SURVEY OF INDIA

TECHNICAL REPORT

1947

(From 1st October 1946 to 14th August 1947)

PART I—TOPOGRAPHICAL AND OTHER SURVEYS

PART II—MAP PUBLICATION AND OFFICE WORK

PUBLISHED BY ORDER OF

THE SURVEYOR GENERAL OF INDIA

PRINTED AT THE OFFICE OF THE GEODETIC & RESEARCH BRANCH,
SURVEY OF INDIA, DEHRA DŪN, 1949

Price Three Rupees, or Five Shillings

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PREFACE

This technical report which is the first of its kind, covers a period of great difficulty. During the war 1939–1945 the great majority of technical personnel in the Survey of India were either mobilised or were employed on special work for the armed forces. The period under report covers the first field season since 1939 in which the greater part of the department was engaged on civil work.

2. Owing to the urgent need for surveys for development projects, nearly all resources were concentrated on these; and practically no progress was made on the programme of topographical surveys begun in 1905 and as yet not nearly finished.

3. This work on projects involving a large use of air photographs combined with much levelling, was a completely new activity. New methods had to be devised and personnel trained in them. As many of those most experienced in the use of air photographs were still in the army, the out-turn was low and general standards of accuracy were not good. This to some extent accounts for the very high cost rates shown in Table 'C'.

4. Much of this project work might be classed as "Engineering Surveys" which would normally fall outside the province of the Survey of India. Owing, however, to the fact that no other organisation in India has the capacity at present for undertaking such work, it seems probable that while the present very high demand for project surveys continues, a large part of the activities of this department will be devoted to such work; and that progress on the topographical surveys which have for many years been the main function of this department will be accordingly decreased.

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

DELHI
April 1949.

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SURVEY OF INDIA

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I.—INTRODUCTION AND SUMMARY

1. Prior to the war, two annual reports were published by the Survey of India:

The General Report
The Geodetic Report

The first named was a brief narrative covering all work of the department and was intended for the information of Government and non-technical readers. The Geodetic Report dealt in detail with the geodetic and geophysical activities of the department, and was intended to have a wide circulation amongst specialists throughout the world.

Neither of the above reports afforded an opportunity for the publication of technical reports on map publication or surveys not included in the scope of the Geodetic Report. Such reports as were considered of interest were recorded in a Technical Supplement to the General Report produced in typescript by circles; but as these were not printed they had a very limited circulation even in the department.

Since the conclusion of hostilities, the Survey of India has been engaged on more varied survey tasks than ever before. New methods, organizations and procedures are constantly being tried and adapted to suit particular conditions.

In order to make the results of experience readily available to this and other departments, it has been decided in future to publish a Technical Report, to cover those technical aspects of the work of the Survey of India not covered by the Geodetic Report. The present volume is the first of the new series of Technical Reports.

The *Technical Report* which supplements the General Report is arranged as follows:—

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

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

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

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 year it is being published as a separate volume.

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

This Technical Report does not contain any technical notes on the work carried out by the Frontier Circle, which covered most of the area which is now Pakistan. Owing to the partition of India it has proved impracticable to include them.

PART I. TOPOGRAPHICAL AND OTHER SURVEYS

II.—ABSTRACT OF TOPOGRAPHICAL WORK

2. In previous issues of the annual General Report of the Survey of India, the abstract of topographical work was usually explained by three Tables namely, Tables A, B and C.

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

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

As normal survey work, both on new and revision surveys practically ceased for the duration of the last war, Tables A and B have been omitted from 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, however, illustrated in *Index A* of this report.

Considerable survey operations mainly for irrigation and other development projects for the Central and Provincial Governments and States have, however, been carried out during the period under report and these are explained by Table C only, which 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. *Index C* at the end of this report shows the surveys in hand in connection with these development projects.

In Table C, although every endeavour has been made to calculate the cost rates accurately, it is extremely difficult to allocate overhead charges fairly to the various classes of work. The cost rates shown in the Table C must therefore be considered to be approximate. The nett 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 nett 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 Dūn.

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
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	**GEODETIC BRANCH**
No. 1 Party.—	**New Delhi Expansion Survey :—**					
Area fairly congested, and country undulating and broken	1. Air survey (outline) scale 6″= 1 mile	49·5	1·3	307·9	384·9	
Area largely built over, in parts undulating and rocky	2. Original ground survey scale 6″ = 1 mile with contours at 5-foot interval	6·5	1·4	738·9	960·1	
	3. Ground verification and surveying of 5-foot contours, scale 6″ = 1 mile	49·5	2·8	417·9	541·6	
	4. Ground control :—					
	(i) Triangulation ..	30	17·6	105·5	137·3	
	(ii) Traversing ..	22 linear miles	33 linear miles	67·7	88·1	
	Complete job ..	56	87	810·0	1,038·5	
City area	Udaipur City. Traversing without heights	16·1 linear miles	5·9 linear miles	304·7	450·2	
Hilly, undulating country covered with dense and open jungle	Kunur Power House (Damodar Valley project) air surveys scale 16 inches = 1 mile, contours at 10-foot interval	2·2	0·4	883·2	1,104·0	

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Nett	*Overall	
No. 1 Party.—*Concld.*		sq. m.	sq. m.	Rs.	Rs.	**GEODETIC BRANCH.—*Contd.***
Mountainous country with jungle and open areas	Ashni river survey (Patiala State) scale 4″ = 1 mile; contours at 20-foot interval :—					
	(i) Height control ..	37	9·7	212·6	307·0	Existing triangulation data of year 1882–87 was quite adequate for planimetric control for air survey. No further triangulation was therefore carried out.
	(ii) Air survey, scale 4″ = 1 mile; contours at 20-foot interval	37	1·7	210·4	263·0	
	Complete job	37	1·4	422·10	568·9	
Mountainous country with jungle and open areas	Dochi Dam site survey, scale 32″ = 1 mile; contours at 20-foot interval :—					
	(i) Triangulation	1·4	1·5	1314·4	1,776·5	
	(ii) Height control	1·4	0·9	2457·14	3,323·9	
	(iii) Air survey	1·4	0·14	3272·14	4,090·2	
	Complete job	1·4	1·1	7045·0	9,191·4	
Mountainous country with jungle and open areas	Contouring on photo-mosaic of Dochi Dam, scale 12″ = 1 mile	1·4	3·5	98·15	122·7	
City area	Levelling (tertiary)	37 linear miles	22·3 linear miles	62·13	79·3	

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month			Cost Rate per acre		Remarks
			No. of stones laid	Area in sq. miles	Linear miles	*Nett	*Overall	
No. 13 Party.—		sq. m.				Rs.	Rs.	**GEODETIC BRANCH** *Contd.*
Open, flat cultivated plains with occasional patches of scrub & trees	Rectangulation to 25 acres ..	1434	153·8	5·2	..	..	0·71	
	Levelling Tertiary, double and single	1298	..	18·1	138·5 (*a*) 120·3 (*b*)	..	0·19	(*a*) For double tertiary. (*b*) For single tertiary.
	Computations of tertiary levelling	685	..	..	..	..	0·10	
	Preparation of spot height charts	685	..	..	..	..	0·05	
	Fair drawing contour charts ..	685	..	..	..	..	0·05	
	Printing 150 copies of each sheet at-4 inch scale	..	..	..	..	..	0·13	Size of sheets without accessory work 20″ × 15″.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per acre		Remarks
				*Nett	*Overall	
		acres	acres	Rs.	Rs.	**GEODETIC BRANCH.—** *Contd.*
No. 20 (Cantt.) Party.—						
Cantonments, heavily congested built up area. Airfield open and lightly built up	16-inch—Traverse and computations	43504	209·2	..	1·5	Karāchi. Lonavala, Meerut and Agra Cantonments and Salua Airfield.
Undulating open area, 30% built up ..	8-inch—Traverse and computations	12491	387·9	..	1·1	Dhond, Dehu Road Avadi.
Very undulating, 40% built up area ..	100′ = 1 inch—Traverse and computations	485	485·0	..	1·5	Madhukari, St. Thomas Mount and Deolali South Military Lines.
Steep wooded hills	10′ = 1 inch—Levelling and computations	740	522·2	..	0·5	Avalanchi, Dam (Nilgiris).
Heavily congested built up areas ..	16-inch—Levelling and computations	43504	243·5	..	0·63	Meerut, Agra and Lonavala Cantonments.
Very undulating, 40% built up area ..	100′ = 1 inch—Levelling and computations	485	121·3	..	2·1	Madhukari, St. Thomas Mount and Deolali South Military Lines.
Fairly open, 60% built up area. Kharakvasla wooded hills	200′ = 1 inch—Levelling and computations	416	78·5	..	0·38	Aundh, Dhond, Saugar and Kharakvasla.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per acre		Remarks
				*Nett	*Overall	
		acres	acres	Rs.	Rs.	**GEODETIC BRANCH.—*Concld.***
No. 20 (Cantt.) Party.—*Concld.*						
Congested bazaar areas	64-inch (No contours) Ground survey and fair mapping	101	6·4	..	63·5	Multan and Drigh Road Cantonment Bazaars.
Very undulating highly built up area ..	32-inch (No contours) Ground survey and fair mapping	1552	273·9	..	14·9	Gummundipundi.
Very undulating 40% built up area ..	100′ = 1 inch, 5 feet V.I. Ground survey and fair mapping	485	52·7	..	38·6	Deolali South and St. Thomas Mount.
Wooded hills and undulating ground slightly built up	200′ = 1 inch, 5 feet V.I. Ground survey and fair mapping	416	46·3	..	21·0	Kharakvasla site for Military Academy.
Cantonments, heavily congested built up areas. Airfields and camps open and lightly built up	16-inch, 5 feet V.I. Ground survey and fair mapping	43504	228·8	..	5·0	Karāchi, Multan, Drigh Road, Ambala, Meerut, Agra, Keti and Jubbulpore Cantonments and Rānchi Military Camps and Salua Airfield.
Steep wooded hills	10-inch, 5 feet V.I. Ground survey and fair mapping	740	941·2	..	3·6	Avalanchi Dam (Nilgiris).
Undulating open area, 30% built up ..	8-inch, 5 feet V.I. Ground survey and fair mapping	12491	1136·2	..	4·3	Avadi, Dehu Road and Arkonam.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	EASTERN CIRCLE.
No. 9 Party.—	Kosi Irrigation (4-inch, 1 foot, V. I.)					
Generally flat ground traversed by many water channels, old and new of the Kosi river. Grass 8 to 16 ft. high	Precise traverse	242·0 miles	13 miles	83·7	110·9	
	Secondary levelling	158·0 miles	24 miles	81·8	108·4	
	Double tertiary levelling ..	208·0 miles	22 miles	71·2	94·4	
	Photo marking (including combination)	235·0	12	68·2	89·6	
	Stone-laying	235·0	4	194·2	257·4	Low out-turn due to late arrival of stones from manufacturers.
	Tertiary levelling	1,921·0 miles	14 miles	34·7	46·0	
Nepal—open and dense jungle and undulating ground	Outline air survey	235·0	9	69·3	89·3	
	Fair mapping & computations ..	235·0	4	130·9	169·6	
	Combined project	235·0	0·70	950·3	1,252·3	Includes mapping done after the period under report, i.e., up to 15th November 1947. The cost rates are burdened with an additional amount of field work (traverse control levelling and stone-laying) to give a 'head' of work for the next field season 1947–48.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
No. 9 Party.—*Contd.*	1/1000 Kosi Dam Survey (10-foot V. I.)					
Steep hilly ground, slopes 45° approx. ..	Triangulation & traverse ..	0·5	0·08	†	†	† No reliable figures available.
	Planetabling	0·466	0·06	†	†	
	Fair mapping	0·2	0·012	†	†	
	Combined project	0·2	0·007	†	†	Includes mapping done after the period under report, i.e., up to 15th November 1947.
	Jogbani Railway Extension (4 inch, 5 feet formlines)					
Undulating ground partly forested ..	Outline air survey	238·4	34	26·4	34·9	
	Ground verification	238·4	34	23·8	31·5	
	Tertiary levelling	58·0 miles	19 miles	32·7	43·4	
	Fair mapping	238·4	7	62·9	81·4	
	Combined project	238·4	4·7	121·0	153·4	Includes mapping done after the period under report, i.e., up to 15th November 1947.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	EASTERN CIRCLE.—*Contd.*
No. 9 Party.—*Concld.*	**Bagaha Land Reclamation Survey (16-inch, 5 feet V. I.)**					
Generally flat and thickly forested country ..	Traverse	46·0 miles	12 miles	112·0	148·4	
	Levelling	159·0 miles	18 miles	35·0	46·4	
	Contour survey	33·4	3	260·2	344·9	
	Combined project	33·4	1·43	581·1	770·3	
	Nepal Triangulation ..	1,945·0	63	21·5	28·5	

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Nett	*Overall	
No. 10 Party.—	**Four-inch irrigation survey with contours at 1-foot vertical interval for the Tista Project**	sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
Flat cultivated plains traversed by number of streams, banks of which are covered with dense vegetation, bamboos, and mangoes.	Precise traverse	542 linear miles	38·16 linear miles	54·32	83·6	
	Triangulation	..	..	..	..	
	Secondary levelling	240 linear miles	27·18 linear miles	143·79	210·7	
	Double tertiary levelling ..	160 linear miles	21·62 linear miles	107·84	158·0	
	Photo marking	315	14·36	4·29	6·0	
	Stone-laying	549	15·40	84·88	150·9	Contains 234 sq. miles advance stone-laying.
	Tertiary levelling	858 linear miles	12·81 linear miles	62·07	94·2	
	Outline air survey	315	22·00	50·50	72·5	
	Computation & fair mapping ..	315	3·03	116·27	188·5	Contains mapping expenditure to end of recess 1947.
	Combined project	315	1·19	745·87	1,171·3	

Note :—Contours were based on a network of levelled spot heights, 10 chains apart. They were not surveyed on photographs.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	EASTERN CIRCLE.—*Contd.*
No. 11 Party.—	4-inch Irrigation survey. Contours at 5-foot vertical interval for the Hirakud project of the Mahanadi Irrigation Scheme					
Undulating country with scattered trees and scrub	Precise traverse	..	..	..	..	
	Triangulation	1005	167·4	4·2	6·0	
	Secondary levelling	85·40 linear miles	27·85 miles	140·2	196·8	
	Double tertiary levelling ..	142·57 linear miles	45·50 miles	92·2	129·4	
	Photo marking	511·8	50·0	5·1	..	Contains 151·8 square miles advance stone-laying and photo marking.
	Stone-laying	511·8	22·0	82·0	115·5	
	Tertiary levelling	2834·2 linear miles	18·6 miles	31·7	44·5	
	Outline air survey	360	30·5	9·7	..	
	Computation & fair mapping ..	360	3·56	78·50	..	Contains mapping expenditure to end of recess 1947.
	Combined project	360	1·0	512·1	705·3	

Note :—Contours were based on a network of levelled spot heights, 10 chains apart. They were not surveyed on photographs.
* For explanation of 'nett' and 'overall' rates see page 3.

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.** *Contd.*
No. 12 Party.—						
	Karnaphuli Reservoir ..					
Intricate, heavily wooded hills	Height control (for 6-inch air survey)	197·0	9	173·3	239·5	
	Karnaphuli Dam					
Steep, wooded gorge	Triangulation (for 32-inch air and ground survey)	2·1	0·6	1523·3	2,301·3	High cost mainly due to bad weather and sickness.
	Tikarpāra Dam					
Steep, heavily wooded hills	Triangulation (for 16-inch air survey)	0·9	0·5	1984·4	3,248·6	With supplementary height control.
	Complete air survey (V.I. 5 & 10 ft.)	1·0	0·4	928·0	1,160·0	
	Combined project	1·9	0·9	2912·4	4,408·6	
	Bermo-Bhāndaridah Gorge					
Hilly, undulating ground, with open jungle..	Triangulation (for 16-inch air survey)	11·4	3·3	373·0	550·0	With supplementary height control.
	Gumti Dam					
Precipitous, heavily wooded gorge ..	Triangulation (for 32-inch air survey)	4·5	1·1	1640·9	2,370·9	High cost due mainly to inexperience and illness.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
No. 12 Party.—*Contd.*						
	Deolbāri Reservoir ..					
Hilly, undulating ground, with open jungle ..	Triangulation (for 6-inch air survey)	40·0	12·1	82·2	116·4	Supplementary height control.
	Deolbāri Dam					
Hilly, undulating ground, with open jungle ..	Triangulation (for 16-inch air survey)	4·8	3·2	320·8	455·0	With supplementary height control.
	Bokāro Dam					
Heavily wooded spurs	Triangulation (for 16-inch ground survey)	1·2	0·9	1303·3	1,681·3	
	Planetabling (V. I. 5 ft.) ..	1·2	0·5	1138·3	1,495·9	
	Fair mapping	1·2	0·4	484·2	605·3	
	Combined project	3·6	1·8	2925·8	3,782·4	

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Nett	*Overall	
No. 12 Party.—*Contd.*		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
	Jamshedpur Town Extension					
Hilly, undulating ground, with open and medium jungle	Triangulation and traverse (for 16-inch air and ground survey)	12·7	3·3	161·3	211·9	
	Ground survey of contours (V. I. 5 ft.)	4·6	0·2	2438·7	3,336·8	
	Outline air survey	4·4	1·3	133·6	167·0	
	Fair mapping	4·7	0·2	987·4	1,234·3	For 99 ft. to 1" series. Specially fine drawing required for enlargement.
	Combined project	26·4	5·0	3721·0	4,949·9	
	Konār Dam					
Spurs with medium jungle	Triangulation (for 16-inch air survey)	5·2	2·4	168·8	242·3	
	Konār Power House					
Undulating ground with open jungle ..	Triangulation (for 16-inch air survey)	2·2	1·0	529·1	678·4	
	Konār Reservoir					
Undulating hilly ground with medium jungle	Triangulation (for 6-inch air survey)	14·0	6·4	119·7	152·4	

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	EASTERN CIRCLE.—*Contd.*
No. 12 Party.—*Contd.*						
	Konār Pipe Line					
Undulating ground with medium jungle ..	Triangulation (for 6-inch air survey)	19·0	8·6	94·3	119·9	
	Hirākud Dam					
Sloping plain flanked by hills	Complete air survey (16-inch scale with 5 & 10 ft. V. I.)	3·8	1·2	191·0	238·8	
	Bokāro Coalfield					
Hilly, undulating ground, with open jungle and shallow, cultivated valleys	Height control (for 4-inch air survey)	180·0	21·4	27·1	37·3	For survey next season.
	Ground survey of contours (4-inch scale with 10 & 20 ft. V. I.)	226·0	6·1	85·9	115·9	
	Outline air survey	226·0	9·8	15·4	19·3	
	Combined project	632·0	37·3	128·4	172·4	Excludes triangulation from previous season.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile (or mile)		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Contd.***
No. 12 Party.—*Contd.*						
	Kamptee Coalfield					
Plain with open vegetation and groves ..	Height control (for 4-inch air and ground survey)	190·0	47·5	14·6	19·5	
	Ground survey of contours (10-foot V. I.)	146·0	5·2	86·6	126·4	
	Complete air survey	44·0	9·2	23·4	29·3	
	Outline air survey	146·0	19·0	7·6	9·5	
	Fair mapping	146·0	4·6	41·7	52·1	
	Combined project	672·0	85·5	173·9	236·8	Excludes triangulation and levelling from previous season.
	Bokāro Reservoir					
Undulating ground with open jungle and broad, cultivated valleys	Ground survey of contours (6-inch scale with 10 ft. V. I.)	13·0	1·6	361·9	481·0	
	Outline air survey (4-inch scale)..	13·0	14·4	10·4	13·0	
	Fair mapping	15·0	1·9	75·6	94·5	Includes areas compiled also from other sources.
	Combined project	41·0	17·9	447·9	588·5	Excludes triangulation from previous season.

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

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Nett	*Overall	
No. 12 Party.—*Concld.*		sq. m.	sq. m.	Rs.	Rs.	**EASTERN CIRCLE.—*Concld.***
	Chatra Gorge					
Steep, heavily wooded gorge	Complete air survey (4-inch scale with 20 ft. V. I.)	9·0	3·8	47·4	59·3	Form-lined.
	Hirakūd Reservoir					
Hilly, undulating and cultivated ground, with open vegetation.	Complete air survey (4-inch scale with 10 ft. V. I.)	168·0	3·1	53·6	67·0	
	Hooghly Ship Canal					
Cultivated plain and built up areas ..	Outline air survey (6-inch scale) ..	41·0	2·3	73·9	92·4	
	Naraj Dam					
Cultivated sloping country, flanked by wooded hills	Complete air survey (16-inch scale with 5 ft. V. I.).	2·6	0·7	284·2	355·3	
	Tīsta High Dam					
Heavily wooded, steep, gorge	Complete air survey (32-inch scale with 10 ft. V. I.)	0·8	0·1	2022·5	2,528·1	Requiring verification on the ground.

Figures for control include computations in the field only.
*For explanation of 'nett' and 'overall' rates see page 3.

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

Party and description of country	Class of work (including scale and V. I.)	Area	Out-turn per man per month	Cost Rate per sq. mile		Remarks
				*Nett	*Overall	
		sq. m.	sq. m.	Rs.	Rs.	**SOUTHERN CIRCLE.**
No. 6 Party.—	**Topographical Survey**					
Intricate, rocky and rugged country with fairly dense vegetation	Triangulation (Re-heighting) ..	2850	570	1·69	2·2	
	Computation	2850	570	·67	·84	
	1-inch ground survey (Blue print survey) 50 ft. V. I.	1427	18·9	73·78	98·4	
	1½-inch fair drawing	1427	52·50	27·61	34·5	
No. 8 Party.—						
Undulating plain	**Tungabhadra Project 4-inch Irrigation Surveys (5-foot V. I.)**					
	Planimetric control (Triangulation and Traverse)	726	60	19	25·0	
	Height control (Secondary levelling)	258 linear miles	38 linear miles	13·8	18·0	For 726 sq. miles.
	Detail control (Stonelaying, resection, tertiary levelling)	283	6	148	232·5	
	Mapping (Air survey and fair mapping)	283	..	77	112·5	Only 60% of mapping completed up to date of report.

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

III. TECHNICAL NOTES, GEODETIC BRANCH

DIRECTOR :— { Lt.-Col. J. B. P. Angwin, M.B.E., R.E., to 12-10-46.
Major R. H. Sams, R.E., from 13-10-46.

3. **Summary.**—At the end of the period under report, the following Survey units were under the administrative control of the Director, Geodetic Branch :—

No. 1 Party
No. 13 Party
No. 15 Party
No. 20 (Cantt.) Party
No. 2 Drawing Office
Map Record Office
Stores Office, Surveys
Printing Office
Photo-Zinco Office

Brief reports on the various survey operations carried out by the above mentioned units have been given in the General Report 1947. As this report deals only with work which is of technical interest, no reference is made here to the activities of parties employed on work of a purely routine nature.

During the period under report except for 'All India Development' experimental work, no units under the control of the Geodetic Branch were engaged on geodetic work which was transferred to the Survey Research Institute and full details of which have been dealt with in Part III (Geodetic Work) of this Technical Report.

No. 1 PARTY

Officer in charge :— { Capt. Gambhir Singh, I.A., from 1-10-46 to 14-10-46 and from 15-4-47 to 30-4-47.
Mr. K. L. Dhawan from 15-10-46 to 14-4-47.
Mr. F. M. Hawley from 1-5-47 to 17-5-47.
Mr. A. R. Qureshi from 18-5-47 to 31-7-47.
Mr. Suresh Prasad from 1-8-47.

4. **General.**—The party was employed exclusively on surveys for post-war development schemes. These surveys were of dam and reservoir sites for hydro-electric and irrigation projects, and of areas for urban development. Scales of survey and specifications varied for the different projects, which are briefly described below.

5. **Jawai River Irrigation Project.**—This survey was required by Jodhpur State for planning an irrigation and land settlement scheme of an area of about 110,000 acres falling in sheet No. 45 G. The main reservoir is to be constructed near Erinpura where a hydro-electric plant will be installed and the tail race will be used

for irrigation. One peculiarity of this settlement scheme is that the land is not being divided into rectangles at the outset as has hitherto been the practice in the settlement schemes in the Punjab. The settlement here will be made after the canals, distributaries and roads have been laid out. The farms of 16 to 24 acres will then be laid out in such a way that heavy state agricultural machinery will be able to work them with the greatest efficiency.

The area is flat with occasional mounds and is covered with scrub of varying density.

(i) *Requirements*—The requirements for this survey were—

(*a*) Fixing on the ground the intersections of one minute lines of latitude and longitude in the entire area.

(*b*) Fixing spot level heights at intersections of $\frac{1}{4}$-minute lines of latitude and longitude.

(*c*) Maps on the scale of ten inches to a mile of the entire area showing all detail and heights as in (*b*) above and contours at one-foot intervals. The accuracy required was that of a four-inch survey, even though ten-inch scale maps were asked for, for planning purposes.

(ii) *Method.*—Main traverses, using glass arc theodolites and crinoline chains were run along the perimeter of the area and along the 5-minute meridians of longitude; and were adjusted between control points provided by the All India Development Party. Subsequent methods for fixing positions of the intersections of 1-minute lines of latitude and of longitude and for fixing heights were the same as those described in Professional Paper No. 21, except that the levellers plotted their level lines, on P.T. Sections on the 4 inches to 1 mile scale. They were thus able to go round obstacles and to pick up their lines afterwards.

(iii) *Errors.*—The relative accuracy of position required was one foot between adjacent pillars at the one minute intersections of, i.e., about 1/5,000. This was felt to be too high to attain in the time available for completion of the survey. Consent of the Jodhpur State was therefore obtained to relax it to 1/1,000. A study of the closing errors of the traverses indicates that an accuracy of 1/2,000 was achieved for the main traverses.

In levelling, the maximum misclosure of 0·1 foot per 1 minute of latitude was laid down. About 20% of the lines required re-levelling to attain this standard.

(iv) *Out-turn.*—The averages were rather low due to the inexperience of almost all personnel in this type of work. The average out-turns for the field season lasting $3\frac{1}{2}$ months for the various types of work were :—

Main traverse	.. 1·1 mile per day	including time spent on clearing lines.
Minor traverse	.. 0·8 do.	
Spot height levelling	1·2 do.	

(v) *Mapping.*—The area was photographed at the scale of 3 inches to a mile and enlargements on the 6-inch scale were used. Minor control plots by the radial line method were prepared and detail from the photographs traced on the minor control plots. Positions of the one minute intersections were identified on the photographs by taking them out on the ground; and these points were resected on the minor control plots. The plots were skew gridded using the rectangular values of the one minute intersection lines.

Air survey sections were prepared on the mean scale of minor control plots. Square Cassini grid was ruled in light cobalt and the one minute intersections of latitude and longitude plotted. Detail was then traced on these sections, square by square, from the skew gridded minor control plots. Spot level heights were plotted on a separate section and contours interpolated. Very little help could be obtained from a stereoscopic view of the photographs, as the ground was flat. These sections were then enlarged by photography to the scale of 10 inches to a mile and maps printed in black for detail and brown for contours.

6. **New Delhi Development Survey.**—The Ministry of Works, Mines and Power of the Government of India required surveys of two areas, one to the north and the other to the south of New Delhi for planning schemes for the development of Greater Delhi. The northern area consists of cultivated plains with a number of gardens. The southern area is partly built up and consists of undulating ground with scattered bushes and trees as well as some flat cultivated areas.

(i) *Requirements.*—The requirements of the Government of India were :—

(*a*) Heights correct to 0·1 foot to be fixed throughout the two areas at intervals of about 1,000 yards.

(*b*) Maps of the areas on the scale of 100 feet to an inch showing all detail and contours at 5 feet vertical interval.

(ii) *Method.*—(*a*) The P.W.D. fixed pillars at suitable points about 1,000 yards apart. Single tertiary level lines were run connecting up these pillars with fundamental bench-marks in the area.

(*b*) Minor triangulation, using glass arc theodolites reading to one second, was carried out and connected to stations of the Great Trigonometrical series and intersected points were fixed at intervals of approximately $\frac{1}{2}$ mile. These points were identified and marked on 16 inches to 1 mile photographs which had been taken during 1944. Enlargements of these photographs on the scale of 40 inches to a mile were obtained and outline sections prepared by the radial line method using the above points for control. Blue prints of the outline on drawing paper were taken to the field for verification of detail and the survey of contours. Clinopoles

were used for surveying the contours. For verification of detail, fixings were made from local detail. As the photography was three years old, considerable changes in buildings, tracks and cultivation limits had taken place. In the Lodi Road Colony area the changes were excessive and re-photography was necessary.

Names, heights, headings and footnotes were pasted on the corrected outline sections and these, along with contour originals prepared by tracing contours from ground verification field sections, were used as originals for production of the printed maps.

7. **New Delhi Expansion Survey.**—The New Delhi Improvement Trust required a survey of about 45 square miles in three separate areas around Delhi; one to the north-west, another to the east near Shahdara and the third to the south, near Mahrauli. Survey was required on the scale of 6 inches to a mile with contours at 5 feet vertical interval. The northern and eastern areas are flat cultivated land. The area near Mahrauli consists partly of flat cultivated and partly of broken and undulating ground. Control was provided by traverse in the northern and eastern areas and by triangulation in the southern area. Six inches to one mile scale photographs taken during 1944 were available of most of the area. Air Survey compilations were made, verified and contoured on the ground as for the New Delhi Development Survey vide para 6 above. Areas not covered by air photography were surveyed on the 6-inch scale on the ground by plane-table.

8. **Other Surveys.**—The following air surveys were carried out by the radial line method, control points as necessary being fixed on the ground. Brief notes on these surveys are given below:—

(i) *Konar Dam and Power House Project.*—This project as well as the allied Konar Pipe Line and Reservoir project described at (ii) below are parts of the Damodar Valley Project. The Konar river is a tributary which joins the Damodar river from the north in sheet No. 73 E/13. Survey was required by the Central Technical Power Board on the scale of 16 inches to a mile. Areas involved are 4·7 square miles for the dam and 2·2 square miles for the power house. These were photographed on the scale of 8 inches to a mile and enlargements of the photography at 16 inches to a mile were used for the air survey. Control points for this project as well as for (ii) below, were fixed by No. 12 (Air Survey) Party, Eastern Circle.

(ii) *Konar Pipe Line and Reservoir.*—A survey of about 33 square miles of area was required on the scale of 6 inches to one mile with contours at 10 feet vertical interval. The area was photographed on the scale

of 3 inches to a mile and enlargements on the scale of 6 inches to a mile were used for air survey.

(iii) *Ashni River Project Survey.*—This survey as well as Dochi Dam Project survey described under sub-para (iv) below were required by the Central Waterpower Irrigation and Navigation Commission for the Chief Engineer, P.W.D. Patiala State for planning a dam across the Ashni River in sheet 53 F south of Simla for a hydro-electric power plant. The valley has steep sides covered with fairly thick scrub and occasional clumps of pine trees. Survey was required of an area of about 37 square miles on the scale of 4 inches to a mile with contours at 20 feet vertical interval. The existing points were found to be adequate for planimetric control and were identified on the ground on 2 inches to one mile scale photographs. Additional height control points, about 400 yards apart, were fixed throughout the area. To do this, all existing control points were plotted on plane-table sections on the scale of 2 inches to a mile. From these control points additional points were fixed graphically and their heights were determined by measurement of vertical angles by theodolite and distances from the plane-tables. These auxiliary height control points were sited so far as possible about one mile apart. Further height control, which aimed at providing points about 400 yards apart, was fixed by plane-table and Indian clinometer readings. It was considered that the errors in heights did not exceed the 5 feet permissible.

Positions of these points were then marked on the photographs and air survey was carried out by normal methods on photographic enlargements at the scale of 4 inches to a mile.

(iv) *Dochi Dam Project Survey.*—A survey of 1·4 square miles was required on the scale of 32 inches to one mile. The area was photographed on the scale of 12 inches to a mile and these photographs were enlarged to 28 inches to the mile, and were used for air survey. The finished survey was finally further enlarged to 32 inches to one mile.

Planimetric control was obtained from points about $\frac{3}{4}$ of a mile apart. These were fixed by triangulation based on a Hunter Short Base and an independent azimuth and tied in to existing triangulation.

Height control points were fixed about 50 yards apart throughout the area using a theodolite for measuring

vertical angles and taking distances from the air survey compilation.

9. **Dochi Dam Contoured Photo-mosaics.**—This was also required by the Chief Engineer, Patiala State. The mosaic was prepared by Messrs. Indian Air Survey and Transport Co., Ltd. from the 12 inches to one mile scale contact prints prepared for para 8 (iv) above: it was contoured by No. 1 Party.

10. **Cawnpore Town Survey.**—This was required for the Cawnpore Improvement Trust and covered about 58 square miles of country surrounding Cawnpore. Rectified photographs on the scale of 16 inches to the mile prepared by Messrs. Indian Air Survey and Transport Co., Ltd. were provided and the work was carried out by normal air survey methods based on traverse points laid down in 1918–19 for the Cawnpore town survey.

11. **Udaipur City Traverse.**—This was a traverse survey for the City Improvement Engineer, Udaipur, who required the co-ordinates of all street and road junctions. Traversing was by glass arc theodolite reading to one second and distances were measured by crinoline chain. In some parts of the city chaining was found to be impossible during the day time. In these areas theodolite readings were made early in the morning and around mid-day when traffic was light and distances were measured at night.

12. **Specimens of Air Survey.**—For specimens of air surveys completed in the Party, see Plates A and B. For cost rates and averages of out-turn, see Table "C" on pages 4–5.

No. 13 PARTY

Officer in charge.—Mr. Mohd. Najamuddin, B.A.

13. **General.**—This unit was under the control of the Director Frontier Circle, until 31st July 1947 when it was transferred to the Geodetic Branch.

The party was employed on surveys in connection with the Bhakra Dam project for the Punjab Government. This project involves the construction of a dam across the Sutlej River at Bhakra, which will increase the area irrigated by existing canals and will also provide water for additional canals not yet constructed.

The work was taken up at the request of the Punjab Government in October 1929, and was continued without interruption until November 1934 when it was suspended. It was restarted in October 1935.

14. **Type of country.**—The country consists, for the most part, of flat cultivated plains, interspersed with scrub, long grass and trees particularly around villages and tanks and along roads and canals. In the west and south it is open, sandy and undulating.

15. **Work.**—The survey work for this project consists of:—

(i) Division of the area into main rectangular blocks each

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PLATE A - SPECIMEN OF AIR SURVEY

(Part of Dochi Dam Project Sheet No. 1, Scale 32 Inches to 1 Mile).

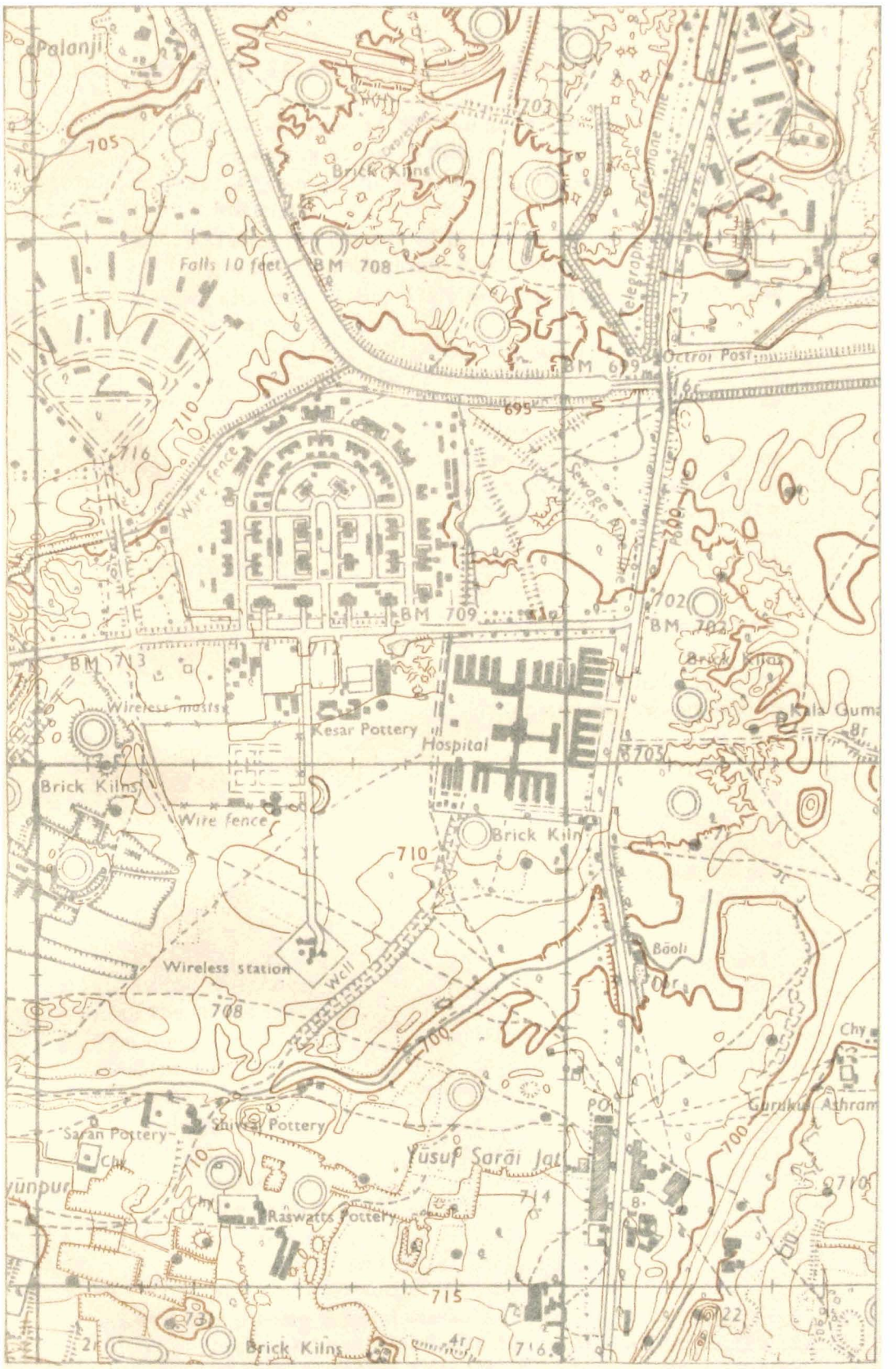

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PLATE B - SPECIMEN OF AIR SURVEY

(Part of Delhi Expansion Survey Sheet No. 1, Scale 6 Inches to a Mile).

with an area of 375 square miles or 240,000 acres measuring 25 by 15 miles.

(ii) Subdivision of the above main blocks into 3,000 acre rectangles.

(iii) Marking the corners of blocks in (i) and (ii) on the ground by embedding mark-stones.

(iv) Subdivision of the 3,000 acre rectangles into 25 acre rectangles.

(v) Levelling along all north and south lines of 25 acre rectangles to provide heights at the top and at ground level of all corner stones, in addition to heights of intermediate points.

(vi) The supply of maps of the area on the scale of 4 inches to 1 mile. For this purpose, the standard 1-inch maps of the area are enlarged to the 4 inches to a mile scale and the positions of spot heights are printed in black. Contours are interpolated at 1 foot interval and printed in brown.

Items (i), (ii) and (iii) in the previous paragraph were completed by the old No. 23 Party during 1929 to 1934.

The origin for the traversing carried out was latitude 30° 0′ N. and longitude 75° 15′ E. This gives a scale error of about one in four thousand at the most distant point of the work.

16. Rectangulation to 25 acres.—This work was carried out during the season under report. The lengths of the sides of the 3,000 acre rectangles to be subdivided were 13,200 feet from east to west and 9,900 feet from north to south. They were subdivided into 12 and 10 equal parts respectively. The lines joining corresponding subdivisions were similarly treated so as to give rectangles of 25 acres measuring 1,100 feet by 990 feet.

Small stones measuring $6 \times 6 \times 30$ inches with 10 inches projecting above the surface of the ground were embedded at each corner of the 25 acre rectangles.

The method of exterior and interior rectangulation followed is described in Professional Paper No. 21, paras 45 to 47, and the following general principles were observed:—

(i) The best men were employed on exterior work.

(ii) Should a village or other large obstacle fall on an exterior line, the next line to it was subdivided by the exterior rectangulator.

(iii) Small obstacles falling on the line were avoided by offsets with an optical square and measuring 3 sides of a rectangle round the obstacle.

(iv) For passing large obstacles such as villages the nearest north and south and also the nearest east and west 25-acre rectangle lines which passed clear of the obstacle were laid out first. When these had been

completed, the remaining 25 acre rectangles were located by prolonging existing lines.

Special partallers checked at least 40% of all work done and camp officers checked 20% including 15% of the work already checked by partallers. The permissible error in dimensions of a 25-acre rectangle was one in one thousand.

17. **Tertiary levelling.**—The Tertiary levelling was controlled by a network of primary and secondary lines, completed in previous years. Double tertiary lines followed the general procedure described in Professional Paper No. 21, paras 53 and 54.

Permissible closing error in feet in the double tertiary circuits was 0·05 M where M is the length of the circuit in miles. The permissible error between work of any 2 double levellers was 0·02 foot at any one stone and the permissible closing error in single tertiary levelling was 0·3 foot in a distance of about 4 miles.

18. **Recess work.**—During recess the levelled heights were plotted on the 4-inch sheets and 1-foot contours were interpolated. As this interpolation was carried out in the office minor features between level lines could not be indicated. The indentor was, however, prepared to accept these local errors in contours.

A specimen of a completed map is shown at Plate C. Average out-turns of survey and mapping (Table "C") are given on page 6.

No. 20 (CANTONMENT) PARTY

Officer in charge :— { Mr. T. M. C. Alexander to 6-4-47.
Mr. K. L. Dhawan from 7-4-47.

19. **Purpose of survey.**—The party surveyed Cantonment and other military lands in all Army commands at various scales, in accordance with the programme approved by the Engineer-in-Chief, India and the Defence Department.

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

(*a*) Record purposes.

(*b*) Planning purposes.

20. **Accuracy of Position or Height required.**—(i) For record purposes surveys were based on very rigid theodolite framework connected to spirit levelled heights. Detail survey at 16-inch scale with contours at 5 foot-V.I. and 64-inch scale without contours (of *bazaar* areas) were of a very high standard of accuracy. At 16-inch scale accuracy aimed at was 5 links in position and at 64-inch scale it was 1 link. Normal methods of fair mapping for publication in black, brown with red tint for buildings were carried out.

(ii) For planning purposes surveys were generally based on a very limited theodolite framework with or without spirit levelled heights. In some cases the survey was based entirely on plane-table traverse with spirit levelled heights.

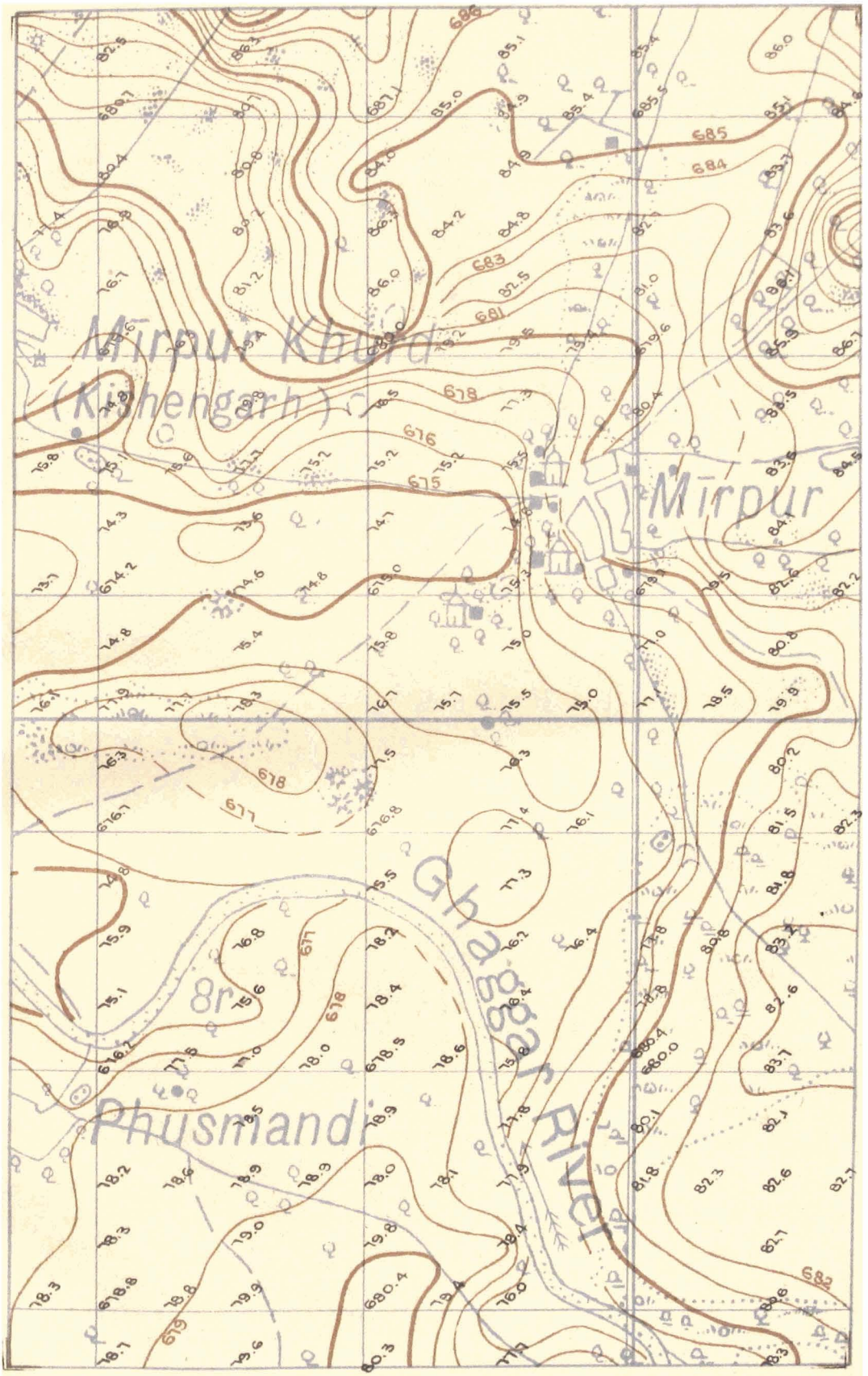

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PLATE C-SPECIMEN OF A COMPLETED PROJECT SURVEY MAP
(Part of Bhakra Dam Project Survey-Scale 4 inches to 1 mile).

Detail survey was much less accurate than that for record purposes. Relative accuracy rather than exact geographical position was aimed at. Fair tracings of the completed plane-table sections were prepared and submitted to Chief Engineers of Commands for preparation of ferro-prints. Normal fair drawing and printing was not done.

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

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

22. Cost rates of survey.—For average out-turns and cost rates of survey and mapping and descriptions of country see Table "C" on pages 7 and 8.

IV. TECHNICAL NOTES, EASTERN CIRCLE

DIRECTOR :— { Lt.-Colonel C. A. K. Wilson, O.B.E., R.E., to 17-2-47.
Major R. T. L. Rogers, R.E., from 18-2-47.

DY. DIRECTOR :— { Major R. T. L. Rogers, R.E., to 28-2-47.
Major R. S. Kalha, I.A., from 1-3-47 to 1-6-47 and from 2-9-47.
Mr. B. N. Saha, M.Sc., (Current duties) from 2-6-47 to 1-9-47.

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

No. 5 Party.
No. 9 Party.
No. 10 Party.
No. 11 Party.
No. 12 (Air Survey) Party.

Technical notes separately by each of the above-named parties except No. 5 Party whose personnel were attached to No. 12 Party, appear in this section.

For areas and cost rates see Table C—'Abstract of Topographical Work', in Section II.

24. **Technical methods.**— The surveys executed in this Directorate come under one or other of the following categories :—

(1) Dam site surveys on 16-inches to 1 mile or larger scales.
(2) Dam site surveys on 1 : 1,000 scale.
(3) Reservoir surveys on 4-inches or 6-inches to 1 mile scale.
(4) Irrigation surveys (commanded area) on 4-inches to 1 mile scale.
(5) Town planning surveys.
(6) Land reclamation surveys.
(7) Surveys for geological investigations.

The technical methods adopted for items (1) and (3) were, in general, identical. Planimetric and height control was provided on the ground and air mapping was done in recess. For planimetric control, observations with the theodolite were the normal practice, though in a few instances plane-table fixings were used for this purpose. For height control, one or more of the following methods were employed—reading vertical angles with a theodolite and taking distances from charts or combination plots ; observations with a clinometer and distances as above ; tachymetry ; levelling with a theodolite and the subtense bar. This type of work was mainly carried out by No. 12 (Air Survey) Party, whose report explains in detail the various methods adopted.

Item (2) could be done only by ground survey. For details, reference should be made to the report by No. 9 Party.

For item (4), which involved three extensive areas—i.e., Kosi, Tista and Hirākud (Mahānadi) carried out by Nos. 9, 10 & 11 Parties respectively—methods were the same and are explained in Appendix II, from which there was barely any departure (except that No. 9 Party had to make a rough compilation at the beginning to assist in stonelaying, as mentioned in that unit's report).

Items (5), (6) and (7) were air surveyed for planimetry only, contouring being done on the ground ; these methods are described in detail in the reports of Nos. 9 and 12 Parties.

25. **Appendices.**—

(*a*) Appendix I gives the description, use, and method of construction of the "Clinopole".

(*b*) Appendix II deals generally with "irrigation" survey methods, outturn and errors. It is adopted from a paper written for the Empire Survey Conference. The Appendices are included in Section VII of this report.

No. 9 PARTY

Officer in charge :— { Mr. J. C. Berry, to 14-4-47. / Mr. H. H. Philips from 15-4-47.

26. **General.**—The unit was employed on surveys for the Kosi Irrigation Project to meet the requirements of the Central Waterpower, Irrigation and Navigation Commission and on the production of suitable maps for the planning of an extensive system of canals covering the area.

Although the main task of the unit was the survey of the Kosi Commanded Area, the following additional surveys were carried out :—

(*a*) A ground survey on the 1/1,000 scale, with 10-foot contours, of the Kosi Dam area around the actual dam site, required for the preliminary investigation and design of the dam.

(*b*) A 4-inch air survey, with 5-foot form-lining, for the proposed railway extension from Jogbani to the Kosi Dam site.

(*c*) A 5-foot contour survey, at 16-inch scale, at Bagaha, Champāran district, Bihār, for land reclamation purposes.

(*d*) Triangulation in Nepāl, for air survey on the 1-inch scale of the catchment area of the Kosi and Gandak rivers, to meet the requirements of the Central Waterpower, Irrigation and Navigation Commission.

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

Gazetted officers	6
Other technical personnel ..	42

28. **Areas surveyed.**—

229·5 sq. miles of 4-inch survey in the "commanded" area of the Kosi Irrigation project.

238·4 sq. miles of 4-inch survey in the Jogbani Railway Extension area.

0·466 sq. miles of 1/1,000 ground survey of the Kosi Dam area.

33·4 sq. miles of 16-inch contour (ground) survey for the Bagaha Land Reclamation project.

1945 sq. miles of triangulation for 1-inch original air survey in Nepāl.

29. **Technical methods.**—(*a*) *Kosi Irrigation surveys.*—At the beginning of the field season, to start the stonelayers on their work, before precise traverse data were available for rigorous photographic combination, a preliminary air photo combination was carried by taking the co-ordinates from 1-inch maps of points which could be identified on the air photographs. Rigorous photographic combination was done later, when all adjusted precise traverse data were available.

Except as above, the standard procedure for irrigation surveys was followed,—see Appendix II.

(*b*) *Kosi Dam survey.*—For the planimetric and height control of this large scale survey, the area was triangulated and points fixed at a density of about 10 points per 200 yards square.

The triangulation was based on the bench-mark at Barāhakshetra and a Hunter Short Base extension.

Intersected points consisted of small white-washed cairns supporting thin poles with white marks at 3 feet from the ground end. Horizontal readings were taken to the poles and vertical readings to the 3-foot marks.

In certain places where triangulation was not possible, theodolite traversing was carried out, measuring distances by subtense bar.

(*c*) *Jogbani Railway Extension survey.*—The scale and layout for this survey was as for irrigation surveys.

The method of survey and fair drawing of these sheets was as for irrigation sheets, except that stones were not embedded and observations were not made for a rectangular mesh of heights; instead, tertiary levelling of low accuracy was carried out along main roads and tracks to provide the requisite height control for form-lining the maps at 5-foot vertical interval. No level charts were required.

(*d*) *Bagaha Land Reclamation survey.*—The air survey of detail was done by No. 12 Party, but the contouring was done on the ground by No. 9 Party, on blank plane-table sections.

For the control, a framework by theodolite traverse, using a crinoline chain, was provided and the traverse stations were marked, *pari passu* with the work, on 6-inch contact photographs, and a

secondary levelling line was run approximately through the middle of the area, with tertiary levelling lines emanating from and closing on secondary levelling bench-marks.

Contours were surveyed by plane-table height traverse based on the foregoing traverse and levelling data.

(*e*) *Triangulation of Kosi Catchment area.*—Minor triangulation was done to provide planimetric and height control for 1-inch air survey of the area. In addition, one of the triangulators engaged on this work carried out experimental observations with a Wild photo theodolite.

30. **Description of country.**—In the plains, the course of the Kosi River changes frequently, shifting westwards at the rate of about a mile a year. With this movement a thick layer of sand is laid over land, formerly fertile, and many villages and towns are washed away. The old beds of the Kosi River were found to be overgrown with reeds and grass, sometimes to a height of 16 feet or so. Setting fire to the reeds and grass before stonelaying and levelling was found to be the most economical method of clearing these obstructions to the work.

In Nepāl, the plains area was undulating ; about half of it was covered with dense jungle.

The hills forming the Kosi Catchment area were, generally, open, with occasional patches of cultivation.

The area of the Bagaha Land Reclamation survey was densely wooded and very malarious.

No. 10 PARTY

Officer in charge :— (Khan Sahib Chowdhury Muhammad Aslam, to 14–6–47.
(Mr. S. C. Chatterjee, from 15–6–47.

31. **General.**—No. 10 Party was employed on four-inch irrigation surveys of the Tīsta Commanded Area, for the Bengal Irrigation Department.

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

Gazetted officers	6
Other technical personnel ..	58

33. **Area surveyed.**—315 sq. miles of the commanded area were surveyed.

34. **Planimetric control.**—Planimetric control was provided by 542 miles of theodolite traversing. No triangulation was done.

35. **Height control.**—Height control was supplied by 240 miles of secondary levelling and 160 miles of double tertiary levelling connected to Main-Line No. 77 (Howrah to Raniganj).

36. **Description of country.**—The area surveyed consisted of very flat cultivated plains, traversed by a number of streams bordered with dense vegetation. The nature of the country allowed

of quick levelling, but as the crop cultivated was paddy, levelling could not be started before early December when the harvesting was completed.

37. **Climate.**—The climate was pleasant and the heat did not interfere with the work till May.

No. 11 PARTY

Officer in charge :—Mr. M. M. Ganapathy.

38. **General.**—No. 11 Party was employed on 4-inch irrigation surveys of the Hīrākud Commanded area of the Mahānadi Scheme, for the Central Waterpower, Irrigation and Navigation Commission.

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

Gazetted officers ..	.. 4
Other technical personnel	.. 45

40. **Area surveyed.**—The total area of the Hīrākud Commanded area is approximately 1944 sq. miles. Of this, 360 sq. miles were surveyed leaving a balance of about 1,584 sq. miles.

41. **Planimetric control.**—The existing planimetric control was supplemented by triangulation starting from and closing on Hunter Short Bases and connected with Great Trigonometrical Stations. No traversing was done.

42. **Height control.**—The height control in this area was supplied by 85 miles of secondary and 143 miles of double tertiary level lines, connected to Main Line No. 117 (Raipur to Bhadrak). All heights were in terms of this line of levelling of precision and trigonometrical heights were not used.

43. **Description of country.**—The area surveyed consisted mainly of undulating country, the lower parts of which were covered with scattered trees and large areas of paddy cultivation and the higher parts with scrub and low jungle. The low ground necessitated a large number of close stations when levelling, while the high ground further slowed down the progress on account of the jungle clearing required. In the paddy cultivated areas, levelling could not be started before the end of November or early December when the harvesting was completed.

44. **Climate.**—The climate was very pleasant during the cold weather, but towards the end of March, the heat radiation necessitated closer level stations, while April was so very hot that both accuracy and outturn were seriously affected.

No. 12 (AIR SURVEY) PARTY

Officer in charge :— { Lt.-Colonel C. A. K. Wilson, O.B.E., R.E., to 9-10-46.
{ Mr. J. C. Ross, from 10-10-46.

45. **General.**—This unit, assisted by technical personnel from No. 5 Party, who worked under the supervision of No. 12 (Air

Survey) Party, carried out ground control, large scale air and/or ground surveys, fair mapping, contouring on photo-mosaics and anaglyphs and computations for various irrigation, flood control, hydro-electric, town extension, geological investigation and similar projects.

46. **Personnel.**—The average technical strength which could be utilized for work from both units was 10 gazetted and 35 non-gazetted officers (including about 30 surveyors and draftsmen).

47. **Areas surveyed.**—Areas for which planimetric and/or height control was provided—either by triangulation, traverse, theodolite levelling or clinometer—totalled approximately 685 square miles.

Areas surveyed by air and/or ground methods, on 4-inch, 6-inch, 16-inch and 32-inch scales, totalled 709 square miles.

48. **Control.**—Control was provided for the following projects :—

(*a*) *Bokāro Dam ; sheet No. 73 E.*—Triangulation for ground survey on the 16-inch scale. It was planned, originally, to do enough planimetric and height control for complete air survey. In actual practice, due to existence of dense forest, it was found extremely difficult to identify and mark all but a few control points on the photographs.

(*b*) *Karnaphuli Dam ; sheet 84 B.*—Triangulation for air survey of planimetry and ground survey of contours on the 32-inch scale. Here, too, the intention was the same as for the Bokāro Dam, but climatic conditions retarded progress.

(*c*) *Tikarpāra Dam ; sheet 73 D.*—Triangulation, with supplementary height control, for complete air survey on the 16-inch scale. Height control was done by (i) tachymetry and (ii) using the theodolite as a clinometer.

(*d*) *Bermo-Bhāndaridah Gorge ; sheet No. 73 I* —As for Tikarpāra Dam, except that height control was done by tachymetry.

(*e*) *Jamshedpur Town Extension ; sheet 73 J.*—Triangulation (with traversing in jungle-clad areas), for air survey of planimetry and ground survey of contours on 16-inch scale.

(*f*) *Gumti Dam ; sheet 79 M.*—Triangulation, with supplementary height control, for complete air survey on the 32-inch scale. Much time was wasted during reconnaissance by building and flagging about twice the number of stations and planimetric control points required. Due to a very steep, narrow, and deep gorge, the trig. stations were well above the actual area for survey, and, therefore, not very helpful in

providing the requisite density of height control. This difficulty was overcome by running a line of levels, with the help of boats, by theodolite and staff, along the river bank, commencing from and closing on known triangulated heights at two extremeties of the area. All height control points, together with those levelling stations from which heights were thrown to them, were identified and pricked on the photos; heights were computed in recess after the stations and points had been intersected on the air survey section.

(*g*) *Konār Reservoir and Pipe Line ; sheet 73 I.*—Triangulation with supplementary height control, for complete air survey on the 6-inch scale. A great deal of time was wasted here, too, by reconnaissance being done for stations only and not for planimetric control points also at the same time. Height control was provided by clinometer, distances being taken off the triangulation chart (which was projected on a scale large enough to give suitable accuracy).

(*h*) *Konār Dam and Power House ; sheet 73 I.*—As for Konār Reservoir and Pipe Line, but for complete air survey on the 16-inch scale.

(*i*) *Deolbāri Reservoir ; sheets 82 L & 73 I.*—Triangulation with supplementary height control, for complete air survey on the 6-inch scale. Height control was provided by any of three methods, as convenient :— (i) by plane-table resections (from existing triangulated points), using the theodolite as a clinometer and taking distances off the triangulation chart; (ii) by reading with the theodolite, clamped at zero, and set up at a known height, the intercept on a levelling staff placed at the point whose height was required, and (iii) by running lines of theodolite levelling (as for Gumti Dam). No more than seventy per cent of plane-table resections gave sufficiently accurate results, so that about thirty per cent of the height control could not be computed till the positions of the points had been intersected on air survey sections, to obtain accurate distances.

(*j*) *Deolbāri Dam ; sheets 73 L & 73 I.*—As for Deolbāri Reservoir, but for complete air survey on the 16-inch scale and without resort to theodolite levelling. Due to a scarcity of existing triangulation points, distances from the chart were almost wholly unreliable in this instance, and could not be obtained till the photographs had been combined and height control points laid down on the combination plot sheet.

(*k*) *Karnaphuli Reservoir ; sheets 84 A & B.*—Supplementary height control for complete air survey on the 6-inch scale. Originally, it was planned to provide planimetric and height control for this project, the former by triangulation and/or traversing and the latter with the aid of Paulin barometers. It was found, however, that sufficient topo. triangulation already existed and this was used for planimetric control. As Paulin barometers were not available, height control was fixed using the theodolite with levelling staff.

In general, the method was the same as used for the supplementary height control of Gumti Dam, but with the following variations :—

(i) Only one reliable triangulated station—and that at one extremity of the area—could be satisfactorily connected for obtaining a height datum.

(ii) Theodolite level lines were run up all main valleys. In no case could they be closed on triangulated points, as these were invariably situated on the crests of heavily wooded ridges. The best that could be done was to close them on plane-table resections whose heights had been deduced from such points. Sometimes no such heights could be obtained, and the line had, of necessity, to be left unadjusted. However, judging from instances where adjustment was possible, it is considered that the discrepancy should not exceed about ten feet—a discrepancy which would have been met with, even in using barometers. Branch-lines up minor valleys had, almost invariably, to be left unadjusted.

(iii) Where visibility (on account of jungle) was reasonably good, the subtense bar was used in preference to short lines of levelling, for throwing heights direct to points.

Adjustments and computations, which had to be done mainly in recess, were extremely laborious and complicated.

(*l*) *Kamptee Coalfield ; sheets 55 K & O.*—Supplementary height control, for ground contouring, on the 4-inch scale. This was provided either by supplementary triangulation or by reading angles with a theodolite and measuring distances off the chart.

(*m*) *Bokāro Coalfield ; sheet 73 E.*—Supplementary height control for complete air survey on the 4-inch scale. Method was the same as that used for Konār Reservoir and Pipe Line.

Miscellaneous notes on control.—(i) Observations for planimetric control emanated from and closed on a base of previous triangulation or, where this was not possible, were made to a station of such triangulation to obtain geographical position ; observations were also made, independently, to establish or check scale and azimuth. Co-ordinates of previous triangulation were not always in terms of G.T. data.

(ii) Observations for height control were based on spirit-levelled heights, where possible ; otherwise, on heights of previous triangulation, which were not in adjustment with G.T. heights in certain areas.

(iii) The following figures give an indication of the density of planimetric and height control demanded in the field for complete air survey. In practice, however, personnel usually exceeded these limits, whereas a reduction in density by about twenty-five per cent of that laid down would not have had an adverse effect on survey.

Scale of survey	Planimetric control	Height control
4″	3,500 yards apart	800 yards apart
6″	2,500 do.	500 do.
16″	800 do.	200 do.
32″	500 do.	100 do.

(iv) All control points were identified and pricked on the photographs in the field.

(v) To enable distances to be measured accurately, charts on one-third the scale of subsequent survey are about the best ; where areas to be controlled are extensive, this may even be reduced to one-quarter. Charts projected to the approximate scale of the contact prints do not help identification appreciably and merely increase the number of charts to an undesirable extent.

49. **Ground survey.**—Ground survey was carried out as detailed below :—

(*a*) *Bokāro Coalfield.*—Sheets 73 E & I ; on 4-inch scale. Blue prints of air surveyed planimetry were supplied to plane-tablers, who were asked to (*a*) survey contours ; (*b*) check detail in blue, inking it up in appropriate colours where found correct or where altered ; (*c*) survey all items which it was not possible to identify on photographs ; (*d*) pick-up road and track classification, and (*e*) verify names appearing on the existing published sheets of the area.

The contour interval originally laid down for this survey was 10 feet. As this was considered to be too small, a reference was made to the Geological Survey of India, who eventually agreed to increase it to 20 feet in certain unimportant localities.

(*b*) *Bokāro Reservoir.*—Sheet 73 E; on 6-inch scale, with contours at a vertical interval of 10 feet. Method was the same as used for Bokāro Coalfield.

(*c*) *Bokāro Dam.*—Sheet 73 E; on 16-inch scale, with contours at a vertical interval of 5 feet—Plane-table survey of outline and contours.

(*d*) *Kamptee Coalfield.*—Sheets 55 K & O; on 4-inch scale, with contours at a vertical interval of 10 feet. The intention was to carry out this survey on the same lines as those employed for Bokāro Coalfield; but this project assumed a sudden high priority and as time was short, plane-tablers had to be sent down to the field before blue prints of air surveyed planimetry could be supplied and, consequently, contouring had to be done on blank boards. At the same time as this contouring was carried out, detail not identifiable on our photographs, e.g., milestones, was surveyed on the ground and the classification of tracks was also carried out.

(*e*) *Jamshedpur Town Extension.*—Sheet 73 J; on the 16-inch scale, with contours at a vertical interval of 5 feet. Method was the same as that used for Bokāro Coalfield. As construction was most unlikely to be done on hilly and rocky outcrops, such areas were only form-lined (in consultation with the indentor).

Miscellaneous notes on ground survey.—(*a*) Most of the contouring in flat and undulating areas was done with the help of an improvised "Clinopole", so as to maintain accuracy with speed and tie surveyors, with little or no knowledge of contouring, down to a rigorous and foolproof method. A description of the "Clinopole" will be found in Appendix I.

(*b*) The following was the accuracy demanded from personnel in the field :—

Scale of survey	Position	Height
4″	5 yards	2 feet
6″	3 do.	2 do.
16″	1 do.	1 do.
32″	½ do.	1 do.

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

(*a*) *Chatra Gorge; sheet 72 N.*—Complete air survey on 4-inch scale, with form-lines at a vertical interval of 20 feet, based on very unsatisfactory planimetric and height control.

(*b*) *Kamptee Coalfield; sheets 55 K & O.*—Air survey of planimetry [see para 49 (*d*), above] and complete air survey, with contours at a vertical interval of 10 feet, on 4-inch scale.

(*c*) *Bokāro Coalfield ; sheets 73 E & I.*—Air survey of planimetry only, on 4-inch scale ; [see para 49 (*a*), above].

(*d*) *Bokāro Reservoir ; sheet 73 E.*—Air survey of planimetry only, on 4-inch scale, which was enlarged to the 6-inch scale for supply of blue prints to field personnel ; [see para 49 (*b*), above]. Also complete air survey of a portion on the same scale with contours at a vertical interval of 10 feet ; this was enlarged and incorporated in the 6-inch reservoir map.

(*e*) *Hīrākud Dam ; sheet 64 O.*—Complete air survey on 16-inch scale, with contours at a vertical interval of 10 feet, and form-lines at 5 feet (in flat areas).

(*f*) *Tikārpara Dam ; sheet 73 D.*—As for Hīrākud Dam.

(*g*) *Hīrākud Reservoir ; sheet 64 O & 73 C.*—Complete air survey, on 4-inch scale, with contours at a vertical interval of 10 feet. The area was first surveyed up to the 630 feet contour on the outer limit of the reservoir, according to the original specification. Subsequently, the limit was raised to 640 feet. As part of the additional areas was not covered by photographs and there was no time available for photographing it, recourse had to be made to verifying detail (enlarged from 1-inch published sheets) and contouring on the ground, at the 4-inch scale. This ground work was done by No. 11 Party.

(*h*) *Hooghly Ship Canal ; sheet 79 B.*—Air survey of planimetry only, on 6-inch scale. Indentor did not require contours. Detail not identifiable on photographs—particularly religious buildings—was verified on the ground as satisfactorily as possible during the disturbances in Calcutta.

(*i*) *Karnaphuli Reservoir ; sheets 84 A & B.*—Complete air survey, on 6-inch scale, with contours at a vertical interval of 20 feet, was commenced.

(*j*) *Narāj Dam ; sheet 73 H.*—Complete air survey, on 16-inch scale, with contours at a vertical interval of 5 feet.

(*k*) *Tīsta High Dam ; sheet 78 A.*—It was intended that this should be a complete air survey, on 32-inch scale, with contours at a vertical interval of 10 feet. In actual practice, however, it was found that due to heavy forest and shadows resulting from the narrowness and depth of the gorge, most of the details and features could not be identified with any certainty ; the details were, therefore, shown broken and the features by form-lines. The whole survey had to be verified on the ground, but was found to be more reliable than expected.

In future, it is recommended that, to avoid shadows blotting out topography in similar country, photography should be made both in the forenoon and afternoon.

(*l*) *Jamshedpur Town Extension ; sheet 73 J.*—Air survey of planimetry only, on 16-inch scale ; [see para 49 (*e*), above].

Miscellaneous notes on air survey.—(i) Combination in all cases was carried out by the Principal Point Radial Line method. Slotted template combination was not employed mainly because (*a*) very few technical personnel here were trained in this method, and (*b*) sufficient floor space was not available for assembly. With suitable planimetric control, an average accuracy between common points during combination of 2 mm. was aimed at and generally maintained.

(ii) Air surveyed planimetry was frequently reported on from the field as being unreliable. This might have been due to a variety of causes, chief among which were, (*a*) work done by indifferent air surveyors, (*b*) verification carried out by inexperienced plane-tablers, (*c*) errors in combination due to faulty identification and marking of points on photographs, and (*d*) working from enlargements (with consequent loss of definition).

(iii) Unless otherwise stated, detail which could not be identified on photographs, road and track classification, names, relative heights, etc., for areas where complete air survey was done, were picked-up in the field by the individual responsible for providing the control, or, failing that, were taken from the largest scale published sheets of the area.

51. **Mosaics and Anaglyphs.**—Mosaics were prepared by Messrs. Indian Air Survey and Transport Ltd., Dum Dum, and sent to this unit for contouring. The following mosaics were contoured—

(i) Kosi Reservoir, on 2-inch scale, at a vertical interval of 10 feet.

(ii) Hīrākud Dam, on 2-inch scale, at a vertical interval of 100 feet.

(iii) Mahānadi Canal, on 2-inch scale (for publication on scale 1 inch = $\frac{3}{4}$ mile), at a vertical interval of 100 feet.

Contouring for anaglyphs was done in this unit and the photographs sent down to the reproduction offices in Calcutta for preparation of the anaglyphs.

52. **Fair mapping.**—Fair mapping was carried out for the Bokāro Dam, Kamptee Coalfield and Jamshedpur Town Extension projects ; (see relevant paragraphs above).

In connection with the last named it should be pointed out that although the survey and fair mapping were done on the 16-inch

scale, working plan maps were required, in the first instance, on the scale of 99 feet to 1 inch from these surveys. In the circumstances, fair mapping had to be done to an exceptionally high standard in order to minimize the effects of so large a photographic enlargement from scale of drawing to scale of publication.

As regards Bokāro Coalfield, it was decided at this stage, to show 10-foot form-lines in unimportant localities. As these had not been surveyed—see para 49 (*a*), above—they were interpolated with the help of height traces.

As production of drawing material in Calcutta became almost a bottleneck, all mapping was done on transparent media, at the expense of quality. It is worthwhile noting here that excellent draftsmen on drawing paper, often failed in working on Kodatrace, as they had no previous training of drawing on this medium.

A separate name original was always prepared by cutting out and pasting typed names, heights, headings, grid values, etc., on to a sheet of thin white paper. As this paper very soon became crumpled and the pastings fell off, a stouter quality was later used and gave more statisfactory results.

It was found that where planimetry had been surveyed from photographs and contouring done independently on the ground—as for Kamptee Coalfield—it was difficult (even in such open and easy country) to reconcile the two at fair mapping stage. This type of independent survey is, consequently, not recommended.

53. **Computations.**—Computations were done either in the field or in recess or both, as convenient. Wherever possible, these were done in duplicate—usually in original by the observer and later, independently, by some other individual.

54. **Miscellaneous technical notes.**—(*a*) *Supervision.*—With a large number of inexperienced officers and surveyors the time taken to complete the work was appreciably longer than expected, although accuracy was maintained.

(*b*) *Vegetation.*—It was decided to omit redundant vegetation symbols on the project maps as follows :—

(i) Dam maps should carry no indication of vegetation, because as soon as construction was commenced, all growth would be cleared and no such information would be required; (ii) Maps, such as for the Geological Survey of India, reclamation purposes, etc., would bear no vegetation symbols, but the limits of jungle areas would be shown by a suitable boundary symbol and remark, while other areas (of scrub, trees in cultivation, etc.) would only have the appropriate descriptive remark typed across them, because such information on maps of this class was of secondary importance; (iii) reservoir maps would, of course, carry vegetation symbols as hitherto.

(*c*) *Grids.*—The principle applied to vegetation was also applied to grids, except that grid lines were not omitted altogether, a greater or lesser number of squares being drawn depending on the use to which such information was likely to be put.

(*d*) *Colours.*—Project maps were usually published in black for detail, names, heights, headings, borders, etc., brown for contours and yellow for cultivated areas. This combination was not, however, rigidly followed where it was considered that a different combination would improve matters. For example, maps on which planning would be done—i.e., Hooghly Ship Canal—had black only for typing, detail being shown in grey and cultivated areas in yellow; or again, at the request of Tata's, blue and green were substituted for black and brown respectively, on the Jamshedpur Town Extension 99 feet to 1 inch series. Occasionally in sheets where broad rivers occurred, a blue surprint for water was a very useful addition.

(*e*) Much time was wasted in surveying and drawing redundant detail—e.g., masses of tracks, tiny streams, etc.

(*f*) Considerable inconvenience was often caused and layout, programme, accuracy and morale were affected on account of the indentors altering specifications after work had progressed for some time, or even as late as at proof stage. Final publication was also delayed by indentors not returning proofs promptly.

(*g*) *Methods.*—Owing to the lack of experienced air surveyors, the surveying of the planimetry from air photographs and completing the contouring on the ground was found to be the most satisfactory way of carrying out these project surveys.

55. **Description of country.**—As must be expected from a field programme so varied and scattered, parties had to work in several completely different types of country. For example, terrain in the Central Provinces consisted of comparatively open plains interspersed with low, isolated hills; while projects falling in Bihār lay among low hills freely covered with jungle and undulating ground with shallow, cultivated valleys. Vegetation in the first named province consisted mainly of numerous orange groves and large patches of thorny acacia. In Bihār, the forest was of a mixed type, *sāl* generally predominating, while the *mahuwa* tree was found in quantities in the low lying areas, in and around cultivation.

In Assam, the country consisted almost entirely of low, intricate and heavily jungle covered hills, with cultivation in the broader valleys. The forest was tropical and of a mixed type, consisting mainly of bamboo and cane brakes, interspersed with clearings for *jhum* cultivation.

56. **Climate.**—Due to various reasons, both avoidable and unavoidable, detachments took the field unusually late, some not leaving recess headquarters till the middle of January. Consequently, the heavy programme was adversely affected by climatic and weather conditions and was protracted into June.

Generally speaking, the winter was mild everywhere and calls for no special remarks. Summer varied; in the C.P., Bihār and Orissa it warmed up rapidly and despite liberal rain during March, April and May, temperatures rose to over 110° F in the shade, Fortunately, it was a dry heat, so that no undue physical inconvenience was caused. In Assam, on the contrary, the humidity, coupled with work in closed-in valleys, resulted in considerable discomfort.

V. TECHNICAL NOTES, SOUTHERN CIRCLE

DIRECTOR :— { Major I. H. R. Wilson, B.E., to 6-7-47.
{ Mr. M. R. Nair, in charge current duties, from 7-7-47.

57. **Summary.**—This report covers Southern Circle's first operations as a topo circle since the abolition of the circle in 1931. Only two topographical parties were engaged ; No. 6 Party carried out work in 47 H and 47 G by routine methods; No. 8 Party was, however, entrusted with the Tungabhadra Project, which is described in some detail in the unit report.

Comparison of cost of the novel method employed for the Tungabhadra project has shown a very considerable saving over irrigation surveys carried out by the more standard rectangulation methods ; the adoption of this 'spur and valley' method seems worthy of serious consideration for all projects in similar gently undulating country.

No. 6 PARTY

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

58. **General.**—No. 6 Party carried out the following programme during 1946–47 :—

(*a*) New Blue print survey of 1,427·4 square miles on the scale of 1 inch = 1 mile in sheets 47 H/5, 8, 9, 12, 13 and 16.

(*b*) Revision of the heights in 47 G by theodolite observation (2,850 square miles).

(*c*) Fair mapping of the surveys mentioned in para (*a*). Forty per cent of the mapping was completed.

(*d*) Computation of the revision of heights. Seventy-five per cent of the computation was completed.

59. **Methods.**—The blue print survey was carried out by normal ground methods laid down in Chapter V of Topo. Handbook.

(*a*) The blue prints used for the survey were foil-backed in addition to being mounted on cloth. The cloth-mounted field sections were stripped off the foil after photography.

(*b*) Redetermination of heights in 47 G :

A comparison of the heights of G.T. stations in the 1890 computations of No. 11 Party with the heights of the same G.T. stations in the latest triangulation pamphlets revealed discrepancies as tabulated below :

	G.T. Ht.	Old Ht.	
Mahabaleshwar H.S.	4719	4710·7	Vol. 1 Page 304, 1904–05.
Kumbharli H.S. ..	3445	3431·9	Vol. 10 „ 15, 1903–04.
Adhur H.S. ..	380	369·1	Vol. 238 „ 329, 1884–85.
Mirya H.S. ..	473	477·2	Vol. 242 „ 215, 1884–86.
Kaljhondi H.S. ..	748	743·5	Vol. 238 „ 309, 1884–85.
Kanta H.S. ..	1134	1121	Vol. 108 (List of points in 47 F/4).

This necessitated the reobservation of heights to all stations and intersected points before they could be used for plane-tabling. Many of the old intersected points were trees, whose heights naturally have changed in the course of years.

The revision of heights was carried out by observing vertical angles from identified stations to identified points. The identification was carried out on a grey print of 47 G, on the scale of $2\frac{3}{4}$ miles to one inch, on which the old data was plotted.

The distance between the station of observation and the point observed was taken from the old computations or was computed from the co-ordinates.

Two observations were generally taken for each height, the average discrepancy being 4 feet.

(*c*) The fair mapping was done by normal mapping methods laid down in Chapter VI of Topo. Handbook.

The cost rates of the items mentioned in (*a*), (*b*), (*c*), and (*d*) in para 58 are given in Table C in Section II.

No. 8 PARTY

Officer in charge :—Mr. P. A. Thomas, from 12-8-46.

60. **Introduction.**—The object of the survey described in this report is the production of maps for the canalization of the commanded area of the Tungabhadra Project for the Hyderabad State (Deccan) Government.

The Project itself is a revival on new lines of previous proposals to utilize the water of the Tungabhadra river for irrigation purposes necessitated by the increasing post-war demands for development and a vigorous Government 'grow more food' campaign. The idea was originally mooted in 1859 by the Madras Irrigation Company and a reinvestigation recommended by the Irrigation Commission of 1901–03. This investigation resulted in the proposal that a dam about 145 feet high and 4,000 feet long should be built near Hospet (Sheet 57 A/7), where the river cuts through some low hills, to hold back the water for a distance of nearly 40 miles and form a reservoir with an area of 160 square miles and a capacity of 180,000 million cubic feet of water or $4\frac{1}{2}$ times that of the Assuan reservoir on the Nile. The canal leading thence into Hyderabad State would command an area of about 1,500,000 acres on the left bank. The river here forms the boundary between the Province of Madras and Hyderabad State and agreement between the two Governments was not reached until 1946 when construction commenced.

The survey work herein described relates only to the Hyderabad side of the river as the work on the Madras side of the river is being undertaken by the Madras Government. The dam is being constructed about 4 miles west of the town of Hospet and 3 miles

above the point where the Hubli-Guntakal (M.S.M.) railway line crosses the river. The offtake level of the main canal will be about 1,550 feet above mean sea level and after passing through rocky hilly country for a distance of about 24 miles, the canal will continue through an undulating plain in a north easterly direction until it reaches the backbone of the ridge separating the Kistna and Tungabhadra valleys, a few miles west of Raichur. Continuing along this main ridge, it then commands the entire area on both sides of the ridge until it terminates at the junction of the two rivers the Kistna and the Tungabhadra, about 20 miles north-east of the town of Kurnool (Sheet 57 I/1).

61. **Description of country.**—The country comprising the greater part of the commanded area consists of open gently undulating plain, mostly of black cotton soil under cotton and *jowar* cultivation. Numerous isolated rocky hills 200–300 feet high rise out of the plain, and rock and stone outcrops abound. The river flows between high banks of red loam and much of its bed is deep. This characteristic and the manner in which the country rises rapidly away from either bank are two of the reasons why the river has hitherto not been greatly utilized for irrigation. The undulating nature of the country combined with the absence of dense tree growth and presence of hill and rock outcrops tends to make the fixing of planimetric control fairly easy.

62. **Requirements.**—Requirements are :—

(i) The production, on the 4-inches to a mile scale, of maps of the commanded area in 2 colours with a contour interval of 5 feet.

(ii) The laying of pillars to form bench-marks at intervals of 1 furlong (approx.) along all spurs and streams over 2 miles in length. Heights to tops of pillars are required correct to 0·1 foot relative. Pillars are hollow cylindrical precast concrete 3 feet in length. Large pillars of 6″ internal diameter are buried at mile intervals and smaller pillars of 3″ internal diameter are buried at intermediate furlong intervals. Pillars are buried to a depth of 2 feet with 1 foot projecting and the inside is packed with earth and stones to within 6″ of the top. The last 6″ are filled with cement flush with the top of the pillar.

(iii) Contoured photo. mosaics on 2″ scale. Mosaics are roughly 40″ × 30″ and 13 such mosaics cover the area. 10 Bromide copies of each mosaic are also required on scale 2-inches to 1 mile but the maximum size of available bromide paper limits these copies to approximately 20″ × 30″. The mosaics are therefore photographed in two equal portions.

63. **Method.**—(*a*) Planimetry.—

(i) *Control for Air Survey combination.*—This is by Hunter Short Base traverse lines about 10 miles apart across the line of flight of the photographs with at least 2 points fixed in each photo. strip on each traverse line. The close control of existing primary triangulation and subsidiary triangulation based on primary enabled the traverse lines to be kept reasonably short (about 10 miles). All computations are done in Standard Indian Lambert Grid terms (Grid IIIA).

(ii) *Survey.*—This is from air photographs by the graphic radial line method after combination by slotted template. Photographs on 2″ contact scale enlarged to 4-inches to 1 mile were used. The positions of pillars on main spurs are fixed by theodolite traverse and on minor spurs and streams by resection and identification respectively.

(*b*) Heights.—

(i) *Secondary levelling.*—Lines are run to follow the lines of traverse in (*a*) (i) above and are connected to primary bench-marks. Thus main lines of height framework about 10 miles apart are produced.

(ii) *Tertiary levelling.*—Lines of single tertiary levelling are run between the bench-marks (pillars) of secondary levelling along spurs and streams heighting the tops of pillars laid on these spurs and streams.

(iii) *Subsidiary control.*—In some areas on spurs and streams less than 2 miles in length some subsidiary spot levelled heights are necessary to control contouring. Positional fixation is by resection or identification. Offset spot heights are also taken at intervals in the beds of streams over 5 chains wide in the course of levelling along stream banks.

64. **Errors.**—(*a*) The criteria for errors laid down are :—

Main traverse	..	1/5,000
Minor traverse	..	1/2,000
Secondary levelling	..	·01 ft./mile
Tertiary levelling	..	·5 foot (Total closure in any line)

(*b*) Actual errors produced were :—

Main traverse	..	1/10,000
Minor traverse	..	1/2,000
Secondary levelling	..	·004 ft./mile for 258 miles of levelling.
Tertiary levelling	..	·054 ft./mile for 390 miles of levelling.

65. **Outturn.**—The annual outturn of a unit composed of, 2 Traverse detachments .. (22 Class IV personnel per (2 observers each) H.S.B. detachment)

2 Secondary levelling detachments (22 Class IV personnel per detachment)
6 Air surveyors
8 Stonelayers resectors .. (6 Class IV personnel per squad)
10 Tertiary levellers .. (6 Class IV personnel ,, ,,)
2 Traversers (minor) .. (8 Class IV personnel ,, ,,)
2 Computers.

with normal supervisory personnel, is about 800 sq. miles of 4-inch Irrigation survey up to publication stage.

The commanded area for survey totals about 2,500 sq. miles.

66. Mapping.—Air survey is carried out on two originals (outline and contour) on kodatrace and a name original is prepared on a blue print on drawing paper of the outline original.

Village boundaries are taken from revenue maps on the 8-inch scale and transferred to photographs with the help of recognizable detail and proportional compass.

A reference system consisting of a grid of 1,000 yard squares covers the whole layout of sheets. This reference system coincides with the Lambert grid but carries arbitrary numbering though grid numbering could have been adopted.

Graticule ticks with spherical values are entered in the borders of each sheet.

Each sheet is 12,000 yards East and West and 9,000 yards North and South. 91 such sheets cover the whole area.

VI. APPENDICES TO TECHNICAL NOTES

APPENDIX I

THE IMPROVISED " CLINOPOLE "

67. **Introductory.**—The "Clinopole" may be described as a crude vertical subtense bar used in conjunction with a Survey of India clinometer. It is commonly used to fix any point on a particular contour, when the position of another point on the same contour is known. The method employed is to position the base of the pole at the same level as the foot of the plane-table (on which the clinometer stands) and to obtain the distance to that point by dividing a known distance on the pole by the difference of the clino. readings to the extremeties of this known distance. Alternatively, the "clinopole" may be used for surveying detail. The method is independent of slope provided the clinometer is always levelled.

68. **Description of the Clinopole.**—The pole (see Plate D) consists of a piece of wood, about fifteen feet in length. Divisions are marked carefully with paint, one foot apart, *commencing from the bottom.*

Three targets are made from kerosene oil tins, about $9'' \times 9''$. The upper (or lower) half is painted white and the other half bright red. They are riveted to the pole exactly at the 4′, 12′ and 14′ marks.

Tables are prepared (see page 54)—giving the distance of the pole from the plane-table for any particular clinometer reading between (i) the 4′ and 12′ targets and (ii) the 4′ and 14′ targets.

Alternatively, a graph may be prepared on each plane-table for the 8 and 10 feet distances, one axis representing the difference in clino. readings and the other, the distance to the pole, in yards. This, of course, is not nearly as precise as the tables.

69. **Drills for using the Clinopole**

A. *For inexperienced plane-tablers.*—

(i) Make a plane-table fixing *on* a contour.

(ii) Send a *khalasi* with the pole to a point about twenty-five yards away, where it is considered that the contour will run.

(iii) Level the clinometer.

(iv) Signal to the *khalasi* to move a little in one direction or another, the pole being held as nearly vertical as possible, till the clinometer reading is 00 on the 4′ target.

(v) Read the elevation to the 14′ target.

(vi) Obtain the distance from the (10′) tables, interpolating if necessary.

(vii) Keep the clinometer levelled and the pole in the same position, and read the elevation to the 12′ target (as a check reading). Both distances should agree.

(viii) Plot the distance, along the ray to the pole, from a diagonal scale of yards. This gives the exact location of the contour on which the plane-table is fixed.

(ix) Repeat, placing the pole at about two, three, four, etc., times the original distance.

(x) After about a hundred and fifty yards length of contour on each side has been surveyed, move on to the next fixing on the same contour about three hundred yards away. This is done by the usual expedient of reading 00 to the 4′ target, at that distance and drawing a ray to the pole and plotting the distance. Place the plane-table on the spot where the pole was situated, set on a distant trig. station, intersected point or auxiliary point in the direction of the previous fixing, and cut in from two or more near points at right angles.

(xi) The height may be accepted as being the same as that of the last fixing. It will only be necessary to deduce a fresh height (from trig., etc., points) at about every fifth fixing, distributing any slight discrepancy which may arise.

B. *For experienced plane-tablers.*—(*a*) Drill as detailed in para A, above, should be modified as follows :—

(i) Set the pole in position at *salient features further apart* and not at particular distances. Put in intervening features by eye.

(ii) Check observation is not necessary up to about one hundred and fifty yards. Beyond that, targets are apt to become indistinct, giving rise to appreciable errors.

(iii) Reliable heights (from trig., etc.,) need only be deduced at the beginning and end of a day's work.

(*b*) Concurrently with the procedure at para B (*a*), above, the following drill is also to be carried out to fix the next contour below the plane-table :—

(i) Send a second clinopole to a point where it is considered the lower contour will run.

(ii) Level the clinometer.

(iii) Have the pole moved till the clinometer reading is 00 on the 14′ target.

(iv) Read the depression to the 4′ target.

(v) Obtain distance from (10′) tables, as before.

(vi) For check readings (for distances beyond about one hundred and fifty yards), keep the clinometer levelled, read the depression to the 12′ target; subtract this reading from that at (iv), above and obtain distance from (8′) tables.

(*c*) Experienced plane-tablers may set up the plane-table almost anywhere and not necessarily on a contour. For example, if the ground height of a fixing is 352 feet, then the clinometer is at 356 feet (i.e., six feet above the 350 contour). Tie a handkerchief round the pole at the 6′ mark and move the pole till the levelled clinometer reads 00 at the handkerchief. The pole is now on the 350 contour.

(*d*) Where not more than either one of the 4′ or 14′ targets is visible in jungle, obtain distance (in feet) by reading to top and bottom of any consecutive number of one foot markings on the pole (say x feet) and then dividing x by the algebraical difference of the clino. readings.

70. **Miscellaneous notes.**—(*a*) Clinopoles used here have been improvised locally from unavoidably bowed and bent bamboos. For work of high accuracy, something straighter and more rigid would have to be produced by skilled workmen. A drawing (Plate D) and specifications for such a clinopole will be found at the end of this appendix (see page 56).

(*b*) The foot of the pole should have a metal shod spike, otherwise *khalasis* are liable to break off damaged pieces without informing anybody.

(*c*) Poles fitted with a plumb-bob would be useful for work of high accuracy.

(*d*) All the targets of any one surveyor should be riveted with either the white (or the red) uppermost. Because it happens frequently, that due to poor reflection or failing light the white does not show up. The surveyor, therefore, reads to the top of the red, convinced that it is the centre of the target, whereas, in reality the other colour is actually below it.

(*e*) Targets should be secured with two rivets.

(*f*) The handkerchief—para 69 B (*c*) above—often cannot be seen clearly from more than about seventy-five yards. It would be an improvement to have a moveable target of a different colour combination.

(*g*) With a careful plane-tabler an accuracy of the order of 1 in 300 can be achieved ; with a careless surveyor it will be about 1 in 100. But even this maximum error (for about three hundred yards—the greatest distance at which the pole is likely to be used) is scarcely plottable on the 6-inch scale.

(*h*) It is possible, also, to survey the next contour above the plane-table with the "clinopole". But the result is not strictly accurate. The method consists of sending the pole to a position

where the contour is believed to run. Obtain the distance to the pole by reading to the targets and then obtain the height of the base of the pole with the help of the Survey of India height indicator. It will generally be found that the pole stands only a foot or two above or below the contour. The latter can, therefore, be sketched in with a very fair degree of accuracy.

(*i*) It will probably be found, in actual practice, that greater outturn can be achieved by working *down* a slope (*across* successive contours) than by working *along* them.

(*j*) Some plane-tablers are not very familiar with decimal measure. It is as well to give them tables made out for targets 14 feet apart (i.e., the distance between the base of the pole and the uppermost target). This obviates serious errors in subtraction [see para 69 B (b) (vi)]. Perhaps the most satisfactory way of avoiding both the subtraction and the use of 14′ tables (as the base of the pole is not always visible) is by tying a handkerchief, or placing the moveable target, at the six-foot mark. This will give the requisite check value.

(*k*) The "clinopole" will be found quite rapid provided the user has the confidence and ability not to place it at very short intervals.

(*l*) Detail can be surveyed very successfully with this device ; especially on ground which is too undulating for accurate chaining or where there is likely to be confusion in identifying rays (from some previous fixing) for intersection.

(*m*) As the life of clinopole tables would be very short, indeed, in the hands of the average plane-tabler, they should be placed permanently in sealed tracing linen envelopes.

(*n*) For ease in carrying, the pole may be in two sections. This has the disadvantage that if several poles are mixed up and the component halves do not have the same identification number, the resulting distance between targets may not be correct, unless all halves have been very carefully constructed to be interchangeable.

71. **Conclusion.**—The clinopole may have further and more elaborate applications, but it has not yet been possible to devote any time to it. Recently, it was used successfully over steep, undulating ground and across the shallow but broad water channel of a river, for demarcating a dam alignment by pegs at a horizontal distance of a hundred feet from one another.

TABLES FOR CLINOMETER

Clinometric Reading	Distance in yds. for Dist. between Targets		Clinometric Reading	Distance in yds. for Dist. between Targets	
	8′	10′		8′	10′
0·007	380·96	476·2	0·055	48·5	60·6
8	333·33	416·7	56	47·6	59·5
9	296·29	370·4	57	46·8	58·5
			58	46·0	57·5
0·010	266·67	333·3	59	45·2	56·5
11	242·43	303·0			
12	222·22	277·8	0·060	44·4	55·6
13	205·13	256·4	61	43·7	54·6
14	190·48	238·1	62	43·0	53·8
			63	42·3	52·9
15	177·78	222·2	64	41·7	52·1
16	166·67	208·3			
17	156·86	196·1	65	41·0	51·3
18	148·15	185·2	66	40·4	50·5
19	140·35	175·4	67	39·8	49·8
			68	39·2	49·0
0·020	133·3	166·7	69	38·6	48·3
21	127·0	158·7			
22	121·2	151·5	0·070	38·1	47·6
23	115·9	144·9	71	37·6	46·9
24	111·1	138·9	72	37·0	46·3
			73	36·5	45·7
25	106·7	133·3	74	36·0	45·0
26	102·6	128·2			
27	98·8	123·5	75	35·6	44·4
28	95·2	119·0	76	35·1	43·9
29	91·9	114·9	77	34·6	43·3
			78	34·2	42·7
0·030	88·9	111·1	79	33·8	42·2
31	86·0	107·5			
32	83·3	104·2	0·080	33·3	41·7
33	80·8	101·0	81	32·9	41·2
34	78·4	98·0	82	32·5	40·7
			83	32·1	40·2
35	76·2	95·2	84	31·7	39·7
36	74·1	92·6			
37	72·1	90·1	85	31·4	39·2
38	70·2	87·7	86	31·0	38·8
39	68·4	85·5	87	30·7	38·3
			88	30·3	37·9
0·040	66·7	83·3	89	30·0	37·5
41	65·0	81·3			
42	63·5	79·4	0·090	29·6	37·0
43	62·0	77·5	91	29·3	36·6
44	60·6	75·8	92	28·9	36·2
			93	28·7	35·8
45	59·3	74·1	94	28·4	35·5
46	58·0	72·5			
47	56·7	70·9	95	28·1	35·1
48	55·5	69·4	96	27·8	34·7
49	54·4	68·0	97	27·5	34·4
			98	27·3	34·0
0·050	53·3	66·7	99	27·0	33·7
51	52·3	65·4			
52	51·3	64·1	0·100	26·7	33·3
53	50·3	62·9	1	26·4	33·0
54	49·4	61·7	2	26·1	32·7
			3	25·9	32·4
			4	25·6	32·1

TABLES FOR CLINOMETER—(*contd.*)

Clinometric Reading	Distance in yds. for Dist. between Targets		Clinometric Reading	Distance in yds. for Dist. between Targets	
	8′	10′		8′	10′
0·105	25·4	31·7	0·155	17·2	21·5
6	25·2	31·4	56	17·1	21·4
7	24·9	31·2	57	17·0	21·2
8	24·7	30·9	58	16·9	21·1
9	24·5	30·6	59	16·8	21·0
0·110	24·2	30·3	0·160	16·7	20·8
11	24·0	30·0	61	16·6	20·7
12	23·8	29·8	62	16·5	20·6
13	23·6	29·5	63	16·4	20·4
14	23·4	29·2	64	16·3	20·3
15	23·2	29·0	65	16·2	20·2
16	23·0	28·7	66	16·1	20·1
17	22·8	28·5	67	16·0	20·0
18	22·6	28·2	68	15·9	19·8
19	22·4	28·0	69	15·8	19·7
0·120	22·2	27·8	0·170	15·7	19·6
21	22·0	27·5	71	15·6	19·5
22	21·9	27·3	72	15·5	19·4
23	21·7	27·1	73	15·4	19·3
24	21·5	26·9	74	15·3	19·2
25	21·3	26·7	75	15·2	19·0
26	21·2	26·5	76	15·2	18·9
27	21·0	26·2	77	15·1	18·8
28	20·8	26·0	78	15·0	18·7
29	20·7	25·8	79	14·9	18·6
0·130	20·5	25·6	0·180	14·8	18·5
31	20·4	25·4	81	14·7	18·4
32	20·2	25·3	82	14·7	18·3
33	20·0	25·1	83	14·6	18·2
34	19·9	24·9	84	14·5	18·1
35	19·8	24·7	85	14·4	18·0
36	19·6	24·5	86	14·3	17·9
37	19·5	24·3	87	14·3	17·8
38	19·3	24·2	88	14·2	17·7
39	19·2	24·0	89	14·1	17·6
0·140	19·0	23·8	0·190	14·0	17·5
41	18·9	23·6	91	14·0	17·5
42	18·8	23·5	92	13·9	17·4
43	18·6	23·3	93	13·8	17·3
44	18·5	23·1	94	13·8	17·2
45	18·4	23·0	95	13·7	17·1
46	18·3	22·8	96	13·6	17·0
47	18·1	22·7	97	13·5	16·9
48	18·0	22·5	98	13·5	16·8
49	17·9	22·4	99	13·4	16·8
0·150	17·8	22·2	0·200	13·3	16·7
51	17·7	22·1			
52	17·5	21·9			
53	17·4	21·8			
54	17·3	21·6			

Specifications—Clinopole 15 feet, with targets

1. Pole is made of strong wood, straight and rigid, $15' \times 2\frac{1}{2}'' \times 1\frac{1}{2}''$. It should be in two sections (of say, $7\frac{1}{2}'$ each), which can be fitted together. *All* sections of all poles are to be accurately interchangeable.
2. Pole should have a metal-shod base.
3. One foot-divisions (without numbering) are to be etched across the front of the pole. Each mark (except those at 4 below) should have a slot ($\frac{1}{3}''$ diameter and $\frac{3}{4}''$ deep) punched in the middle. Alternate one-foot lengths are to be painted *bright* red and white.
4. Three targets ($9'' \times 9''$) of galvanized iron sheeting—upper half black and lower half lemon yellow are to be riveted to the pole (with two rivets—one at the top and one at the bottom of each target) centrally over the top of the 4, 12 and 14 ft. divisions (commencing from the foot of the pole).
5. One target (as at 4 above), but painted *bright* red and white, with a hole $\frac{1}{3}''$ diameter punched in the middle.

   Hard wood plug, about $1\frac{1}{2}''$ long, to fit slot at 3 above, and hole at 5 above.

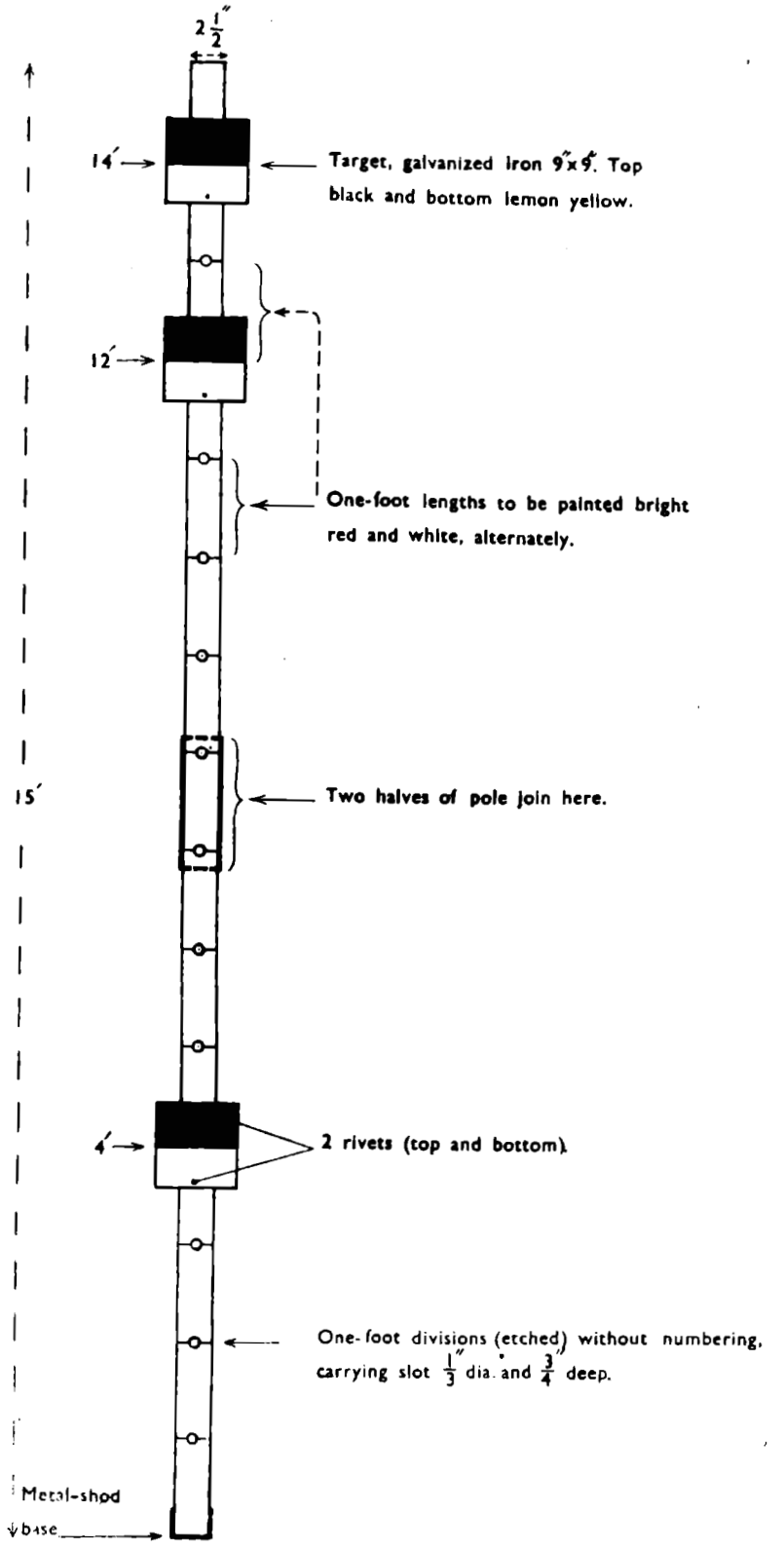

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PLATE D-CLINOPOLE 15-FEET WITH TARGETS

APPENDIX II

NOTES ON 4-INCH IRRIGATION SURVEYS

72. **Object.**—(*a*) To produce a 4-inch map of the commanded areas with 1 foot generalized contours. [The planimetry should have no local plottable errors, (i.e., detail to be accurate to 4½ yards)].

(*b*) To fix a framework of mark-stones at the approximate corners of a 30-chain grid. [The positions of mark-stones should be accurately surveyed and their tops should be levelled to an overall accuracy of 0·3 foot].

73. **Terrain.**—Flat or gently undulating country. Types of vegetation encountered are :—

(*a*) Open cultivation.
(*b*) Scattered tree plantations.
(*c*) Areas of scrub or jungle.
(*d*) Large areas of high (6′ to 10′) grass.

74. **Method.**—(*a*) *Planimetry.*—

(i) *Control.*—By traverse (Hunter Short Base or crinoline chain) and occasionally, triangulation. Existing primary and topo. triangulation enabled the traverse lines to be kept reasonably short (up to 15 miles).

(ii) *Survey.*—From air photos by graphic radial line method. Photos of approximately 2-inches contact scale enlarged to 4-inches to 1 mile were used. Mark-stones positions are post-pointed on the photos after emplacement.

(*b*) *Levelling.*—

(i) *Control.*—By a framework of secondary and double tertiary levelling connected to primary bench-marks. This produces lines of height framework not more than 8 miles apart.

(ii) *Single tertiary levelling.*—Lines of single tertiary levelling are run between secondary bench-marks. These are run along the lines of mark-stones, the tops of which are levelled.

(iii) *Spot levels.*—Offset spot levels are taken along the tertiary lines by observing bearing and tachymetric distance. A final mesh of spot levels, 10 chains apart, is produced. These are published on a level chart. The level values are printed in red on the 4-inch map which, for this purpose, is printed in a neutral colour. The Level Chart is complementary to the Line Map.

(*c*) *Contouring.*—Generalized 1-foot contours are drawn with the aid of the outline survey, the 10-chain "spot" levels and the photos (in difficult areas).

75. **Errors.**—(*a*) The criteria for errors laid down were :—

Traverse or triangulation	1/5,000 to 1/2,000 for short lines, (5 miles).
Secondary levelling	0·006 ft./mile.
Double tertiary levelling	0·009 ft./mile.
Single tertiary levelling	Total closure of any line not to exceed 3 feet.

(*b*) Actual errors produced were :—

(i) Traverse	Well within the allowable limit, i.e., all long lines had an error of between 1/6,000 and 1/5,000.
(ii) Secondary levelling	0·004 ft./mile for 446 miles of levelling.
(iii) Double tertiary	0·0049 ft./mile for 371 miles of levelling.
(iv) Single tertiary	0·024 ft./mile for 2,521 miles of tertiary levelling.

76. **Outturn.**—The *annual* outturn of a unit composed of,

2 Traverse or triangulation detachments.
2 Secondary levelling detachments.
6 Air surveyors (of whom two are fully trained and 4 are useful auxiliaries).
8 Stone-layers (ground surveyors).
28 Tertiary levellers.
and 9 Computers (of whom 3 are fully trained topo. computers and 6 are level checkers),

with normal supervisory personnel, is 1,000 sq. miles of 4-inches irrigation surveys, complete up to publication stage.

77. **Other interesting data.**—(*a*) The total area in hand for such irrigation surveys is :—

	Sq. miles
Tista Project	19,141
Kosi Project	17,305
Mahanadi Project ..	1,971
Total	38,417 sq. miles.

(*b*) As a result of the first year's work it was calculated that the *actual* cost (including unit overheads) of these surveys is Rs. 350/- per sq. mile. This figure includes photography, mark-stones, survey, drawing and publication of 100 copies of line maps and level charts. For future estimating purposes, 25% departmental charges must be added to this figure.

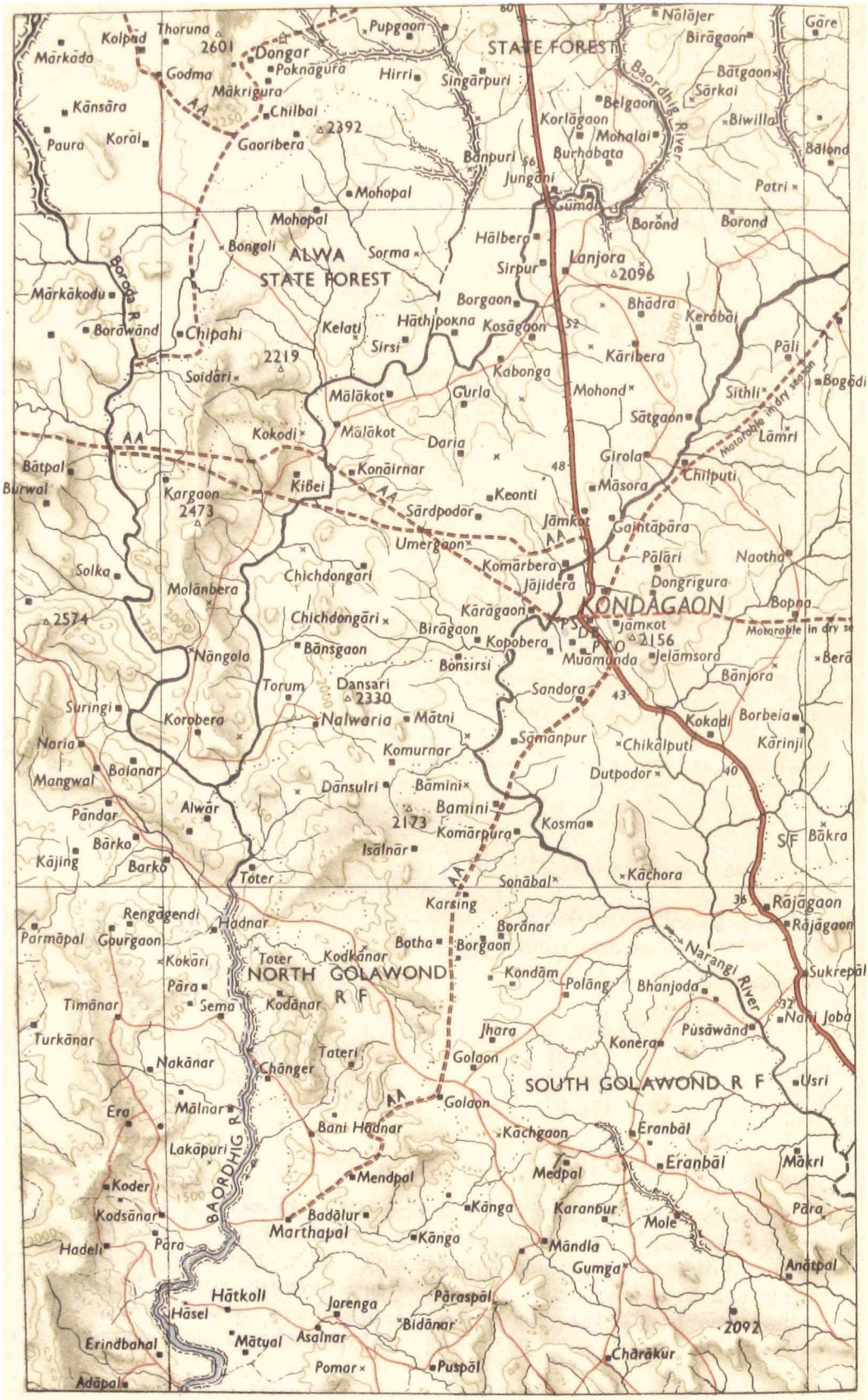

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PLATE 'E'-SPECIMEN OF A QUARTER INCH SHEET PREPARED BY THE NEW RAPID COMPILATION METHOD

PART II.—MAP PUBLICATION AND OFFICE WORK

TECHNICAL NOTES

DIRECTOR :— { Major H. W. Wright, O.B.E., R.E., to 24-5-47.
Major Gambhir Singh, I.A., from 25-5-47.

VII. GENERAL

The period under review was that of recovery from war, during which all reproduction offices remained centralized under the Director Map Publication. To replenish stocks and meet increasing demands, map production had to be accelerated. As a result, pre-war multi-colours on our regular series could not be undertaken and as an interim measure, the wartime expedient of fewer essential colours had to be continued ; and where possible separate name originals for maps were introduced.

VIII. MAP COMPILATION

78. **Quarter inch—Rapid Compilation.**—A new method was introduced as an experimental measure to speed up production of quarter inch to 1 mile sheets from half inch or larger scale material as available, which used before to take about a year. In this method, details suitable for quarter inch mapping are traced separately on Kodatrace for each of the component sheets of the basic material. Reductions of these tracings on $\frac{3}{8}$-inch scale are obtained on bromide prints and mosaiced on to a projection on a sheet of zinc. Names obtained either by letter-press printing or hand-typing on separate pieces of paper are then pasted on it. The mosaic is then completed for borders and marginal items and forms the "Outline Original".

Contours are similarly traced on Kodatrace, and film positives obtained on reduction to $\frac{3}{8}$-inch scale, which are then mosaiced on a zinc mounted blue print of the outline original. Contour values are typed on this mosaic, which forms the "Contour Original". Colour guides and green tree original are prepared as usual.

It may be stressed that this method is only an interim measure for rapid production, as the drawing of sheets produced by it is not uniform or quite up to standard and the originals are of a very temporary nature.

A specimen of a sheet compiled by the above method with combined horizontal and vertical shading with north light incidence is given at Plate E.

79. **Bold Style—1/M Province maps.**—These were based on 1/M Carte Internationale du Monde maps and designed for rapid production with a minimum of drawing effort.

Two sets (one in black and the other in full colours) of combined prints on Hollingworth paper of Black, Red, and Blue plates of the component 1/M sheets are obtained. On the black print, district boundaries are drawn, Headquarters names boxed, and spaced names and tinted sites blocked in. These prints are then mosaiced and completed for borders and marginal detail to form an "Outline Original". Colour prints are combined to form colour separation guides.

Separate prints in black of the contour plates are also obtained and mosaiced on a dyed glass helio to form basis for a "Shade Original". The boundary riband and other guides and the shade originals are prepared as usual.

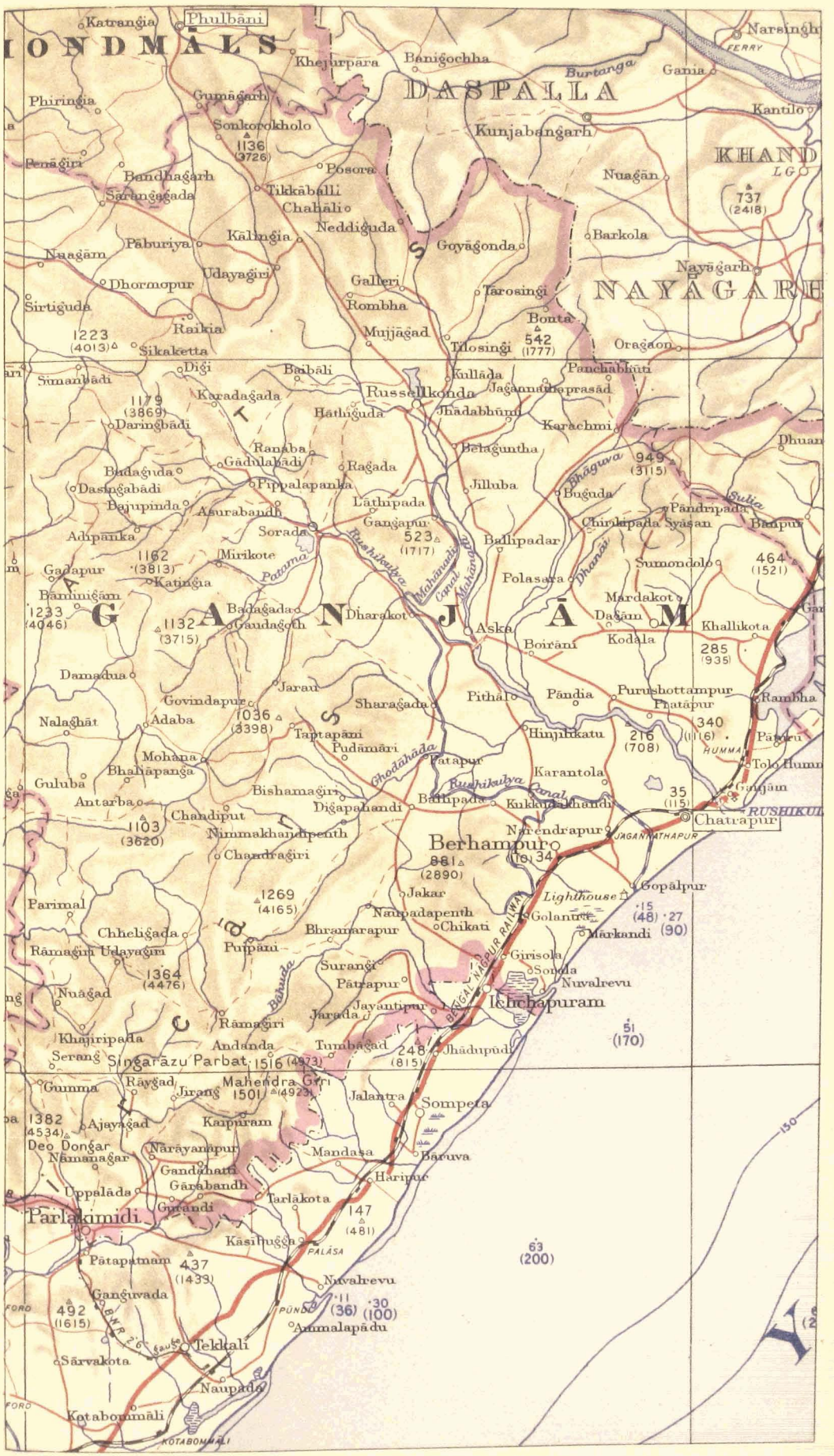
This method has been a success and is likely to replace permanently the previous method of producing such maps.

A facsimile reproduction of a part of "ORISSA PROVINCE MAP" prepared by the above method is given at Plate F.

80. **Separate Name Originals.**—With the possibility of eventually having vernacular editions and also to expedite production, separate name originals for our maps, where possible, were considered necessary as a rule. Experiments may be initiated for preparation of separate name originals on an enamelled surface. Name slips obtained either by letterpress or hand-typing are pasted with Amyl Acetate on blue prints on the enamelled surface. The surface is afterwards varnished by three to four coats of Cellulose to protect these slips.

IX. ENGRAVING

81. **Carte Internationale du Monde Series.**—The following new method was used for the production of Carte Internationale du Monde sheets, originals of which are engraved on copper plates. Four or five copper plates are prepared for each sheet depending on the number of colours to be used in the final printed map. The plates are not, however, used for printing purposes but pulls from them are made on chromo paper and these are used as the originals for reproduction. To obtain correct colour registration, it is necessary to ensure that the chromo pulls remain the same size as the original copper plates. To effect this, a stiff sheet of brown paper is glued to one side of a thin zinc plate ; on the other side of the zinc plate, a sheet of plate paper is glued. Plate paper is a very soft, fairly thick absorbent paper. On top of the plate paper a sheet of chromo paper is pasted. The use of plate paper enables a better impression to be obtained from the copper plate on the chromo paper and the mounting on zinc ensures that the chromo paper does not distort.


KONDMĀLS
Katrangia
Phulbāni
Khejurpāra
Baniĝochha
DASPALLA
Burtanga
Gania
Narsingh
FERRY
Kantilo
Phiringia
Gumāĝarh
Sonkorokholo
1136
(3726)
Kunjabangarh
KHAND
LG
Pemāĝiri
Bandhaĝarh
Sārāmĝaĝada
Posora
Tikkāballi
Chahāli
Nuaĝān
737
(2418)
Kālinĝia
Neddiĝuda
Goyāĝonda
Barkola
Pāburiya
Nuaĝām
Udayaĝiri
Dhormopur
Galleri
Tarosingi
Nayāĝarh
NAYĀGARH
Sirtiĝuda
Rombha
Bonta
1223
(4013)
Raikia
Sikaketta
Mujjāĝad
Tilosingi
542
(1777)
Oraĝaon
Baibāli
Kullāda
Panchabhūn
Sumanbādi
Russellkonda
Jaĝannāthaprasād
Karadaĝada
1179
(3869)
Hathiĝuda
Jhādabhūmi
Karachmi
Darinĝbādi
Ranaba
Dhuan
Gādulabādi
Bālaguntha
949
(3115)
Bhāgwa
Budaĝuda
Ragada
Dasinĝabādi
Pippalapanka
Jilluba
Buĝuda
Suka
Bajupinda
Asurabandh
Lāthipada
Pāndripada
Adipānka
Sorada
Gangapur
523
(1717)
Chirikpada Syāsan
Bāapur
Rushikulya
Mahānadi Canal
Mahānadi
Ballipadar
Dhanai
1162
(3813)
Mirikote
Sumondolo
464
(1521)
Gadapur
Katingia
Patama
Polasara
Bānunĝām
Mardakot
1233
(4046)
Badaĝada
Dharakot
Aska
Daĝam
Khallikota
1132
(3715)
Gaudaĝoth
Boirāni
Kodala
285
(935)
Damadua
Govindapur
Jarau
Sharaĝada
Pithāl
Pāndia
Purushottampur
Rambha
Nalaghāt
Adaba
1036
(3398)
Taptapāni
Hinjilikatu
216
(708)
340
(1116)
Pratāpur
Pāikuru
Mohana
Pudāmāri
Patapur
Tolo Humma
Bhabāpanga
Chodāhāda
Karantola
Guluba
Rushikulya Canal
35
(115)
Ganjam
Bishamaĝiri
Antarba
Digapahandi
Baliipada
Kukkundahandi
RUSHIKUL
Chandipur
Chatrapur
1103
(3620)
Nimmakhandapenth
Narendrapur
JAGANNATHAPUR
Chandraĝiri
Berhampur
881
(2890)
Gopālpur
Parimal
1269
(4165)
Jakar
Lighthouse
Naupadapenth
Golanthi
15
(48)
27
(90)
Chheliĝada
Bhramarapur
Chikati
Markandi
Rāmaĝiri Udayaĝiri
Puipāni
Girisola
Surangi
Sonda
1364
(4476)
Pātrapur
Nuvalrevu
Nuāgad
Bahuda
Jayantipur
Ichchapuram
Rāmaĝiri
Jarada
Khajiripada
Andanda
Tumbaĝad
248
(815)
Jhādupudi
51
(170)
Seranĝ
Singarāzu Parbat
1516 (4973)
Gumma
Rāyĝad
Jirang
Mahendra Giri
1501 (4923)
Jalantra
Sompeta
1382
(4534)
Ajayaĝad
Kaipuram
Deo Dongar
Nārāyanapur
Mandasa
Bāruva
Nāmanagar
Gandahati
Haripur
Uppalāda
Gārabandh
Tarlākota
Parlakimidi
Gumandi
147
(481)
Kāsinugga
PALASA
63
(200)
Pātapatnam
437
(1433)
Nuvalrevu
Ganguvada
492
(1615)
PUNDI
11
(36)
30
(100)
Ammalapādu
Tekkali
Sārvakota
Naupada
Kotabommāli
KOTABOMMALI
150
Y
PLATE F — SPECIMEN OF A PROVINCE MAP PREPARED IN BOLD STYLE.
Reg. No. 3139 D '49—250.
PRINTED AT THE SURVEY OF INDIA OFFICES. (P.L.O.)

X. PRINTING

82. **Photo-Chromo process.**—This method is a combination of half-tone work and litho-drawing and is employed to overcome the size limitations of the half-tone screen available for doing large sized commercial printing of coloured posters. Colour plates are made from half-tone negatives and to these plates is later added chalk and medium work by litho-drawing in accordance with the original.

83. **Monotype Keyboard and Casting Machine.**—During the war, a "Monotype Keyboard and Casting Machine" was received from military surplus stores, and was particularly welcome as the department was getting extremely short of type founts.

The machine can be used for mechanical composing and casting of type and is equipped with inter-changeable parts to enable the composition of different combinations of type faces and body sizes to be carried out.

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, 1947.

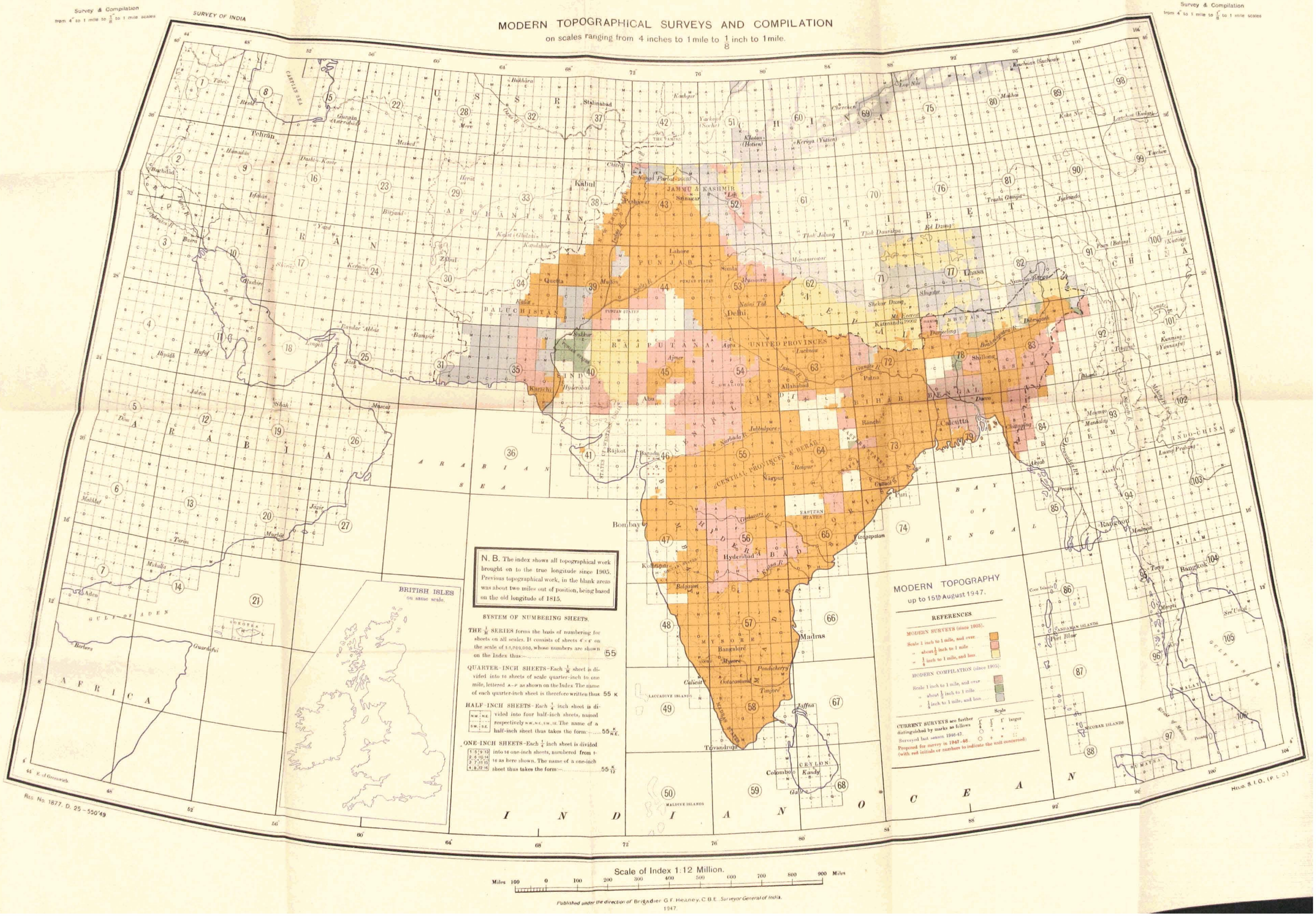
INDEX A

Survey & Compilation
from 4" to 1 mile to $\frac{1}{8}$" to 1 mile scales

SURVEY OF INDIA

MODERN TOPOGRAPHICAL SURVEYS AND COMPILATION

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



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

SYSTEM OF NUMBERING SHEETS.

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

QUARTER-INCH SHEETS—Each $\frac{1}{M}$ sheet is divided into 16 sheets of scale quarter-inch to one mile, lettered A–P as shown on the Index The name of each quarter-inch sheet is therefore written thus 55 K

HALF-INCH SHEETS—Each $\frac{1}{4}$ inch sheet is divided into four half-inch sheets, named respectively N.W., N.E., S.W., S.E. The name of a half-inch sheet thus takes the form:—..... $55\frac{K}{N.E.}$

ONE-INCH SHEETS—Each $\frac{1}{4}$ inch sheet is divided into 16 one-inch sheets, numbered from 1–16 as here shown. The name of a one-inch sheet thus takes the form:— $55\frac{K}{12}$

MODERN TOPOGRAPHY
up to 15th August 1947.

REFERENCES

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

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

CURRENT SURVEYS are further distinguished by marks as follows
Surveyed last season 1946-47.
Proposed for survey in 1947-48.
(with red initials or numbers to indicate the unit concerned)

Scale: $\frac{1}{4}$" $\frac{1}{2}$" 1" larger

Scale of Index 1:12 Million.

Miles 100 0 100 200 300 400 500 600 700 800 900 Miles

Published under the direction of Brigadier G.F. Heaney, C.B.E., Surveyor General of India.
1947.

Helio. S.I.O., (P.L.O.)

Reg. No. 1877. D. 25–550'49

INDEX C

SURVEY OF INDIA

INDEX SHOWING PROJECT SURVEYS IN HAND

References to Projects

1. Srinagar Town
2. Dochi (Nagaon) Dam
3. Bhakra
4. Delhi Expansion & Development
5. Jhatpat
6. Gandak Catchment
7. Kosi Catchment
8. Bagaha Land Reclamation
9. Kosi Dam
10. Cinchona Research Station
11. Tista High Dam
12. Kosi
13. Tista
14. Um Tru Dam & Reservoir
15. Karachi Industrial Area
16. Bihar Mica Belt
17. Son Valley Coalfields
18. Konar Dam (Damodar Project)
19. Hazaribagh Coalfields
20. Bokaro Dam (Damodar Project)
21. Bokaro Coalfields
22. Deolbari Dam (Damodar Project)
23. Bermo-Bhandaridah Gorge (Damodar Project)
24. Gumti Dam & Reservoir
25. Morvi City
26. Jamshedpur Town
27. Hooghly Ship Canal
28. Karnaphuli Dam & Reservoir
29. Mahanadi Coalfields
30. Kamptee Coalfields
31. Mahanadi
32. Hirakud Dam
33. Tikarpara Dam & Reservoir
34. Naraj Dam & Reservoir
35. Tungabhadra
36. Kalinadi Reservoir
37. Sandur Reservoir & Town Development
38. Davangere Town Development
39. Bangalore City Development
40. Chamarajanagar-Mettupalyam Railway
41. Poringalakuthu Reservoir

References

Commanded Area .....

Catchment Area .....

Area for Rectangulation...

Other Projects .....

Dam Sites .....

Scale of Index 1:12 Million.

Miles 100 0 100 200 300 400 500 600 700 800 900 Miles

Published under the direction of Brigadier G.F. Heaney, C.B.E., Surveyor General of India.
1947.

Reg. No. 3138 D'49-550.

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