out the contour came to Rs. 38/13/- per linear mile, against the estimated cost of Rs. 80/- per mile worked out by the local P.W.D. authorities on the basis of similar survey done by them in the previous year.

PART II.—MAP PUBLICATION AND OFFICE WORK

TECHNICAL NOTES

DIRECTOR:— Major J. S. Paintal, I.E., to 22-8-49.
Colonel I. H. R. Wilson, from 23-8-49.

DEPUTY DIRECTOR:— Major J. S. Paintal, I.E., to 3-9-49.
Colonel I. H. R. Wilson, from 4-9-49 to 19-2-50.
Mr. K. L. Dhawan, from 20-2-50.

VII. MAP COMPILATION

66. General.—The period under review has been uneventful in so far as the introduction of any major new technique is concerned.

With the easing of the map stock situation of departmental sheets, the pre-war policy of printing maps in full colours has been revived. On the reproduction side, the printing of large size multi-colour posters for various Government Departments continued.

67. Separate Colour Originals.—In order to speed up drawing, and to save the Reproduction Office the laborious task of colour separation at the Negative stage, the World Aeronautical Chart, International Civil Aviation Organization 1 : 1,000,000 sheets are being drawn on separate originals for each colour, on zinc mounted 210 lb. drawing paper. Names for printing in black are also on a separate name original, as described in detail in para 68 below. While it can safely be stated that the saving in time in the Reproduction Office is considerable, the checking of registration in the Drawing Office is a formidable task and little total saving of time results. This method is not recommended for mapping when time is of no great consideration.

68. Separate Name Originals.—For World Aeronautical Chart, International Civil Aviation Organization 1 : 1,000,000 sheets, all lettering for printing in black is being prepared on a separate blue print on white enamelled zinc. Name and height slips, obtained either by letterpress or hand-typing on art paper, are stuck down in position with Amyl Acetate on the enamelled surface. The slips stick permanently as a result of the chemical action of the Amyl Acetate on the enamel. If a name has to be removed this can be done with a knife. If the surface of the enamel gets spoilt or peels off, a little white cellulose applied with a brush will repair the damaged part.

How these enamelled originals will stand up to storage is yet to be experienced. The fear is that the enamel may crack and

peel off as the result of the extremes of climate in India. Experiments are in hand to varnish the finished original by spraying it with clear lacquer as a protection. The lacquer available in Hathibarkala Litho Office has resulted in turning the enamelled surface yellow. This may be due to the fact that it is old stock, but it is feared that even when using fresh stock, the lacquer will in course of time turn yellow. Experiments are being continued.

The most suitable enamelled surface is obtained by the application of three coats of white enamel cellulose finely grained to give an even matt surface.

Separate name originals prepared on zinc mounted drawing paper by pasting name slips have not proved satisfactory as in the dry weather the name-slips come off. Hand-typing directly on to zinc mounted blue prints is not satisfactory either as the surface is too hard and most impressions require touching up.

INDEX MAPS

INDEX A.—Modern Topographical Surveys and Compilation.

INDEX C.—Index showing Project Surveys in hand.

N.B.—The above two indexes are the same as Indexes A and C which appear in the General Report, 1950.

G. & T.C.—P.O.—J.S. 584—1-11-50—250 bks.