

Chatham

SURVEY OF INDIA

TECHNICAL REPORT
1952

(From 1st April 1951 to 31st March 1952)



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 & RESEARCH BRANCH
SURVEY OF INDIA, DEHRA DUN, 1955.

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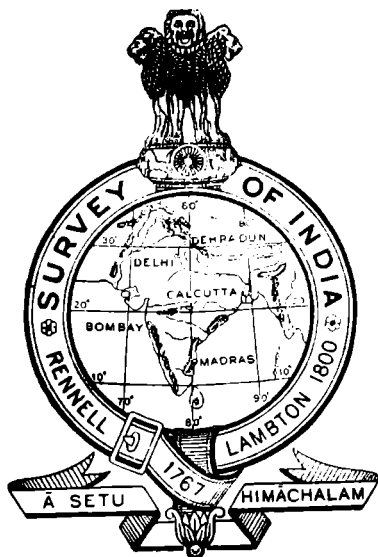
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FOREWORD

Part I of this Technical Report is prepared by Officers in charge of Units and Directors of Survey Circles. 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.

DEHRA DUN :
June, 1954.

I. H. R. WILSON,
Brigadier,
Surveyor General of India.

SURVEY OF INDIA

TECHNICAL REPORT
1952

From 1st April 1951
To 31st March 1952

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The Technical Report which has superseded the Geodetic Report not only deals in detail with the geodetic and geophysical activities of the department, but also covers technicalities of survey work,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 present Report like others covers the period of the financial year, i.e., from 1st April 1951 to 31st March 1952.

The Technical Report is arranged as follows :—

Part I contains Table C giving a detailed statement of areas, out-turns and cost rates of surveys. It also contains technical notes on topographical and other surveys, descriptions of the country surveyed, notes as to weather, communications, availability of food and on other subjects likely to be of interest to surveyors.

Part II deals with 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 published as a separate volume.

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

PART I.—TOPOGRAPHICAL AND OTHER SURVEYS

II. ABSTRACT OF TOPOGRAPHICAL WORK

2. In the annual General Report of the Survey of India, the abstract of topographical work is explained by three Tables A, B and C.

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

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

Table C shows in detail the figures for areas surveyed, out-turns and cost rates of surveys, compilation and mapping by the various survey parties of the Department.

Tables A and B are published in the General Report ; but Table C forms part of this Report.

In Table C, although every endeavour has been made to calculate the cost rates accurately, it is extremely difficult to allocate overhead charges accurately 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 and departmental overhead charges. The information contained in this Table is intended to be useful to those familiar with survey organization, in estimating costs in subsequent years.

The costs 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 Dun.

Indexes A and C published in the General Report also appear at the end of this 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, during the period under report, 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	
No. 1 Party.—		sq. m.	sq. m.	Rs.	Rs.	<u>NORTHERN CIRCLE</u>
	Gobind Sāgar (Bhākra Reservoir) Survey—Scale 4 inches to 1 mile contours at 20 feet vertical inter- val.					
<i>Partly hilly and partly undulating ground, covered with forests, cultivated along river- beds with scattered trees</i>	Supplementary triangulation ..	2·0	3·0	112·5	158·6	
	Plane-tableing	24·0	1·7	71·2	100·7	
	Fair-mapping	44·5	1·1	221·5	288·0	Fair mapping in hand.
	Scale 6 inches to 1 mile, contours at 20 feet V.I.					
<i>Bilāspur Town area</i>	Plane-tableing	2·0	2·1	305·0	429·0	
	Pālam Obstruction Chart—Scale 1/12,000					
<i>Area fairly congested and country undulating and broken</i>	Supplementary triangulation ..	6·0	10	105·0	152·1	Fair mapping of the chart is being done in No. 1 Drawing Office.
	Levelling	20·0 linear miles	30·0 linear miles	16·2 per linear mile	26·3 per linear mile	
	Plane-tableing	10·0	7·5	62·2	86·3	

* For explanation of 'net' and 'overall' rates see page 2.

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.	<u>NORTHERN CIRCLE.—</u> <u>Contd.</u>
	Scale 16 inches to 1 mile					
	Rapid revision survey ..	3.0	2.1	254.3	353.2	
	Scale 1 inch to 1 mile					
	Verification survey ..	83.0	60.7	11.8	16.3	
	Tractor Going Plans—Scale 4 inches to 1 mile					
<i>70% open area, mostly full of Kans and scattered trees, frequently cultivated and occasionally having open forests, 20% undulating and 10% hilly area with open forests</i>	Plane-tableing	1112	20.9	67.8	92.0	Rapid revision survey to C.T.O. specification.
	Finalization of plane-tables for direct publication	317.0	14.8	10.3	13.4	..
	Rapid revision survey for departmental mapping—Scale 4 inches to 1 mile					
	Plane-tableing	74	92.5	1.5	2.1	
	Punāsa Reservoir Survey—Scale 4 inches to 1 mile, contours at 10 and 20 feet V.I.					
<i>70% open forest and undulating area with cultivation and villages, 30% hilly and forested area, with high grass</i>	Supplementary triangulation ..	15.0	7.6	311.1	490.2	

* For explanation of 'net' and 'overall' rates see page 2.

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 sq. m.	Out-turn per man per month sq. m.	Cost Rate per sq. mile (or mile)		REMARKS	
				*Net	*Overall		
No. 1 Party.— <i>Concl'd.</i>	Original air survey of detail only ..	392.0	9.3	Rs. 23.2	Rs. 30.2	NORTHERN CIRCLE.— <u>Contd.</u> Area with no photographic cover.	
	Original ground survey ..	14.0	3.8	105.3	146.4		
	Ground verification of air surveyed detail and ground contouring	159.0	4.9	351.4	488.4		
	Ground verification of air surveyed detail and ground revision of air surveyed contours	17.0	10.2	39.4	54.7		
	Original air survey ..	134.0	0.8	423.6	550.7		
	Mahrauli (East) Survey—Scale 6 inches to 1 mile, contours at 5 feet V.I.						Air survey in hand.
	Fair mapping ..	6.0	0.9	283.0	367.9		
	Complete job ..	6.0	..	1214.3	1606.1		
	<i>Fairly open but mostly undulating area interspersed with ravines</i>						

* For explanation of 'net' and 'overall' rates see page 2.

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. 2 Party.—		sq. m.	sq. m.	Rs.	Rs.	<u>NORTHERN CIRCLE.—</u>
	Chambal Hydel and Irrigation Project—Scale 4 inches to 1 mile, contours at one foot vertical interval					<u>Contd.</u>
<i>Undulating area under cultivation with scattered villages, about 4 miles apart and broken ground along streams and rivers</i>	Triangulation	1,606	187.5	7.9	11.3	
	Levelling	1,130.7 linear miles	48.1 linear miles	34.5 per linear mile	48.6 per linear mile	
	Ground verification of detail and post-pointing on photographs	448	38.4	21.8	30.7	
No. 3 Party.—	Ganga Barrage Project—4-inch scale with 1-foot contours					
<i>Cultivated plains with numerous water channels, scattered trees, mango groves and tanks</i>	Fair mapping and computations ..	430	..	84.19	172.0	
	South Bihâr Irrigation Projects—4-inch scale with 1 foot contours					
<i>Flat country with a few mounds, innumerable field bunds, scattered trees, wells and excavated water channels</i>	Triangulation	670	216.1	10.35	19.6	

* For explanation of 'net' and 'overall' rates see page 2.

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. 3 Party.—Concl'd.		sq. m.	sq. m.	Rs.	Rs.	<u>ORTHERN CIRCLE.—</u>
	Traversing	91·5 linear miles	45·0 linear miles	43·96 per linear mile	83·1 per linear mile	<u>Cont'd.</u>
	Double tertiary levelling ..	170 linear miles	37·2 linear miles	46·78 per linear mile	82·6 per linear mile	
	Tertiary levelling	2,010 linear miles	52·9 linear miles	17·90 per linear mile	31·6 per linear mile	
	Stone laying	225 stones	88 stones	13·65 per stone	24·1 per stone	
	Ground verification	710	50·4	17·07	30·1	
	Plane-tabling	12	12·0	75·51	133·2	
No. 4 Party.—						
	Gandak Barrage Scheme—Scale 4 inches to 1 mile and contours at 1 foot V.I.					
<i>Flat cultivated plains with numerous ponds, mango gardens, several perennial streams and marshy areas</i>	Traversing	148·5 linear miles	26·05 linear miles	52·96 per linear mile	93·6 per linear mile	
	Secondary levelling	97·37 linear miles	55·12 linear miles	57·70 per linear mile	102·0 per linear mile	

* For explanation of 'net' and 'overall' rates see page 2.

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. 4 Party.— <i>Concl.</i>		sq. m.	sq. m.	Rs.	Rs.	<u>NORTHERN CIRCLE.—</u> <u>Contd.</u>
	Double tertiary levelling ..	229·80 linear miles	45·96 linear miles	47·11 per linear mile	83·3 per linear mile	
	Tertiary levelling	3,865·70 linear miles	72·21 linear miles	15·05 per linear mile	26·6 per linear mile	
	Ground verification of 2-inch air photographs	2,240	260·47	3·00	5·3	Half the work carried out on bicycle and the other half on foot.
	Rapid ground verification of 1-inch sheets	157	277·06	4·33	7·7	Work carried out on foot.
	Fair mapping	778·5	8·1	39·32	56·4	
	Computations (Levelling) ..	4,192·87 linear miles	146·80 linear miles	3·00 per linear mile	5·2 per linear mile	
Computations (Traverse) ..	148·5 linear miles	63·6 linear miles	12·67 per linear mile	21·6 per linear mile		

* For explanation of 'net' and 'overall' rates see page 2.

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.—		sq. m.	sq. m.	Rs.	Rs.	<u>NORTHERN CIRCLE.—</u>
	Bhakra Dam Project—Scale 4 inches to 1 mile, contours at 1 foot V.I.					<u>Contd.</u>
<i>Open, flat, cultivated plains thickly populated, except for area falling in Nakodar Tahsil which is soft and sandy</i>	Tertiary levelling to 25-acre (in Jullundur Block)	575	19·8	62·9	86·3	
	Computations .. .. .	..	..	2·8	3·8	
	Traversing and 3,000-acre rectangulation (in Ambala Block)	1,050	51·8	50·1	67·5	Excludes limited work done in Hissar area.
	Computations .. .. .	..	..	3·8	5·1	
	100-acre rectangulation (in Barara-Kurukshetra Block)	1,101	12·0	127·7	169·5	
	Tertiary levelling to 25-acre ..	623	17·0	76·7	104·0	
	Computations .. .. .	..	..	3·5	4·7	
	†Ground verification of 1-inch sheets (on 1½-inch enlargements)	537	67·1	11·2	15·5	†Carried out as a part of survey work for Bhakra Project for the second year.
	Compilation and rapid drawing ..	900	7·1	49·2	64·0	Includes recess computation of levelling.

* For explanation of 'net' and 'overall' rates see page 2.

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	
<p>No. 13 Party.—Concl'd.</p> <p><i>Patches of fairly dense mixed jungle full of dhāk and babūl.</i></p>	<p>Forest Surveys—Scale 6 inches to 1 mile, contours at 5 feet V.I.</p>	sq. m.	sq. m.	Rs.	Rs.	<p><u>NORTHERN CIRCLE.—</u> <u>Concl'd.</u></p>
	Traversing along Reserved Forest boundaries	20·7 linear miles	32·7 linear miles	33·6 per linear mile	44·6 per linear mile	
	Original ground survey	3·2	1·5	600·6	799·9	

* For explanation of 'net' and 'overall' rates see page 2.

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. 5 Party.—	Original Survey—1-inch scale with contours at 50 feet V.I.	sq. m.	sq. m.	Rs.	Rs.	<u>EASTERN CIRCLE</u>
<i>Flat, open cultivated plains interspersed with scattered trees, mango groves, swamps and numerous tanks</i>	Traversing	106·3 linear miles	49·1 linear miles	93·2 per linear mile	149·2 per linear mile	High cost due to the employment of Gazetted Officers, under training, on the job.
	Rapid tertiary levelling	308·8 linear miles	72·4 linear miles	24·9 per linear mile	40·6 per linear mile	
	Ground verification including con- touring.	500·4	71·3	30·3	50·8	
	Supplementary ground verification	235·0	119·4	14·2	23·4	
	Air survey, outline only	1,075·9	22·4	16·8	21·8	
<i>Open cultivated plains with numerous towns and village areas overgrown with trees and containing numerous tanks</i>	Revision Survey—1-inch scale with contours at 50 feet V.I.					
	Correction survey (from air photo- graphs) of outline only	831	15·0	18·4	23·9	
	Fair mapping	831	17·0	23·7	30·8	Cost higher than original survey due to heavy corrections.
<i>Heavily wooded steep hills</i>	Dihāng Reservoir—4-inch scale with contours at 50 feet V.I.					
	Air survey of outline only	25·0	23·5	17·7	23·0	
	Fair mapping	25·0	9·7	51·6	67·1	

* For explanation of ' net ' and ' overall ' rates see page 2.

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. 5 Party.—Concl'd.	Kopili Flood Control Scheme— 4-inch scale, contours at 1 foot V.I.	sq. m.	sq. m.	Rs.	Rs.	<u>EASTERN CIRCLE.—</u> <u>Contd.</u>
<i>Low-lying plains interspersed with swamps and high grass</i>	Fair mapping	18.0	6.0	114.2	148.5	
	Manās Project					
<i>Heavily wooded steep hills</i>	Triangulation	210.0	49.3	30.0	71.6	
	Double tertiary levelling	42.1 linear miles	26.4 linear miles	41.1 per linear mile	91.0 per linear mile	
	Tea Estates—16-inch scale with- out contours					
<i>70% tea gardens with open flat country and 30% densely wooded land</i>	Air survey of outline only	50.0	2.8	173.7	225.8	
	Fair mapping	50.0	0.9	510.5	663.7	High cost due to ancillary work, e.g., taking out areas, etc.
	Tripura Cadastral Survey— 16-inch scale without contours					
<i>Low wooded hills, cultivated plains and villages, overgrown with trees</i>	Triangulation	149.2	18.3	112.4	202.7	} High cost due to the air lifting of stores, etc., to the area.
	Traversing	154.5 linear miles	13.0 linear miles	158.8 per linear mile	286.5 per linear mile	
	Ground verification	39.6	0.93	894.1	1,594.1	
	Plane-tableing	1.6	0.41	2,040.4	3,587.4	

* For explanation of 'net' and 'overall' rates see page 2.

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 sq. m.	Out-turn per man per month	Cost Rate per sq. mile (or mile)		REMARKS
				*Net	*Overall	
No. 9 Party.—	Upper Dámodar Valley Survey— 6-inch scale with contours at 10 feet V.I.	sq. m.	sq. m.	Rs.	Rs.	EASTERN CIRCLE.— Contd.
<i>Undulating plains with occasional hillocks, rocky outcrops and small jungle patches. Cultivated areas with scattered trees and numerous tanks</i>	Air survey and mapping ..	752.9	4.8	81.2	116.7	
	Computations ..	752.9	18.3	16.7	25.2	
No. 11 Party.—	Kosi Irrigation Surveys—4-inch scale with contours at 1 foot V.I.	sq. m.	sq. m.	Rs.	Rs.	
<i>Open cultivated plains astride the old beds of the Kosi River, patches of jungle and scat- tered trees, numerous tanks, patches of low marshy land</i>	Double tertiary levelling ..	256.1 linear miles	64.8 linear miles	30.0 per linear mile	46.7 per linear mile	
	Tertiary levelling ..	3,717.5 linear miles	59.0 linear miles	21.4 per linear mile	33.2 per linear mile	
	Ground verification ..	1,283.5	42.9	21.7	33.8	
	Computations in field ..	3,973.6 linear miles	413.9 linear miles	1.0 per linear mile	1.6 per linear mile	
No. 11 Party.—	Rānchi District Forest Boundary Surveys	sq. m.	sq. m.	Rs.	Rs.	
<i>Jungle covered hills and partly jungle covered plains</i>	1/25,000 plane-table traverse survey ..	2,201.8	41.2	26	33.8	Out-turn could have been more if some of the reserved forest bounda- ries were found already cleared.

* For explanation of 'net' and 'overall' rates see page 2.

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	
<u>EASTERN CIRCLE.—</u>						
<u>Contd.</u>						
No. II Party.—Contd.	1-inch Topographical Survey with contours at 50 feet V.I.	sq. m.	sq. m.	Rs.	Rs.	
<i>Partly jungle covered hills and partly undulating cultivated plains</i>	2-inch air survey and tracing from 2-inch reductions of Hirakud Dam sheets for compiling 1-inch sheets 64 P/9, 13, 14.	†574·1	21·8	22	28·6	†Excludes 260·1 sq. miles of compilation from 2-inch reductions of Hirakud Dam sheets.
<i>Jungle covered hills and river bed</i>	Upper Mahānadi Dam—32-inch scale with contours at 5 feet V.I. Fair mapping	4·76	0·35	1,283	1,667·9	
<i>Cultivated plains and jungle covered hills here and there</i>	Orissa Cadastral Surveys—Ground work for subsequent 16-inch air survey Triangulation	188	28·5	140	187·2	
	Traversing	124·6 linear miles	28·9 linear miles	78 per linear mile	105·3 per linear mile	
	Computations (Triangulation)	188	..	10	14·3	
	Computations (Traverse)	124·6 linear miles	..	7 per linear mile	9·1 per linear mile	

* For explanation of 'net' and 'overall' rates see page 2.

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.—Concl'd.		sq. m.	sq. m.	Rs.	Rs.	<u>EASTERN CIRCLE.—</u> <u>Concl'd.</u>
	Detailed ground verification including plot marking on 16-inch photos	52.1	2.3	893	1,228.5	Out-turn could have been much higher with better co-operation from the villagers whose lands were surveyed. Also, this type of work was being attempted for the first time by the Survey of India personnel.
No. 12 Party.—	Bihār Mica Belt Survey—1/25,000 scale with contours at 25 feet V.I.					
<i>Hilly, undulating ground, with open and fairly dense jungle</i>	Air survey	202	4.2	71.4	92.8	} These figures refer to the whole project.
	Fair mapping	202	6.2	64.7	84.1	
	Upper Mahānadi Reservoir Survey—4-inch scale with contours at 10 feet V.I.					
<i>Undulating ground with open and fairly dense jungle and cultivation</i>	Air survey	121	3.8	99	128.7	
	Fair mapping	121	4.4	76.5	99.5	
No. 18 (Boundary Survey) Party.—	East-West Bengal Boundary Survey on 8-inch scale					
<i>Open cultivated plains</i>	Ground verification	313	10.6	69.3	110.2	
	Plane-table traversing	197	57.3	34.4	82.2	

* For explanation of 'net' and 'overall' rates see page 2.

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 sq. m.	Out-turn per man per month sq. m.	Cost Rate per sq. mile (or mile) Rs.		REMARKS	
				*Net	*Overall		
No. 8 Party.—						SOUTHERN CIRCLE	
<i>Steep precipitous and flat-topped hills with deep narrow valleys, covered by fairly dense forest</i>	Navja-Pophli Tunnel, Koyna Project—4-inch scale with contours at 10, 20 and 50 feet V.I.	18†	6.7	137.9	198.1	} †18 sq. miles was done to serve 11 sq. miles of the Project area. } †Carried out during the year 1950-51.	
	‡Supplementary triangulation and height control	..	..	..	..
	Computations	18†	25.7	7.2	9.4		
	Air survey and fair mapping	11	1.0	346.9	451.0		
	Combined project	11	0.8	584.5	790.5		
	Koyna Reservoir—4-inch scale with contours at 10 feet V.I.	200	104.0	10.6	14.4		†Carried out during the year 1950-51.
	‡Identification of old planimetric control and supplementing them where necessary	..	..	..	..
	‡Height control	84	3.3	218.2	297.7		†Carried out during the year 1950-51.
	Computations	84	168	0.7	0.9		
	Contouring on air photographs and transferring them on to the photo-mosaics	84	2.8	94.1	122.3		
Combined project	84	1.4	338.2	455.8			

* For explanation of 'net' and 'overall' rates see page 2.

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	
SOUTHERN CIRCLE.—						
<i>Contd.</i>						
No. 8 PARTY.—Concl'd.		sq. m.	sq. m.	Rs.	Rs.	
	Pej-Ulhās Extension—4-inch scale					
<i>Open undulating plains, flanked by wooded hills</i>	‡Supplementary triangulation and computations	93	35.3	23.3	33.9	Only planimetric control was asked for. ‡Carried out during the year 1950-51.
	Pej-Ulhās, Kāl and Kundalika Valleys—4-inch scale with contours at 5 feet V.I.					
<i>Open undulating plains, interspersed with open jungle</i>	‡Supplementary triangulation and computations	150†	17.1	34.0	50.4	†150 sq. miles was done to serve 47 sq. miles of the Project area. ‡Carried out during the year 1950-51.
	‡Outline air survey	47	4.7	45.6	59.3	‡Carried out during the year 1950-51.
	‡Ground verification and contouring	47	2.6	173.8	253.1	‡Carried out during the year 1950-51.
	Fair mapping	47	2.0	117.1	152.2	
	Combined project	47	0.8	445.1	625.4	
	Topographical Survey—					
<i>Steep, wooded hills and narrow valleys with coastal plains</i>	1-inch verification survey for communications	370 linear miles	194.7 linear miles	4.96 per linear mile	6.9 per linear mile	

* For explanation of 'net' and 'overall' rates see page 2.

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. 10 Party.—		sq. m.	sq. m.	Rs.	Rs.	SOUTHERN CIRCLE.—
	Bangalore Airport and Surroundings—1/2,500 scale with contours at 1 foot V.I.					<u>Contd.</u>
<i>Undulating ground, partly open and partly snake infested dry scrub and high grass</i>	Stone and peg laying	1,535 acres	1,001 acres	1·4 per acre	1·8 per acre	
	Tertiary levelling	43·2 linear miles	43·2 linear miles	13·4 per linear mile	17·4 per linear mile	
	Traversing	25·9 linear miles	31·1 linear miles	35·8 per linear mile	46·5 per linear mile	
	Original survey	1,535 acres	84 acres	7·8 per acre	10·1 per acre	
No. 17 Party.—	Santa Cruz Aerodrome Obstruction Chart—1/12,000					
<i>Open plain country, lightly built up</i>	Triangulation and computation ..	45	18	128·6	182·8	
	Traversing	4 linear miles	40 linear miles	9·0 per linear mile	11·7 per linear mile	
	Tertiary levelling	4 linear miles	40 linear miles	8·0 per linear mile	10·4 per linear mile	

* For explanation of 'net' and 'overall' rates see page 2.

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		Cost Rate per sq. mile (or mile)		REMARKS
		sq. m.	sq. m.	*Net	*Overall	
No. 17 Party.— <i>Concl'd.</i> <i>Hilly area with dense jungle</i>		sq. m.	sq. m.	Rs.	Rs.	SOUTHERN CIRCLE.—
	Detail survey of obstructions ..	5·0	2·5	955·0	1,313·8	<u><i>Concl'd.</i></u>
	Combined field work	5·0	1·5	2126·0	3,080·0	
	Sharāvati Project Survey Reser- voir Area—4 inches to 1 mile scale with 20 feet contours					
	Triangulation and computation ..	600·0	77·5	33·8	43·9	
	Levelling (double tertiary) ..	102 linear miles	20·4 linear miles	45·1 per linear mile	58·6 per linear mile	
	Heighting and photo verification ..	162	3·9	308·8	401·4	
	Plane-tabling	1·5	1·5	433·3	563·3	
	Combined field work	163·5	..	462·0	640·1	
	Station and Dam Site—16 inches to 1 mile scale with 10 feet con- tours					
Triangulation and computation ..	18†	6·4	467·7	612·8	†18 sq. miles was done to serve 3 sq. miles of the Project area.	
Heighting and photo verification ..	3	0·63	1,498·7	2,017·6		
Combined field work	3	..	4,304·7	5,694·9		

* For explanation of ' net ' and ' overall ' rates see page 2.

III. TECHNICAL NOTES, NORTHERN CIRCLE

DIRECTOR :— { Mr. H. M. Critchell, to 4-11-51.
Colonel Gambhir Singh, M.I.S. (Ind.), from 5-11-51.

DY. DIRECTOR :— { Lt.-Col. J. S. Paintal, Engineers, to 13-6-51.
Mr. H. M. Critchell, from 14-6-51 to 5-7-51 (in addition to his duties as Director, Northern Circle).
Lt.-Col. J. S. Paintal, Engineers, from 6-7-51 to 20-10-51.
Mr. H. M. Critchell, from 21-10-51 to 4-11-51 (in addition to his duties as Director, Northern Circle).
Colonel Gambhir Singh, M.I.S. (Ind.), from 5-11-51 to 21-11-51 (in addition to his duties as Director, Northern Circle).
Lt.-Col. J. S. Paintal, Engineers, from 22-11-51 to 25-12-51.
Mr. C. T. Hurley, M.I.S. (Ind.), from 26-12-51.

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. 2 Party.
- No. 3 Party.
- No. 4 Party.
- No. 13 Party.
- No. 2 Drawing Office.

No. 1 PARTY

Officer in charge :— { Shri P. S. Shinghal, O.E., A.M.I.E., to 13-10-51.
Mr. J. C. Ross, A.R.I.C.S., from 14-10-51.

4. **General.**—The party was employed almost wholly on paid-for surveys for various development schemes sponsored by the Central and State Governments. The methods adopted, together with scales and specifications for the different surveys, not already described in the preceding General and Technical Reports are briefly described below.

5. **Technical Methods**—(i) *Pālam (Delhi) Aerodrome Obstruction Chart.*—The preparation of this chart was the first of its kind, and hence, of an experimental nature.

(a) *Framework.*—This was carried out by triangulation. Prominent obstructions and other high objects, to be used as control for the 1/12,000 plane-table section, were selected and fixed as intersected points. In addition, a number of navigational aids such as High Frequency, Very High Frequency and Medium Frequency beacons and the ends of runways were fixed by three-ray intersections or by traversing.

Accuracy aimed at being 1/4,000, a base was measured with Hunter Short Base equipment and azimuth was observed from Polaris.

The geographical co-ordinates and height of the Aerodrome Reference Point were obtained by connecting it to the triangulated framework.

(b) *Plane-tabling.*—A 1/12,000 plane-table section, extending to a radius of about $2\frac{1}{2}$ miles from the intersection of the aerodrome runways, was completed.

The 16-inch Cantonment survey covering the Runway area was also revised.

One-inch verification and revision survey of areas lying beyond the limits of the Obstruction Chart was also carried out. Heights were observed to high objects, likely to form obstructions, and revision, or insertion, of important detail such as roads and localities was carried out.

(c) *Levelling.*—Levelling had to be done in two stages. Closed tertiary level lines were first run to fix the heights of

- (i) the ends of runways
- (ii) the intersections of runways
- (iii) profile points on runways
- (iv) the intersections of the centre line (produced) of the runways with frequently used roads or railways which were within 3,000 feet of the ends of the runways.

Some temporary but identifiable bench-marks were also established during the course of the levelling.

Later, when the 1/12,000 plane-table survey was completed, levelling by closed circuits was done to obstructions in the Runway area and in part of the Approach area. The top heights of such obstructions were obtained by actual measurement of the top of the object above ground level. Closing errors of 0.2 feet in field levelling and 0.75 to 2 feet in levelling for obstructions could be obtained without any difficulty.

(d) *Obstruction Guide.*—An Obstruction Guide was prepared on tracing cloth showing all obstructions according to definitions given in the specification. To determine which objects would qualify for being classed as obstructions in the Approach areas the tangent of the vertical angle to the top of a probable obstruction from a point 200 feet from each end of the runways was calculated by dividing the relative height of the obstruction by its distance from the point. The idea of the guide was to show the nature (tree, or pole, or building, etc.) and the extent of the obstructions. The positions and heights of only selected obstructions were marked on the plane-table section and height trace, but the Obstruction Guide showed all obstructions.

(ii) *Tractor Going Plans.*—During the summer of 1951, at the request of the Chairman, Central Tractor Organization (Ministry of Agriculture), specimen surveys to certain special specifications were done on the 3-inch and 4-inch scales in Bhopāl State. On

completion, these specimen surveys were examined and it was found that the 4-inch scale would be more suitable for surveys for the purpose required.

(a) *Framework*.—Since it was decided that rapid revision survey without contours on blue or grey enlargements of the largest scale topographical map of the area would be adequate, framework was not considered necessary. Plane-table fixings were made from the existing detail. In actual practice, however, the accuracy of the detail frequently fell off owing to the considerable enlargement, especially where the basic existing map was on the half-inch scale. Quite often, also, no dependable or recognizable detail was available, with the result that fixings first had to be made on the map itself with the help of triangulated points and detail appearing thereon, and then transferred to the plane-table section, before survey could be commenced. In any case, it was usually found necessary for adjoining plane-tables to adopt the same basis of control, to avoid appreciable disagreement and complications along common edges.

(b) *Plane-tabling*.—In addition to revising rapidly the existing detail in areas which were not completely jungle-clad or hilly, the plane-tables also had to pick up the following, which were felt either to be obstacles to tractorization or would help in planning a programme for tractorization :—

- (i) Small streams, with relative heights and width of beds at frequent intervals along their courses.
- (ii) Width of narrow bridges.
- (iii) Village trijunction pillars.
- (iv) Form-lines at an approximate vertical interval of 20 feet in Bhopāl State only.
- (v) Density of vegetation in four groups—i.e., under 50, 50 to 100, 101 to 150 and over 150 trees and bushes per acre.
- (vi) Nomenclature of vegetation, i.e., the type of tree and bush.
- (vii) Percentages of different types of vegetation.
- (viii) Cultivation limits.
- (ix) *Kans* growth (most important from the C.T.O. point of view).
- (x) Fallow land, recent or old.
- (xi) Pot holes.
- (xii) Waste land.
- (xiii) Stony, etc., wastes.

(c) *Fair-mapping*.—As the plans were urgently required it was decided that fair drawing would only delay publication and the quickest way to produce the plans would be by completing the plane-table sections themselves for all accessory work, lettering, etc. To achieve this, however, with some degree of uniformity,

every endeavour was made to co-ordinate the drawing of plane-tables in the field. Hand-printing by the Plane-tablers could not easily be so co-ordinated, and, as typing would have been a lengthy process, a separate section of draftsmen was specially maintained to do the hand-printing. The plane-tablers were not permitted to hand-print anything on their sections, but were required to enter all information on a field trace which, in addition to being a guide to the draftsmen for the hand-printing, also became the colour guide to facilitate reproduction.

The plans were printed with detail, form-lines and hand-printing in black, a yellow wash for cultivation and a light green wash for orchards and areas with a density of over 50 trees and bushes per acre.

No. 2 PARTY

Officer in charge :—Major D. N. Sharma, Engineers.

6. **General.**—The party carried out ground verification, levelling and triangulation for the Chambal Hydel and Irrigation Project covering parts of Rājasthān and Madhya Bhārat in sheets 45 O and 54 C.

7. **Technical Methods.**—Maps on 4 inches to 1 mile scale with generalized contours at one foot vertical interval were required.

(a) *Triangulation.*—The following specifications were laid down for field work :—

- (i) The average triangular error was not to exceed 6 seconds and the maximum triangular error not to exceed 12 seconds.
- (ii) The number of zeros required for horizontal angles was three.
- (iii) The discrepancy between the value of any common side as obtained from G.T. values and that measured by Hunter Short Base was not to exceed 1 in 5000. Base measurement to be done at approximately 30 mile intervals to provide the above check.
- (iv) An astronomical azimuth observation was required with every Base measurement.

(b) *Levelling.*—Closed circuits of secondary levelling were run along the perimeter of the area under survey. Tertiary levelling lines at approximately half-mile intervals were run between secondary bench-marks.

The closing error in any line of tertiary levelling was restricted to $0.1 \sqrt{M}$ feet where M indicates the length of the line in miles.

8. **Description of the Country.**—The country is generally slightly undulating, interspersed with streams and ravines. Communications were fairly good.

No. 3 PARTY

Officer in charge:—{ Mr. T. M. C. Alexander, to 15-10-51.
Major C. M. Sahni, Engineers, from 16-10-51.

9. **General.**—The party was employed on extra-departmental surveys for the South Bihār Irrigation Projects required by the Government of Bihār.

10. **Technical Methods.**—The Government of Bihār required this survey for the planning of irrigation channels. Maps on 4 inches to 1 mile scale were required showing all topographical features, contours at one foot interval and bench-marks approximately $\frac{1}{2}$ mile apart.

Maps were compiled from air photographs on the 2 inches to 1 mile scale. Contours were interpolated with the help of spot heights obtained by tertiary levelling.

(a) *Planimetric control.*—Triangulation and precise traverse were carried out, starting and closing on Geodetic Triangulation stations to provide planimetric control for the air survey combination. All stations and intersected points were pricked through on the 2-inch photographs of the area.

(b) *Height control.*—

(i) Tertiary level lines were run approximately 40 chains apart, starting from and closing on secondary or double tertiary bench-marks and these levelled heights were pricked accurately by levellers on the photos. Thus a mesh of levelled heights for interpolation of 1-foot contours was provided.

(ii) Tertiary bench-marks were cut about $\frac{1}{2}$ mile apart, on wells, culverts, bridges, milestones, bases of trees, P.W.D. pillars and embedded stones.

(c) *Ground verification.*—All detail which could not be clearly identified on the air photographs, even under fusion, was verified on the ground and special colour traces prepared. Clinometric readings were observed to isolated hills from levelled bench-marks and their heights computed later for entry on the fair sheets.

(d) *Combination plot.*—Projection was done in Grid terms and a combination plot prepared by the normal radial line method. Air survey sections were compiled at the photo scale of 2 inches to 1 mile and later enlarged for publication on the scale of 4 inches to 1 mile.

11. **Description of Country.**—The area was open and gently undulating except in the vicinity of the hills in the south. Villages were approximately $1\frac{1}{2}$ miles apart and most of the trees were in or around the villages with a few trees in the fields. The main crop grown is rice which is usually cut in November/December. Wherever water for irrigation is available the fields are heavily irrigated till mid-November. Rabi crops are scanty. A number of small

non-perennial streams exist in the area. In the dry season most of the unmetalled roads are deeply rutted and motorable only with difficulty, whereas some of the ordinary cart-tracks offer more comfortable motoring.

12. **Miscellaneous**—The health of personnel remained good. Paludrine was regularly supplied as a safeguard against malaria. The climate was good and healthy for work till the end of January 1952, after which occasional showers and storms hampered the progress of work. The temperature also rose considerably and caused "shimmer" early in the day, thereby making observations difficult. High winds prevailed after February 1952.

No. 4 PARTY

Officer in charge :—Mr. L. J. Bagnall, B.Sc.

13. **General**.—The party continued work on the 4-inch irrigation survey in the Priority II area of the Gandak Barrage Scheme in Sheet 72 K.

14. **Technical Methods**.—The technical methods employed for areas for which air cover was available have been fully described in para 15 of the Technical Report 1951. Certain areas, however, were not covered by air photography, and the method adopted of levelling-cum-plane-table traverse was as follows :—

Relevant portions of the 1-inch topographical sheets covering the area, were enlarged to 2-inch scale and blue print plane-table sections supplied. Levelling was started from a bench-mark, the position of which was identified or resected on the plane-table section. A ray to the next bench-mark was drawn on the plane-table section, and its position plotted by means of stadia distances. No chaining was carried out. The traverses were adjusted at intervals of $\frac{1}{2}$ mile to 1 mile on to detail that could be identified on the plane-table section.

In recess, outline originals were prepared by direct tracing of detail from photo-mosaics prepared on the 4-inch scale (approx.). Contours were interpolated from the mesh of levelled heights. Later it was decided to drop this method of direct tracing from photo-mosaics, and air survey compilations on 2-inch scale were made. The 2-inch air survey sections were fair drawn for enlargement and publication on the 4-inch scale.

15. **Description of Country**.—The area surveyed consists of flat cultivated plains with numerous ponds, mango orchards and several perennial streams and marshy areas. There are many unmetalled roads throughout the area. The few metalled roads that do exist are, in most cases, under repair. Numerous local post offices are spread throughout the area. There are several dispensaries in the interior, but they sometimes lack even ordinary medical equipment.

16. **Climate.**—Frequent sand storms were experienced during April and May 1951. The weather during this period was very hot, and out-turn slowed down slightly. From the middle of November 1951 to the middle of March 1952 conditions were quite pleasant.

17. **Miscellaneous.**—Considering that the field season was carried on through the hot months of April and May 1951, the health of the party was, in general, quite good. Paludrine was regularly taken by all members as a safeguard against Malaria.

No. 13 PARTY

Officer in charge:—{ Major O. P. Anand, A.M.I.S. (Ind.), Engineers, to 21-10-51.
Shri P. S. Shinghal, C.E., A.M.I.E., from 22-10-51.

18. **General.**—The party continued to be employed chiefly on irrigation and settlement survey work in connection with the Bhākra Dam Project for the Punjab Government. In addition to this principal task the following surveys were also completed during the period under report :—

(a) 6-inch survey for 4-inch maps of Reserved Forests in sheets 53 C and G.

(b) 1½-inch verification survey in three 1-inch sheets in degree sheets 53 B and F.

19. **Technical Methods.**—(i) *Bhākra Project Work.*—The method of work has been described on pages 26, 27 and 28 of the Technical Report 1947. Rectangulation was done to 100-acre rectangles only, but levelling was broken down to 25-acre rectangles.

(ii) *6-inch survey of Reserved Forests.*—This survey was done by ordinary plane-table traverse methods, using as control the forest boundary pillars that had been fixed by running theodolite traverses of 1 in 2,000 accuracy. 5-foot contours were surveyed by clino-pole.

(iii) *1½-inch verification survey.*—This was completed by ordinary plane-table methods on grey prints of the outline of the standard 1-inch sheet. An overdrawn mesh of the 100-acre rectangulation corner stones, wherever available, was used as the principal control for plane-table fixings. The field sections were inked up completely on the ground in appropriate colours.

20. **Description of Country.**—The area rectangulated and levelled during the period under report is all flat plain, mostly cultivated, with numerous villages. In Karnāl district there are extensive patches of *dhāk* jungle and low thorny bushes, whereas in the north-east portions of Ambāla district the traverse camp met with stretches of broken and undulating ground at the foot of the Siwāliks. Much of this cut-up country is unsuitable for 100-acre rectangulation and subsequent contouring at 1-foot vertical interval.

The Reserved Forest areas in Karnāl district consisted of patches of fairly dense mixed jungle comprising *dhāk* and *babūl* trees which required a fair amount of clearing in order to run plane-table traverses.

21. **Miscellaneous.**—The accuracy of traverse work in the Bhākra area, this year, was below the required standard. The reason is traceable to the triangulated framework being somewhat out of sympathy with the exterior 3,000-acre corner stones of the previous year. This in turn resulted in the accuracy of 100-acre sub-rectangulation dropping as low as 1 in 700 against the accuracy of 1 in 1,000 aimed at.

A comparative study of out-turn shows that the overall monthly out-turn on *Bhākra* survey work has been improving fairly steadily and that, given fair opportunities, the forecast averages for 1952-53 could be as tabulated below :—

Type of work involved	Expected average out-turn per man per month	Range of possible fluctuation	Locality
	Sq. miles	%	
(<i>Field Work</i>)			} PEPSU and the PUNJAB.
(i) 3,000-acre rectangulation . .	56.5	10	
(ii) 100-acre rectangulation . .	12.5	4	
(iii) Tertiary levelling net . .	21.0	5	
(<i>Recess Work</i>)			
(iv) Compilation and Mapping	7.6	..	..

IV. TECHNICAL NOTES, EASTERN CIRCLE

DIRECTOR :—Colonel R. T. L. Rogers, M.A. (Cantab.) F.R.I.C.S., M.I.S. (Ind.).

DY. DIRECTOR :— $\left\{ \begin{array}{l} \text{Shri M. M. Ganapathy, B.A., to 14-4-51 and from 21-5-51 to} \\ \text{14-1-52.} \\ \text{Mr. J. C. Berry, from 15-4-51 to 20-5-51 (current duties).} \\ \text{Lt.-Col. J. S. Paintal, Engineers, from 15-1-52.} \end{array} \right.$

22. Summary.—This report deals with the technical work carried out by the following parties :—

- No. 5 Party.
- No. 9 Party.
- No. 11 Party.
- No. 12 Party.
- No. 18 (Boundary Survey) Party.

There was no new change in the methods adopted for 1-inch departmental and large scale Project Surveys. For 16-inch cadastral surveys, however, a new method was evolved, which is described separately in the reports of the units concerned.

No. 5 PARTY

Officer in charge :— $\left\{ \begin{array}{l} \text{Shri K. C. Gosain, B.A., M.I.S. (Ind.), to 26-11-51.} \\ \text{Mr. H. H. Phillips, B.Sc., A.M.I.S. (Ind.), from 27-11-51.} \end{array} \right.$

23. General.—The original field programme of the party was meant to cover only extra-departmental jobs such as

- (i) the surveying of the dam site and reservoir areas of the Manās Project, planned by the Central Water and Power Commission, and
- (ii) Cadastral surveys in the Kamalpur sub-division of Tripura State.

After the fixing of a triangulation station in Bhutān and the establishing of bench-marks at the probable dam sites, further survey work for the Manās Project was suspended and, instead, field work for departmental 1-inch surveys in sheet 78 D was carried out.

In addition, at party headquarters, the air survey and mapping of tea estates in Assam for Messrs. Jardine Henderson Ltd., Calcutta were continued.

24. Technical Methods.—(i) *Manās Project Surveys.*—The Central Water and Power Commission, required :—

- (a) 4-inch scale maps with 50-foot contours up to the height of 1,050 feet above Mean Sea-Level,
- (b) 32-inch scale maps with 20-foot contours covering the probable dam sites, and

- (c) the fixing of bench-marks, one at Mothārguri, in India, and one at each of the three probable dam sites, up the Manās gorge in Bhutān.

The planimetric control for (a) and (b) above was necessarily required, but only preliminary work for the fixing of a triangulation station, nearer the area, inside Bhutān, could be done prior to the programme for Manās Project surveys being dropped. For determining the geographical position of this triangulation station a Hunter Short Base connection to NĀRIKHOLA h.s. and to SIBANSĪLA h.s. (as a check), and an astronomical azimuth were observed.

For (c) above, to begin with, check levelling by two levellers was carried out between two known bench-marks. Then, starting from one of the bench-marks made along the check levelling line, the two levellers carried out simultaneous double tertiary levelling connecting the Central Water and Power Commission bench-mark at Mothārguri, and thence carried the levelling up the Manās gorge, in Bhutān, establishing bench-marks at each of the three probable dam sites. In all 42·14 linear miles of levelling was done. The levellers set up instruments alongside each other and observed to the same pair of staves, reading simultaneously.

(ii) *Cadastral Surveys in Tripura State.*—The Tripura State government required 16-inch scale cadastral maps of the settled areas in Kamalpur sub-division, and for this purpose it was decided that the best method would be to do air survey by Multiplex.

The ground operations consisted of :—

- (a) fixing of the planimetric framework to control the air survey,
- (b) fixing of the planimetric positions of the village trijunctions, and
- (c) marking of detail required for cadastral maps, on the air photographs, such as village boundaries and the limits of individual holdings and plots.

For (a) above, minor triangulation was carried out based on the G.T. base ATARMURA H.S.—BATCHIA H.S., Hunter Short Base extensions and astronomical azimuths were observed as checks. This series of triangulation provided a fairly close network of trig. stations and points scattered all over the valley, from or to which some theodolite traverse lines were run thereby providing an adequate number of control points for the multiplex air survey. Village trijunction pillars were also connected. Astronomical azimuths controlled the traverses.

For (b) above, a rapid reconnaissance of the village boundaries and trijunctions was done. The locations of these were marked on the available 8-inch scale photo-mosaics to assist the triangulators/traversers. This rapid reconnaissance had the advantage of giving one an early idea of the extent of the villages and the approximate amount of field work required to be done.

For (c) above, the original intention was that the state government would provide a sufficient number of *Amins* who, after being trained by the Survey of India field staff to read and interpret details on air photographs, would help in marking up on alternate 16-inch scale air-photo. enlargements the limits of individual holdings and plots. This process is commonly known as '*Khānāpuri*'. Survey field staff would also mark up on the remaining air-photo. enlargements the same limits of individual holdings and plots and, in addition, village limits and trijunctions and other items of detail normally shown on cadastral maps. This marked set of alternate air-photo. enlargements would be used for the final compilation of the cadastral maps. The method planned, however, could not be carried out as the state government failed to provide the *Amins* and, therefore, to avoid delays in completing the field operations, the survey staff proceeded to carry out their own task as well as part of the '*Khānāpuri*' work, of compiling the list of plot claimants.

Two small areas for which there was no photo. cover were completed by plane-table survey methods on 16-inch scale.

(iii) *1-inch Original Surveys*.—In sheet 78 D the existing 1-inch maps were either surveyed prior to 1905 or compiled from cadastral and/or *thāna* maps of the Bengal Land Records Department, 1914–29. These 1-inch maps contained no contours nor spot heights to indicate the general level of the country and the detail shown was very sketchy. Original air survey was, therefore, necessary from 2-inch scale air photographs by the principal-point-radial-line method. The ground work required was :—

- (a) planimetric control for the air survey,
- (b) spot heights in the area and the marking of the contours on the photographs and
- (c) ground verification of detail, collection of names, road classifications, etc.

For (a) above, due to the ground being flat open plains the planimetric control was provided by theodolite traverse. Distances were measured with standardized crinoline tapes and checked for gross error by re-measurement with 66-foot chains. Planimetric control points that were easily identifiable on the air photographs and lying generally in the lateral overlaps were pricked on the photographs at approximately 8-mile intervals.

For (b) above, previously selected positions for spot heights in each 1-inch sheet were connected by tertiary levelling circuits, and the precise height points (staff positions) were pricked on the air photographs.

The Leveller computed his line as he went and marked the positions on the air photographs where the 50-foot contour crossed the line. The photographs were then passed on to Plane-tables who, by means of a clinometer and clinopole surveyed the contours on them.

For (c) above, normal departmental practice was followed.

In the area covered by the Indo-Pakistan boundary sheets, done by No. 18 (Boundary Survey) Party, in 1950-51, supplementary ground verification for relative heights, surveyed trees and cultivation limits, not previously shown on these boundary sheets, was done with the intention of using these maps in future compilations of the 1-inch sheets.

(iv) *Air Survey and mapping of Tea Estates.*—Messrs. Jardine Henderson Ltd., Calcutta required 16-inch scale maps (outline only) of certain of their tea estates in Assam. For this purpose 16-inch enlargements of 6-inch vertical air photographs were used for incorporating information picked up by ground verification during the field season of 1950-51.

Originally, the mapping consisted of the drawing of the outline original on Kodatrace and the preparation of a separate name original on drawing paper, but later it was found more economical and simpler to combine the two originals into one by hand-printing names on the Kodatrace outline original.

25. Notes on Out-turn.—

- (i) In the Manās area, up the gorge from Mothārguri the levelling operations were done under difficult conditions due, mainly, to the density of the forest growth extending to the water's edge in most places, and to the lack of suitable ground for setting up instruments because of the precipitous nature of the gorge slopes.
- (ii) In the Kamalpur sub-division of Tripura State some delays in the transportation of stores and camp equipment during moves of camps occurred due to the non co-operative attitude of some of the local people. In the later half of the season, when 'Khānā-puri' operations began the situation, however, improved.

No. 9 PARTY

Officer in charge :—{ Mr. H. H. Phillips, B.Sc., A.M.I.S. (Ind.), to 12-11-51.
Major J. N. Sinha, M.Sc., A.M.I.E., Eugrs., from 13-11-51.

26. *General.*—The following jobs were carried out by the Party :—

- (i) Air survey compilation and mapping of an area of 752.9 square miles, falling in sheet No. 73 I in the districts Mānblhūm and Hazāribāgh in Bihār on the scale of 6 inches to a mile for the Dāmodar Valley Corporation.
- (ii) Ground control and ground verification for 4-inch Kosi Irrigation surveys in Purnea and Bhāgalpur districts of Bihār falling in sheet Nos. 72 N and O, to meet the requirements of Central Water and Power Commission.

27. Technical Methods—(i) Upper Dāmodar Valley Surveys.—The usual principal-point-radial-line method was adopted for air survey compilation which was based on planimetric control of one point in every 3–4 miles density, fixed by triangulation in the field season, 1950–51. Contouring at 10 feet vertical interval was carried out on photographs, enlarged to 6-inch scale, using height control fixed by levelling in the previous season. Fair drawing was done on Kodatrace, outline in black and contours in white.

(ii) *Kosi Irrigation Surveys.*—(a) The previous method of laying stones 30 chains apart with air survey compilation from 4-inch photo. enlargements was modified as in sub-para (b) below, for the following reasons :—

- (i) Existing 1-inch surveys of the area were of recent date and agreed very well with the photographs.
- (ii) Planimetric accuracy of 1-inch maps was acceptable to the indenter for the irrigation maps.
- (iii) Cost of survey was to be reduced.

(b) *New method of Surveys.*—

- (i) Ground verification was carried out on 2 inches to 1 mile scale contact prints for subsequent revision of detail on 2-inch enlargements of 1-inch maps.
- (ii) Stone laying at 30 chains apart was replaced by the provision of semi-permanent bench-marks about 30 chains apart, on natural and artificial semi-permanent objects like *pakku* wells, culverts or tree roots. Spot heights at approximately 10-chain interval along tertiary levelling lines were provided to control 1-foot contouring.
- (iii) Single tertiary levelling was controlled by double tertiary levelling which, in turn, was based on secondary and/or precision levelling in the area. Tertiary level lines approximately 10 miles in length were run north-south as the ground was generally sloping in this direction, thus facilitating interpolation of contours.

All spot heights and bench-mark positions were identified on the ground and pricked in on 2-inch air photographs (contact prints) by the levellers.

- (iv) The degree of accuracy aimed at was .008 feet per mile for double tertiary levelling and .05 feet per mile for single tertiary levelling, which was easily achieved.

28. Notes on Out-turn.—(a) The Party out-turn for levelling could not be much improved for the following reasons :—

- (i) Lack of good transport facilities in the area.
- (ii) Some computers under training were put on the job and some of their lines had to be revised.

(b) The out-turn for ground verification was satisfactory being over 2 square miles per working day.

No. 11 PARTY

Officer in charge :—Shri J. Chatterjee, B.Sc.

29. **General.**—The following survey operations were carried out by the party :—

- (a) Air survey on 2-inch scale for the major part of the area of 1-inch sheets 64 P/9, 13, 14 with a view to the eventual production of these three sheets on 1-inch scale. The portions of these sheets which were not air surveyed, were compiled from 2-inch reduction of 4-inch Hirākud Dam irrigation sheets.
- (b) Survey, on 1/25,000 blue print enlargements of 1-inch sheets, of reserved forest boundaries in part of Rānchi district, in sheets 73 A and 73 B.
- (c) Ground control and photo. verification for subsequent air survey by Multiplex equipment (by Messrs. Air Survey Co. of India Ltd.) for 16-inch cadastral maps of Athgarh in Orissa.

30. **Technical Methods.**—*I. Air Survey for Production of 1-inch Sheets.*—The air survey was done on 2-inch scale. Two Kodatrace sections were prepared for each 1-inch sheet, one for the north half and the other for the south half. Combination was carried out by the Slotted-template method. Stations and points of the existing minor triangulation, the photographic positions of which were pricked in the previous field season, were used for planimetric control. Height control and ground verification of the photographs were also done during the previous field season and was utilized for this air survey.

II. 1/25,000 Blue Print Survey of Forest Boundaries.—Ground survey was carried out on 1/25,000 enlargements of the 1-inch sheets concerned. The existing detail on the 1-inch maps was used for fixings by interpolation. Such fixings were used as the starting and closing points of plane-table traverses run for fixing the reserved forest boundaries and pillars. The local forest department provided 16-inch sketch maps showing the boundaries and the pillars. They also provided forest guards to mark these on the ground. Gross errors in existing detail and contours on the blue prints, when found astride the forest boundaries, were corrected in the field.

III. 16-inch Orissa Cadastral Survey.—(a) A new air-cum-ground survey method was tried out. In this method, framework and ground verification were carried out by the Survey of India personnel and air survey and fair mapping were to be done under contract by Messrs. Air Survey Co. of India Ltd., on Multiplex machines. It was expected that the advantage of this method over the usual ground survey method followed by the State Survey Department, hitherto, would be that the 'Khānāpuri' operations by the Settlement staff could be carried out on the photographs *pari passu* with the ground verification work by the Survey of India personnel.

(b) In the new method, the field operations consisted of :—

- (i) Reconnaissance and building of the stations for triangulation.
- (ii) Observations from and to these stations.
- (iii) Reconnaissance to find village trijunctions, and the building of white-washed cairns at these positions.
- (iv) Reconnaissance and marking on air photographs of village boundaries.
- (v) Theodolite observations were carried out from the triangulation stations with a view to fixing, as intersected points, as many of the village trijunction cairns as possible. The remaining village trijunction positions and also some extra planimetric control points were fixed by theodolite traverse.
- (vi) Ground verification carried out village by village and the plot limits marked up on the 16-inch photographs by the Survey of India personnel. These same plot limits were also marked up on the overlapping adjacent photographs issued to ' *Amins* ' of the State Settlement Department.
- (vii) ' *Khānāpuri* ' operations, by the ' *Amins* ' of the Settlement Department, including the writing of plot numbers on the 16-inch photographs.

(c) The detailed methods of the above operations are described below :—

- (i) The aerial photography was carried out when the harvesting was over so that all the field bunds appeared on the photographs. Reconnaissance observations for triangulation were completed before photography. The intersected points consisting mostly of village trijunction pillars, which were not demarcated on the ground initially, were reconnoitred and fixed subsequently by triangulation or traverse, after the area was photographed.
- (ii) The village trijunction positions were reconnoitred with the help of the villagers and the ' *Amins* ' of the Settlement Department who consulted old revenue records and 16-inch sketch maps of the villages. Mounds of earth were built over these trijunction positions and were white-washed for identification from distant hill stations by the triangulators.

Those village trijunctions, which could not be observed as triangulation intersected points, were connected by theodolite traverse from fixed intersected points. Whenever a triangulation intersected point, which was

used as the starting or closing point of traverse, was fixed from two stations only, the horizontal angle at the intersected point between the two triangulation stations was observed and the intersected point recomputed to ensure its reliability as the starting or closing point of the traverse. The horizontal angle between the next traverse station and one of the hill stations was always observed at the starting or closing points (which were always triangulation intersected points) of a traverse line. This was done to obtain starting and closing azimuths for the traverse without resorting to astronomical observation, unless the number of stations in a line exceeded 20, when a Polaris azimuth observation was made at one of the intermediate stations.

- (iii) In addition to the village trijunction positions, certain additional control points, required for Multiplex plotting, as indicated by the Air Survey Co. of India Ltd., were also fixed by theodolite traversing.
- (iv) The photo. positions of all those traverse stations which could be readily identified on the photographs, were pricked in.
- (v) The limit of error allowed for triangulation was 1 in 10,000. The limit of error allowed for traverse was in accordance with para 6 of the Handbook of Topography, Chapter IV.
- vi) The limits of villages and those of individual plots were marked on 16-inch photographs as pointed out on the ground by the Settlement 'Amins' in consultation with the owners of the plots and the rough village sketch maps and other old records available with them.

Whenever any point forming a bend along a plot limit was not clearly identifiable on the photograph, its position was obtained by ground measurements from other clearly identifiable sharp points. These measurements were recorded on the back of the photographs. Such measurements were almost invariably necessary where a number of plots fell in a small area. Where the congestion was too much to allow for legible recording of measured distances, enlargements on 32-inch scale of the congested portion were prepared either by plane-tabling on blank pieces of drawing paper or with the help of proportional compasses. Duplicate copies of such enlargements were supplied to the 'Amins' for recording the numbers for the plots at the time of 'Khānāpuri' operations.

(vii) It was considered that during the time an 'Amin' could complete the 'Khānāpuri' operations in a village, a Survey of India ground-verifier could complete detailed marking of plot limits in four such villages. Therefore, four 'Amins' were allotted to one ground-verifier for marking and checking of the plot limits on the photographs carried out by the former. The ground-verifier checked the work of each 'Amin' under his charge, in turn.

(viii) Two sets of photographs, with plot limits of a village marked thereon, were maintained—one set with the ground-verifier and the other with the 'Amin'. After the ground-verifier and the 'Amin' had gone over the ground together, both the sets were compared and the set with the 'Amin' brought into agreement with that of the ground-verifier. The 'Amin' then started the 'Khānāpuri' operations with the help of the set of marked up photographs with him.

31. Notes on Out-turn.—(a) The out-turn of the reserved forest boundary survey was not up to expectations on account of the following reasons :—

(i) In many places boundaries were not cleared beforehand.

(ii) 16-inch sketch maps showing the forest boundary alignment were not readily available with the forest guards accompanying the Plane-tablers.

(iii) Some of the forest guards accompanying the Plane-tablers were inexperienced in their duties.

(b) The out-turn of the cadastral survey operations in Orissa suffered a great deal due to lack of proper co-operation from the villagers. This was to some extent owing to the fact that the usual routine notices from the State government to the villagers informing about the settlement survey operations had not been issued.

The out-turn was further adversely affected because the 'Amins' often made mistakes in showing on the ground, the proper positions of the village trijunction pillars and the limits of villages and plots. Thus, about 50% of the cairns at village trijunction positions, which had been fixed and observed, had later to be refixed and re-observed.

For future operations of this type, it is advisable for the local settlement personnel to erect *pakka* trijunction pillars at proper positions, before the Survey of India personnel take the field. A lot of time and money would thus be saved.

No. 12 PARTY

Officer in charge :— { Mr. J. C. Berry, to 10-4-51 and from 23-5-51 to 24-10-51.
 Shri G. B. Das, M.A., A.R.I.C.S., from 11-4-51 to 22-5-51 (current duties).
 Shri J. C. Sikka, B.A., from 10-11-51 to 27-11-51.
 Shri K. C. Gosain, B.A., M.I.S. (Ind.), from 25-10-51 to 9-11-51 and from 28-11-51.

32. General.—The party continued to be employed on air survey on various scales for the Department as well as for the other departments of the Government of India.

33. Technical Methods—(i) *Upper Mahānadi Reservoir ; Sheet Nos. 64 H/6, 7 and 11.*—Complete air survey on 4-inch scale with 10 feet contouring was carried out by graphical methods.

(ii) *Bihār Mica Belt ; Sheet Nos. 72 L/2 and 6.*—There has been no change in the methods employed for this work, from that reported in para 35(b) of the Technical Report, 1951.

No. 18 (BOUNDARY SURVEY) PARTY

(Reduced to the status of a Detachment with effect from the 12th October 1951)

Officer in charge :— { Major S. K. S. Mudaliar B.A., A.M.I.E., Engrs., up to 11-10-51.
 Shri I. C. Deb, B.sc., from 12-10-51 (as Incharge Detachment).

34. General.—The detachment was employed on ground verification, the preparation of guides and correction of proofs of the East-West Bengal Boundary Survey maps, which were being compiled by Messrs. Air Survey Co. Ltd., London.

35. Technical Methods.—The ground verification was carried out by running plane-table traverse lines along prominent detail based on last year's traverse stations. Distances were measured by crinoline chain and detail correct within 10 yards was accepted. This check showed that the Multiplex plotting carried out by Messrs. Air Survey Co. Ltd., London, was generally accurate.

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V. TECHNICAL NOTES, SOUTHERN CIRCLE

DIRECTOR :— $\left\{ \begin{array}{l} \text{Shri B. N. Saha, M.Sc., M.I.S. (Ind.), to 5-11-1951.} \\ \text{Mr. J. C. Berry, from 6-11-1951 to 14-1-1952 (current duties).} \\ \text{Mr. P. A. Thomas, A.R.I.C.S., M.I.S. (Ind.), from 15-1-1952.} \end{array} \right.$

DY. DIRECTOR :—Mr. J. C. Berry, from 1-11-1951.

36. **Summary.**—During the period under report the following units were under the administrative control of the Director, Southern Circle :—

- No. 6 Party.
- No. 8 Party.
- No. 10 Party.
- No. 17 Party.
- No. 4 Drawing Office.

Brief reports of the various survey operations carried out by the above mentioned field units have been given in the General Report 1952.

The technical methods employed for the various types of surveys are given below in the reports of the respective units.

No. 6 PARTY

Officer in charge :— $\left\{ \begin{array}{l} \text{Shri M. R. Nair, B.A., A.M.I.S. (Ind.), to 1-7-51.} \\ \text{Shri B. N. Saha, M.Sc., M.I.S. (Ind.), from 2-7-51 to 1-8-1951.} \\ \text{Shri M. R. Nair, B.A., A.M.I.S. (Ind.), from 2-8-51 to 31-10-51.} \\ \text{Major J. A. F. Dalal, B.A. (Hons.), Engineers, from 1-11-51.} \end{array} \right.$

37. **General.**—The party carried out the following surveys during 1951-52 :—

- (a) Blue-print surveys in sheets 46 G/14 and 16.
- (b) Air-cum-ground surveys for the Ukāi Reservoir additional area in sheets 46 G and K.
- (c) Fair drawing of Kākadāpār Reservoir sheets.
- (d) Theodolite traversing and triangulation for settlement surveys in Kutch.

38. **Technical Methods**—(a) *Blue-print Survey.*—The normal ground survey methods laid down in Chapter V of the Topographical Handbook were followed using zinc mounted plane-table sections.

(b) *Air-cum-ground survey, Ukāi Reservoir. Additional Area.*—The original survey demand was limited to the 310-foot (above Mean Sea-Level) contour but was later raised to include the 400-foot contour. The survey of the additional area thus demanded was taken up during the field season under report ; the survey and fair drawing for the area originally specified were completed earlier.

Detail was compiled from vertical photographs using Slotted-template and graphical plotting methods. Supplementary heighting was carried out in the field using black prints of the air survey compilations. Vertical angles were measured with theodolite and distances were scaled off the black prints to compute heights. Contouring and ground verification of air-compiled detail were then completed on the ground.

This additional area necessitated a change in the lay-out of sheets (rendering the sheets drawn earlier useless) and fresh drawing of the whole reservoir area will be undertaken during recess 1952-53.

(c) *Fair Drawing of Kākadāpār Reservoir Area.*—The air survey compilation including contouring of about 320 square miles of this area was carried out by the Air Survey Company in the United Kingdom from ground control provided by this unit. Compilation of contour and outline originals was supplied on astrafoil, strip by strip. The delay in receipt of the compilation, the lack of agreement between the common edges and omission of a large amount of detail entailed heavy corrections and ground verification on photographs which, incidentally, were different to those from which the originals were compiled both as regards scale and layout. Equally laborious adjustments were required during the fair drawing of these sheets in attempting to incorporate these corrections. The fair sheets were prepared on drawing paper and not on Kodatrace.

(d) *Topographical Framework for the Settlement Surveys in Kutch.*—This framework consists essentially of modern traverses with main circuits connecting G.T. stations broken up further by tie-lines and short circuits, except in the northern portion where the country is suitable for triangulation and Hunter Short Base traverse. The ultimate object of this framework is to enable traverses to be run along or close to village boundaries, to fix these boundaries and plot them on village plot sheets on a scale of 8 inches to a mile to be supplied to the indentor. The field work for 70 villages was completed during field season 1951-52 involving a total of 847 linear miles of traversing and 162 square miles of triangulation.

39. *Description of Country.*—(a) The Ukāi Reservoir area lies in the densely wooded valley of the Tāpti River whose lower regions contain patches of cultivation inhabited by the *Bhils* (Adibāsis).

(b) The area traversed in Kutch lies in the open treeless plains with the tidal flats on the south and the system of low hills in the north.

40. *Cost Rates.*—As none of the jobs mentioned above has yet been completed cost rates have not been included in the Table C.

No. 8 PARTY

Officer in charge :—Shri M. W. Kalappa, B.A., A.M.I.S. (Ind.).

41. General.—The party was employed on the following surveys, mapping and framework for extra-departmental projects and departmental jobs :—

- (a) Tungabhadra Project.
- (b) Pej-Ulhās, Kāl and Kundalika Valleys of Tail-Waters Project.
- (c) Koyna Reservoir.
- (d) Navja-Pophli Tunnel of Koyna Project.
- (e) Bhadra Reservoir.
- (f) Bombay Oil Refineries Project.
- (g) Miraflores Estate.
- (h) 1-inch Modern survey.
- (i) 1-inch verification survey for communications.

42. Technical Methods.—The methods adopted for item (a) above were described in the Technical Report 1947 (para 63) and the methods adopted for items (b) to (d) in the 1951 Reports. The methods used for the remaining five jobs are given below :—

(a) *Bhadra Reservoir.*—An air survey map, 50 square miles in area, falling in sheet 48 O, on the scale of 8 inches to 1 mile with contours at 100 feet vertical interval and showing village boundaries, was required by the Irrigation Department of the Mysore Government for capacity calculations, determining the exact area that would be submerged by the Reservoir and for getting an idea of the compensation to be paid to villagers.

The area consists of low undulating hills, covered by a dense growth of trees, bamboos and undergrowth, interspersed with narrow cultivated valleys. Most of the wooded area is State Reserved Forest, the external and internal sub-division boundary lines of which provided good clearings for running single tertiary levelling lines and clinopole height traverses for fixing height control.

Planimetric control was fixed by supplementary triangulation. For intersected points, only such objects as could be clearly identified on the photographs were selected. In a few cases, in densely wooded area, helios were used at intersected points for observations from triangulation stations.

A pendant double tertiary levelling line of 94 linear miles was run from a G.T. bench-mark at Hassan to the Bhadra Dam Site at Lakavalli via Belūr to bring the heights and contours of the reservoir survey in terms of spirit-levelling heights.

The area was systematically covered with heights, about a furlong apart, fixed by a combination of single tertiary lines starting from and closing on double tertiary level lines, clinometric and

clinopole heights thrown to identified points on photographs on either flank of the tertiary level lines, and by barometric height traverses. The last method was used extensively in densely wooded areas.

Where identification of barometric height points on photographs in forest areas was difficult, a plane-table traverse, on a Kodatrace overlay, on the mean scale of the photographs combined with the barometric height traverse was run from one identified point on the photograph to another. The closing error was then adjusted and the intermediate adjusted traverse stations were pricked from the Kodatrace overlay on to the photograph and the corresponding heights were recorded.

In one case, where a third identified point was available between two identified points of the traverse, the adjusted traverse station pricked on the photographs was found to agree within the permissible error.

Another method was also used to identify the position of barometric height points in wooded areas. The height-traverser stands at an identified point whose height is known, selects a suitable point on the photograph whose height he proposes to fix with the barometer, orients the photograph in azimuth from 3 other identified points, draws a ray on the photograph in the direction of the new point, observes the magnetic bearing from the known height to the new point by means of a prismatic compass and computes the distance apart between the 2 points from the mean scale of the photograph. With the help of the prismatic compass he then walks along the exact bearing and on reaching the distance previously computed, he records the barometric readings and pricks the point on the photograph after checking local detail wherever possible. This method was used for short distances only, involving not more than 2 traverse stations or about 200 yards away from an identified point in an open area.

Independent checks showed that the heights fixed by a battery of one Paulin and two Aneroid barometers were accurate to within 10 feet, which, considering the nature of the terrain, was satisfactory. The results would have been better if all the barometers were of the Paulin or the latest type, which could be read to 1 foot. Some discordant heights found during the course of the work were promptly investigated and discrepancies were traced to certain errors in the calibration data supplied with the barometers, which were rectified before using such barometers for further heighting.

The field observations were made up to a range of 15 miles from the base station in distance and 200 feet in height.

Some of the special precautions taken in using the barometers were :—

- (i) All the barometers were calibrated before the commencement of the field work.

- (ii) All barometers in a battery of 3 were carried in identical conditions in a thickly padded wooden box, painted with white lead to help radiation of heat.
- (iii) The box was not exposed to direct sun-light.
- (iv) The box was carried horizontally by a *khalasi* in a sling over one shoulder and held firmly under the arm-pit while moving from one point to another to avoid any jolt to the barometers.
- (v) A magnifying glass or the lens of a pocket stereoscope was used for reading barometers more accurately.
- (vi) The base observer recorded the readings every 20 minutes. The field observers, camping away from the base station, synchronized their watches with the watch of the base station every alternate day and corrected the time of previous observations before computing their heights.

Details, including streams in dense wooded areas, that were not clear on the photographs were verified on the ground and then inked up on the photographs.

(b) *Bombay Oil Refineries Project*.—The survey and preparation of a map of an area of 6.3 square miles in sheet 47 A, on the scale 12 inches to 1 mile with contours at 2 feet vertical interval in the plains and 5 feet vertical interval in the hills, was required by Messrs. Burmah Shell Oil Storage and Distributing Company of India, Limited, and by Messrs. Standard Vacuum Oil Company in India for the construction of Oil Refineries. The job was given top priority by the Government.

The area consisted of low undulating hills with scattered trees and scrub, terraced cultivation and the foreshore of Trombay Island of Bombay.

Planimetric control was fixed by supplementary triangulation. A pendant double tertiary levelling line of 10 linear miles was run from the G.T. bench-mark No. 8/47 A, across the centre up to the eastern edge of the area to bring the heights and contours of the survey of the Oil Refineries in terms of the spirit-levelling heights. The stability of the starting G.T. bench-mark was checked by connecting it to 2 adjoining G.T. bench-marks.

A number of single tertiary level lines were run, starting and closing on the double tertiary level line, to provide adequate height control in the area. Clinopole was used to survey the contours.

Of the total area, 4 square miles were covered by 6-inch air photography taken in April 1950. The details of this area were compiled from enlargements, on scale of 12 inches to 1 mile. The verification of detail and contouring was carried out on the ground on blue-prints on 12-inch scale. The plane-table sections were completely inked in proper colours. The detail and contours will be separately traced from the plane-table sections on to Kodatrace fair originals during recess 1952 for the final publication of the map.

The remaining area of 2.3 square miles, for which no photo cover was available, was surveyed by normal ground methods.

(c) *Miraflores Estate*.—The survey and preparation of a map of an area of 1.0 square mile in sheet 58 B, on the scale of 16 inches to 1 mile with contours at 20 feet vertical interval, was required by Messrs. Matheson Bosanquet and Company Limited, for determining the total area as well as the areas under different plantation of the Miraflores Estate.

A plane-table triangulation of the area based on existing triangulation data was first carried out on 4-inch scale. The new points fixed on this plane-table section were subsequently transferred on to a 16-inch plane-table section. A main plane-table traverse with heights along the external boundary and tie-lines along the internal boundaries of the Estate was then run on the 16-inch plane-table section. With the help of these traverse stations, the details and contours were finally surveyed by normal ground methods. Clinopole was liberally used for surveying the contours.

The Estate contained coffee, tea, cardamom and orange plantations with a fairly dense growth of big tall trees, used as shade for coffee and cardamom plants.

This survey revealed that the total acreage of the Estate, as previously surveyed by the local revenue surveyor, was in error by as much as 25%.

(d) *1-inch Modern Survey*.—The survey of sheet 47 G/13 was carried out by normal ground methods, based on the re-computed old topo triangulation data. The method adopted for the re-computations of co-ordinates and heights of this triangulation was described in para 46 of the Technical Report 1951.

(e) *1-inch Verification Survey*.—The office copy corrections to communications in sheet 48 P were verified by normal ground methods, for revising the 40-mile Road Map of India.

This work necessitated very frequent moves by the Plane-table. He was given a squad of 3 Class IV servants, including a *camp khalasi* and was permitted to take only the minimum amount of equipment and private luggage with him. He and one *khalasi* of his squad were provided with bicycles to facilitate quick movement from one plane-table fixing to another.

43. *Miscellaneous*.—It was originally estimated that the wages of local *mazdoors* in Bhadra Reservoir area would be about 2 rupees per man per day. In actual practice, the *mazdoors* had to be paid from 3 to 5 rupees per man per day for clearing jungle in the area. The locality was thinly populated and the survey party had to depend mostly on *mazdoors*, imported by the local Government from outside the Mysore State.

The cost of surveys and mapping completed in the year under report is given in Table C and the remaining projects will be given in the future reports as and when their surveys and mapping are completed.

No. 10 PARTY

Officer in charge :—Mr. F. M. Hawley, A.B.I.C.S.

44. **General.**—The party was engaged throughout the year on training, departmental and extra-departmental mapping and one extra-departmental large scale survey.

45. **Training.**—The batch of 34 trainees from other circles continued their training in fair drawing, theodolite traversing, levelling and air surveying during recess 1951. During this period one trainee resigned and one was discharged. The remaining 32 trainees were given a complete course in 1-inch scale plane-tableing during the field season 1951–52. This training followed the standard syllabus which has already been set down in Section VI as an Appendix to the Technical Notes of the Technical Report 1948–49.

46. **Departmental Fair Mapping.**—The six departmental sheets under fair mapping in the party were drawn according to the normal rules laid down in the Departmental Handbooks.

47. **Extra-Departmental Surveys.**—The large scale (1/2500) survey carried out for the Hindustān Aircraft Limited was exclusively for planning purposes. The accuracy of position and height was in conformity with the standards required.

48. **Technical Methods—Bangalore Airport and Surroundings.**—This survey on the scale of 1/2500 was required by the Hindustān Aircraft Limited in connection with the construction of a new runway. One of the requirements was that the area for survey should be divided into 500 feet squares for the purpose of soil test. The corners of 1000 feet squares were to be marked by stones and those for the intermediate 500 feet positions by wooden pegs. It was not essential for the stones and pegs to be laid exactly on the 500 feet marks, but their co-ordinates and levelled heights were to be provided, and their positions had to be shown in their exact place on the resultant map. Accordingly these stones and pegs were embedded by a plane-tableer by plane-table traversing methods controlled by 3 trigonometrical points on the east, centre and west of the area. After the stones and pegs were embedded, one traverser and two levellers carried out the traversing and levelling of each and every stone and peg which formed the framework for the subsequent plane-tableing which was carried out in the normal departmental manner. Contours were surveyed at 1-foot vertical interval.

No. 17 PARTY

Officer in charge :—Shri B. N. Murthy, B.Sc.

49. **General.**—The party was engaged on the Māhi Project and Sharāvati Project Surveys, and on survey for the Obstruction Chart of Bombay Santa Cruz Aerodrome.

50. **Technical Methods**—(a) *Santa Cruz Aerodrome Obstruction Chart on scale 1/12,000.*—This is a special survey, carried out according to the specification laid down by International Civil Aviation Organization, for the purpose of showing the runways of the aerodrome and the obstructions above a 100 to 1 glide angle from the ends of the runways. Apart from the above no topographical features were required to be shown, but all buildings, etc., with heights were shown. For this purpose, the triangulation previously carried out by No. 8 Party for the survey on 1/50,000 scale of the Aerodrome Landing Chart was utilised, and was supplemented by triangulation over an area of 45 square miles. Traversing and levelling of 4 linear miles were also carried out, for the provision of planimetric and height control. Individual obstacles within an area of 5 square miles were located by plane-table intersections and resections and by theodolite traversing.

The area consists of plain and open country, only lightly built up.

(b) *Māhi Project Commanded Area, on scale of 4 inches to 1 mile.*—This forms part of the survey of the commanded area of the Māhi Canal Project, Stage II, and is being carried out for the Public Works Department of Bombay State, for designing detailed alignment of canals, branches and distributaries in the commanded area.

The method adopted was air-cum-ground survey as described below :—

- (i) Air photographs of the area on 4-inch scale were verified on the ground.
- (ii) The area of survey was divided into a 30-chain grid on 1-inch maps. The corners of this mesh were transferred on to 4-inch photographs with the help of local detail. During photo verification, stones, marking the corners of the 30-chain mesh, were embedded in the ground, using photographs as guide. Later these stone positions were accurately resected on the photographs.
- (iii) Height control for the area was provided by double and single tertiary levelling.
- (iv) Detail survey will be done by carrying out corrections from the verified photographs on 4-inch enlargements on Kodatrace of the existing one-inch maps.

(c) *Sharāvati Project : Reservoir Area 4 inches to 1 mile. Dam-site and Station-Site Areas 16 inches to 1 mile.*—This survey is being carried out for the Mysore Electricity Department in connection with the Honnemaradu Hydro-electric Project.

Requirements are as follows :—

- (i) A map on 4-inch scale with 20 feet contour interval of the reservoir area, i.e., area covered up to the 1840-foot contour, and the area of Talakale valley subsidiary

reservoir up to the 1750-foot contour, and the area covering half a mile on either side of the proposed tunnels connecting the two reservoir areas.

- (ii) Maps on 16-inch scale with 10 feet contour interval of the areas of the proposed dam-site and power station-site of the hydro-electric project.

The survey was carried out by air-cum-ground methods.

Planimetric and height control for the reservoir area, provided by triangulation and levelling, was post-pointed on 4-inch enlargements of air photos.

The triangulation in the area was extended from a G.T. base.

As no levelling line ran through the area, a double tertiary levelling line was carried from Yellapur G.T.S. Bench-Mark to a bench-mark established near the dam-site by the Mysore Public Works Department. The total distance of this line was 78 miles. All the other level lines were run from this bench-mark.

The heights of all the trigonometrical stations and points in the area were determined in terms of the spirit-level net.

In the area above the existing dam at Hirebasagar, the water level of the reservoir in terms of Mean Sea-Level as obtained from local authorities was used for the starting and closing of levelling lines. In the station-site area, existing heights were supplemented with barometric heights.

Six Aneroid barometers were used. Of these, a battery of three was kept at a base station of known height and the other three were carried by the observer in the field. Barometer and thermometer readings at the base station were recorded every half hour. Similarly temperature, barometer and time readings were recorded by the observer at places where spot heights were required.

Barometric heighting was adopted where the slopes were covered with dense jungle and where clinometer or theodolite observations were not possible, without extensive and costly jungle clearing. The air photos covering the area were verified on the ground at the time of providing planimetric and height control. The compilation will be done by normal air survey methods.

PART II. MAP PUBLICATION AND OFFICE WORK

TECHNICAL NOTES

DIRECTOR :— { Colonel I. H. R. Wilson, M.I.S. (Ind.), to 6-5-1951.
Shri K. L. Dhawan, B.A., M.I.S. (Ind.), from 7-5-51 to 17-5-51
(current duties).
Colonel Gambhir Singh, M.I.S. (Ind.), from 18-5-51 to 4-11-51.
Mr. H. M. Critchell, from 5-11-51.

DY. DIRECTOR :— { Shri K. L. Dhawan, B.A., M.I.S. (Ind.), to 30-9-51.
Mr. C. T. Hurley, M.I.S. (Ind.), from 1-10-51 to 30-12-51.
Mr. H. M. Critchell, from 31-12-51 to 27-1-52 (in addition to
his duties as Director, Map Publication).
Shri M. M. Ganapathy, B.A., from 28-1-52.

VI. PRINTING

Experiments are in progress to renovate time-barred and fogged photographic material. The results obtained so far have been very hopeful. The success of the experiment will save the Department a considerable amount of money.

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 1952.