GRID MANUAL

FOR USE
IN THE TOPO MAPS OF THE
SURVEY OF PAKISTAN.

COMPILED BY
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No.2 DRAWING OFFICE
SURVEY OF PAKISTAN, DACCA.

1968.

PHOTOSTAT COPY WITH MINOR CORRECTIONS.
DURING OCTOBER, 1987.

SURVEY OF BANGLADESH

No.1 Party

Tejgaon Industrial Area

Dhaka.

GRID 1

Type No 64 D.O.

No. 38

INTRODUCTION

I joined in the then Survey of Pakistan on the 23rd of October,1952 and scheduled to retire from the service on the 1st August,1989. During this period, I kept some notes on grids from different books and publications,finally compiled these notes during 1968 in the form of a GRID MANUAL as manuscript copy. This is just a photostat copy with minor corrections from the above manuscript.

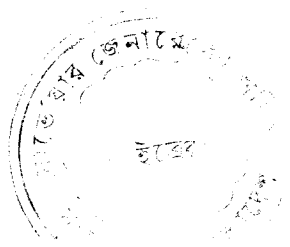
I am sorry that I could not make sufficient copies of it for unavoidable difficulties. I shall hope that officers & staff in possession of this copy of GRID MANUAL will pass it on to a next suitable person on his retirement or while leaving Survey of Bangladesh.

My herd labour will be successful,if any officer or staff of Survey of Bangladesh is slightly benefited out on these notes.

In this connection, I remember Mr S.Q.Hasan,the then Deputy Surveyor General who went through these notes and forwarded suggestions for improvement.

Dhaka,
30th November,1987.

(Waheduddin Ahmad),
Superintendent of Survey,
Officer-in-Charge,
No. 1 Party,
Survey of Bangladesh,
Tejgaon, Dhaka.



P R E F A C E:

Reference books, letters and other publications and their subsequent amendments on grids published by Survey of India from time to time have now become very rare and requires reprinting with sufficient alterations and additions. So, an attempt has been made to compile latest informations, instructions and orders, in this manual from the list of references mentioned in the next page, so that an average worker can overcome the difficulty of having a fair idea of grid system at present used in the Topo Maps of the Survey of Pakistan.

Waheduddin Ahmad 1/8/68

Dacca,
1968

Waheduddin Ahmad,
Extra Asstt Superintendent,
Survey of Pakistan.

LIST OF R E F E R E N C E S.

(i) For theory and computation - special publication No.1 The Lambert Grid for India published in 1930 by the Director Geodetic Branch, Survey of India.

(ii) For system of grid reference - Modified British System Amendment No.2 dated 30-6-66 to the Manual of Map reading photograph reading, and field sketching.

(iii) Section IX (Para 409-425) of TMB Chapter VI, published by Survey of Pakistan.

(iv) "Guide for the preparations of Grids" published by Survey of India 1933.

(v) Indian Army Order 105 Map, published in 1929.

(vi) Chapter VII Section 45 of the Manual of Map reading, Photo Reading, Field Sketching 1929.

(vii) Survey Service Pocket Book (India) published in 1941 Reprinted 1942, 43.

(viii) Auxiliary Table Part III & V published by Survey of Pakistan.

(ix) The book on "General Cartography" by ERWIN RAISZ, Lecturer in Cartography, Institute of Geographical Exploration, Harvard University.

(x) Misc. publications published by U.S.Army Engineer School, Fort Belvoir-Virginia.

(xi) Department of U S A Army Technical Manual Published in July 1958 on U T M Grid.

(xii) Professional paper No.36 of Survey of India or Special Publication No.1 on the Lambert Grid for India by Thompson and Bomford.

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1.INTRODUCTION

(i) All maps, regardless of type, have a common characteristic, in that they should show relative location of objects. For references purposes,maps locate objects appearing thereon by various methods. During the First Wold War it was found that reference to locations and directions was too complex in the usual system of latitudes and longitudes recorded in degree, minute and second. For this reason, the French over printed a net work of squares upon their maps.

(ii) What is Grid:-

The military then employed this system of net work of squares formed by straight, approximately north-south and east-west lines superimposed on military maps.

This system of net work of lines is known as grid.

2.NEED FOR GRID

(i) The grid on maps provides a system of squares which simplify the location of points and the computation of azimuths and distances. The distance between lines on a map represents a distance on the ground in yards or metres.

(ii) Grid Co-ordinates:-

By using a system of simple grid co-ordinates, one can locate points or objects in a map and then communicate their positions to anyone possessing a copy of the same map. The net work of north-south lines are known as Eastings and east-west lines are known as Northings. Reference of a point with the help of Eastings and Northings are known as grid co-ordinates.

3.DISADVANTAGES AND ADVANTAGES.

(i) Disadvantages:-

This grid system apparantly has many disadvantages. First of all, the so-called "Grid north" may be many degrees off from the true north. Then,too,the grid co-ordinate of a certain locality are true only on one set of maps and are not true on another set of maps on another projection. It must be kept in mind, also, that the squares of grid are not exactly square on the earth's surface, and their actual shape and size are different and dependent upon the projection system of map.

The defects can however be controlled in the spacing of grid zones.

(ii) Advantages:

Against these serious objections stands the advantage of easy reckoning. Each point can be exactly located by the use of a celluloid sheet that can be placed on any square.

4. NAMINGS OF GRID:

The grid is named after the name of the projection and the origin of the projection is the 'True Origin' of the grid.

5. DIFFERENT TYPES OF GRIDS:

(a) DOMESTIC:

(i) Lambert grids:

These have the advantage of Lambert projection and have been much used in the Survey of India maps since 1929. If the extent is 8° from North to South, the scale error is limited to about 1:800.

(ii) Cassini Grid:

Since this projection is not orthomorphic, grid angles do not equal to observed angles and computations can only be carried out in grid terms by using complicated formula. They may be done in spherical or in or superposed Lambert grid and afterwards converted to Cassini.

(iii) Transverse Mercator Grid:

These are good grid with all the advantages of Lambert, but neither Survey of India nor Survey of Pakistan is acquainted with this system.

(iv) Simple Polyconic Grid:

These may be met through but they are uncommon. The projection is not orthomorphic.

Simple polyconic grids could be defined by true squares on topo maps but a separate grid would be required for each longitude strip, corresponding to simple map width.

Contd.. 3

b) INTERNATIONAL:

During the 1st War different countries used their own grids and the many overlapping grid systems caused endless confusion. The Cartographers then introduced the following two systems of grid.

i) Universal Transverse Mercator Grid:

Since it is a conformal grid all computations are simplar. The world is divided in 6°N-S belts reaching from 80°N to 80°S; Zones begin at 180° numbered eastwards. The origin of the central meridian of each zone is at the equator. False origin is 500,000 miles west of the equator (for the southern hemisphere 10,000,000 miles south)Twenty five miles of overlapping is provided but never used for reference.

ii) The World Polyconic Grid System:
(See Diagram No.1 for illustration).

The maps of Asia,Africa and Australia were grided by the British. The world polyconic grid system covers all the areas not covered by the British. It can be applied to any part of the world except the polar region north and south of 72° latitude.

Bands:- The world in this system is divided into 5 north-south 'bands',each 73° longitude wide,with 1° overlap. Band I is over the United States,Band II is west of it.Band III is over Pakistan and India. The band is known as N and S as it falls in the northern and southern hemisphere.

Zones:- Each band is divided into nine north-south segments called 'zones' each 9° wide with 1° overlap. They are marked from east to west A,B,C,D,E,F,G,J (from which the latter I is omitted).

A polyconic projection was drawn for each of these zones and upon this was placed a 1000-Yard meter grid. The origin of grid is at the intersection of the equator and the central meridian. To avoid negative values the actually used origins are sometimes away from the trues origin and the so-called imaginary origin is known as 'False Origin'.

6. SYSTEM OF GRID LETTERING:

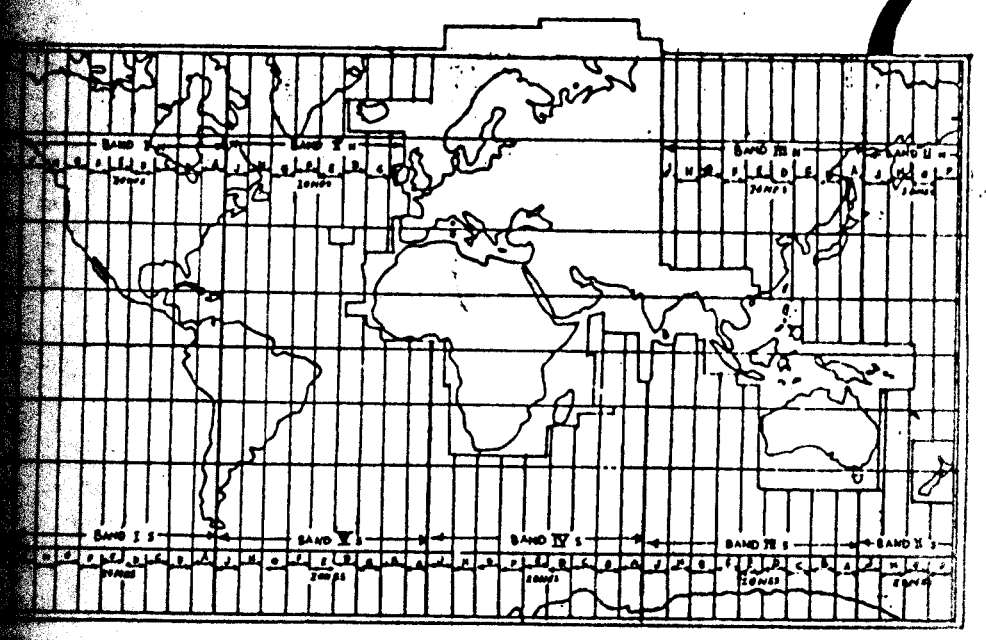
i) Every grid has a point where its north-south and east-west lines coincide with true & south and east & west. This point is known as the 'True Origin' of the grid.Whether it be the only point at which grid lines correspond with True North - South etc.lines depends on the properties of the projection to which the grid is applied.

ii) DETAILED SYSTEM OF GRID LETTERING:

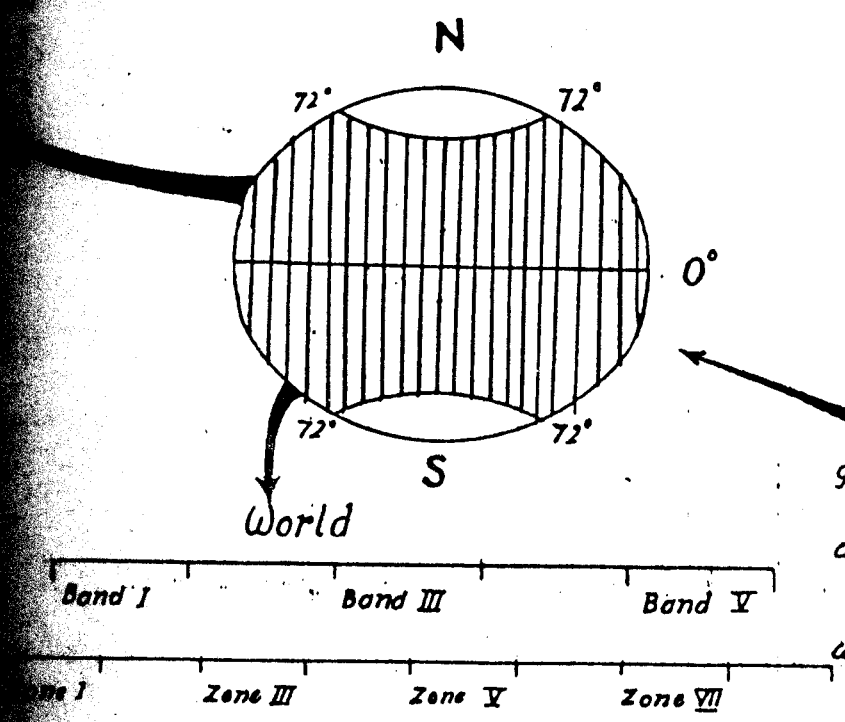
Contd..4

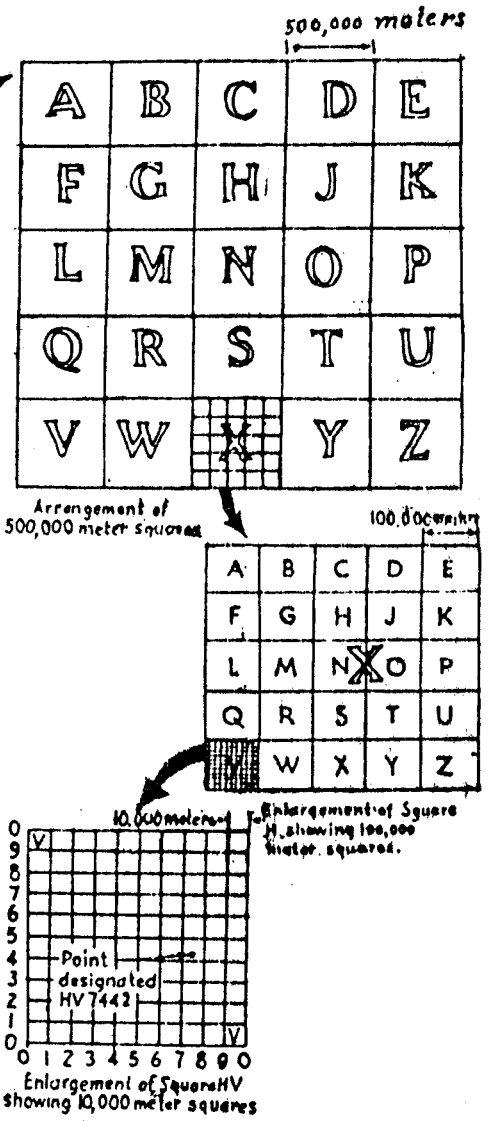
WORLD POLYCONIC GRID SYSTEM

Fig. 1



The progressive military grid of the United States was extended all over the world during ... on those parts where the British and other foreign grids were used. (*From United States*





The British and most other grid systems use a 25-letter system for 500- and 100-kilometer squares; within the 100-kilometer square the position is given by numbers.

The area covered by world policonic grid system shown by hatchurs.

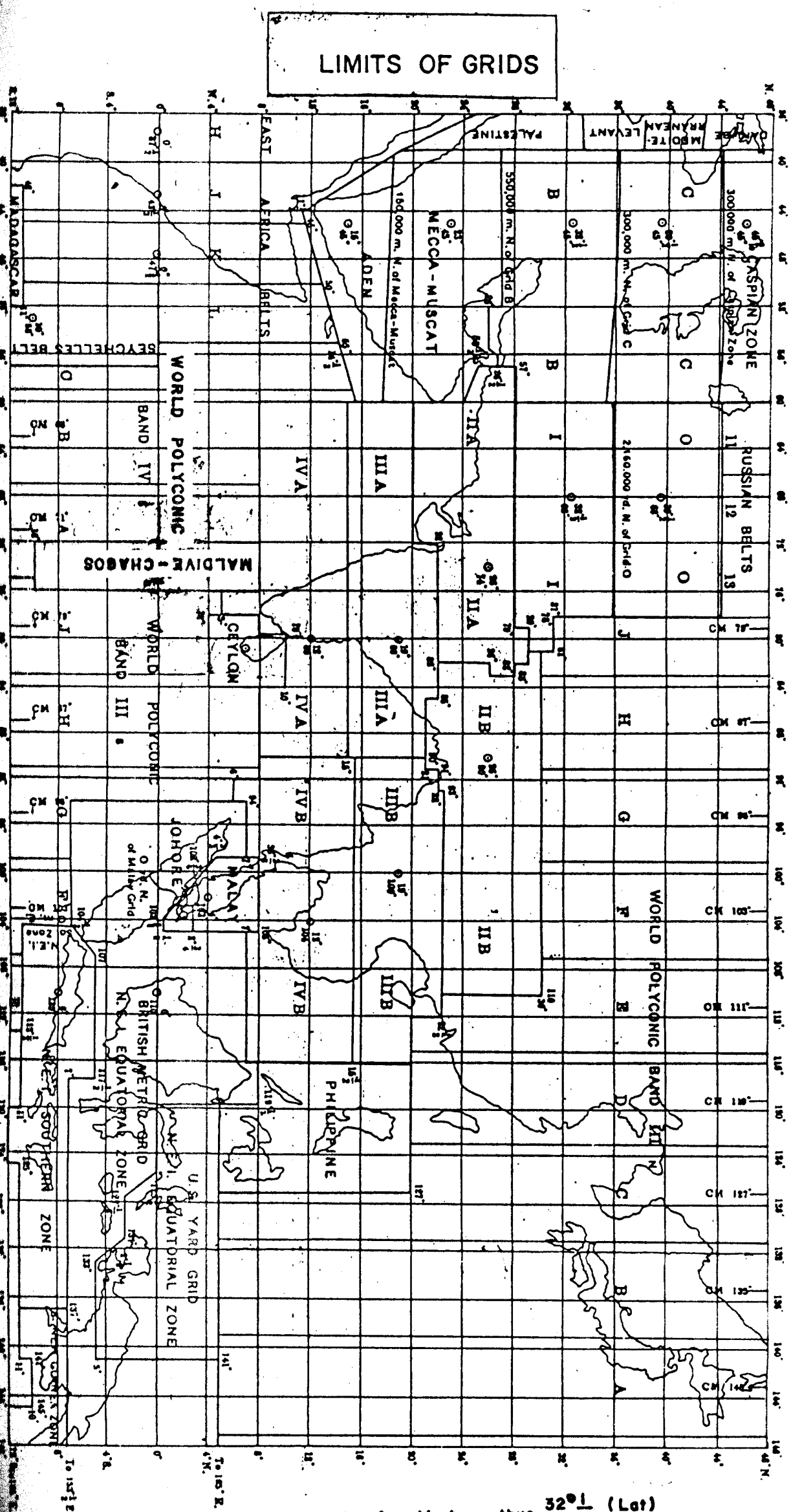
No- of Band-5 (each 73° latitude wide with 1° overlap)

No- of Zone in each band-8 (each 9° wide with 1° overlap)

NOTE — A

To avoid the inconvenience of negative co-ordinates in any area in which the grid is at all likely to be used, all co-ordinates north and east of the grid's true origin are increased by 1,000,000 and 3,000,000 yards respectively. This is sufficient to make them all positive. The co-ordinates are then expressed in terms of a "False Origin" in Arabic. Its exact position is a matter of no consequence. It is important that the true origin and false origin should not be confused. //

LIMITS OF GRIDS



True Origin of grid shown thus $\odot \begin{matrix} 32°\frac{1}{2} \text{ (Lat)} \\ 68° \text{ (Long)} \end{matrix}$

RESTRICTED

1945 Edition

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ii) Detailed system of grid lettering:-

The area covered by each grid is devided into squares 500,000 unit sides. Each of these 500,000 unit squares is again devided into twenty five 100,000 unit sides (See diagram II & figure 'A' of diagram III).

Both sizes of squares are lettered from West to East from 'A' in the north-west to 'Z' in the south-east omitting the letter'I'. The system of 500,000 unit squares is so placed, that the south-west corner of square 'V' is at the false origin of the grid and its grid easting and northing are zero. A reference to the diagram will show that the north-west corner of 500,000 unit square 'A' is 2,500,000 units north of false origin while the south west corner of square 'Z' is 2,500,000 units of it. North and east of these two points respectively, the system repeats itself so that identical references on the same grid recur at intervals of 2,500,000 units or about 1500 miles on a yard grid 100,000 unit sqaures are similarly laid up (See figure 'B' on diagram III).

iii) Rare exceptions of such grid lettering:-

Departure from the system of lettering described above will be made if it is found that the incidence of junctions between two grids brings identical letters two close together. When this is done the conventional order of lettering throughout the grid effected will remain but the 500,000 unit grid squares will, for lettering purposes, not commence at the origin.

7. GRID REFERENCES:

Where full grid reference is necessary, the band, zone and hemisphere have to be given. Thus a full reference may read 111 BNI, 329, 200-2, 625, 400, on large scale maps, however, where the approximate location is known 292-254 would be enough to locate the point with 100 yards.

A grid reference normally consists of two letters followed by a group containing an even number of figures. The first letter is that of 500,000 square and is followed by that of 100,000 squares. The former is smaller in type on the face of the map. It will be apparent from the previous para that the two letters at once indicate the distance of the point east and north of false origin to within 100,000 units. The first half of the group of figures indicates the easting of the point from the western edge of the 100,000 unit square in which it falls; the second half indicates the northing of the point from the southern edge of this square. The first figure of the easting of the reference. represents 10,000 units, the second figure represents 1000 units and the third 100 units and so on. Thus, to describe the position of a point accurately to one unit, two letters and a group of ten figures is required. Except for survey work such precision is seldom necessary and for ordinary references, groups of 8,6 or even 4 are all that are required.

Contd..5.

NOTE — B

The army requires a grid for two reasons viz:
(a) for map reference and (b) for R.A.and survey computation.

In the borders of maps two of the grid lines on each side show the full unit distance from the false origin, so that full reference may be quoted when required. One or two figures of each of these co-ordinates are printed in large type , and when giving grid reference, it is usual to omit the figures to the left of these larger figures, the appropriate letters being substituted for them. The figures in a reference thus give the easting or northing from the south-west corner of the 100,000 square; those in larger type representing the 10,000 and 1000 units respectively.

Intermediate grid lines have one or more figures according to the size of the squares on the maps. 10,000 unit squares on 1:250,000 maps have only one figure, while the 1000 unit squares of 1:50,000 and larger scale maps have two figures (See figures '0' and 'D' on diagram III).

8. FALSE GRID ORIGIN:

All distances to the east and north are positive and are known as 'Eastings' and 'Northings' respectively; those in the reverse directions are negative. As negative values of points would be inconvenient, the north-south and east-west lines passing through the true origin are given positive values such that the values of all points in the area covered by the grid will be positive. The position of the true origin does not concern the ordinary map user.

The point on the grid of which the easting and northing co-ordinates are Zero is known as the "false origin".

9. GRID CONSTANTS:

Spherical co-ordinates are converted to grid co-ordinates with the help of special tables prepared for this purpose These tables depend both on the projection and the spheriod employed; adequate particulars of which must be known to the computers. Distances and bearings computed from grid co-ordinates are some what distorted by projection, but are practically independent of the reference spheriod from which they may have been originated; but computations involving spherical co-ordinates essentially require tables appropriate to the projection and spheriod concerned.

The auxiliary tables for conversion of points and the gridding of maps used in Survey of Pakistan have been computed on Everest's spheroid, and must not be used with data computed on other spheroids or with maps based on such data; more detailed notes on this point will be available in the explanation of auxiliary tables concerned.

Contd..6.

NOTE — C

In the departmental work, old survey of India followed the usual convention of 'X' for Eastings and 'Y' for the Northings, but the war office used 'Y' for easting and 'X' for Northing. To avoid confusion Lambert Co-ordinates in India were referred to as N (Northing) and E (Easting).

Universal Index to GRID LETTERS

Diagram II

A	B	C	D	E
F	G	H	J	K
L	M	N	O	P
Q	R	S	T	U
V	W	X	Y	Z

500,000 000,000 — 400,000 900,000 — 300,000 800,000 — 200,000 700,000 — 100,000 600,000 — 000,000 500,000

000,000 500,000 — 100,000 600,000 — 200,000 700,000 — 300,000 800,000 — 400,000 900,000 — 500,000 000,000

10. METHOD OF READING OF GRIDS:

To give grid reference of a point, first note the letters of the 500,000 and 100,000 squares and put them in this order. Now give the full values of easting. This is obtained by writing the one or two figures of the nearest easting line west of the point followed by the easting of the point measured from this line to the nearest 1/10th or 1/100th of the side of the square. The northing is similarly taken out the same number of figures.

It may be noted that by using all the figures of the full co-ordinates, the use of letters may be dispensed with.Such large figures are likely to give rise of errors.

It is sometimes the practice to omit one or both the letters in a map reference without giving the full co-ordinates. The practice is however dangerous and may give rise to ambigmity.

A two letter grid reference on a yard grid repeats itself in the same grid every 25,00,000 yards (About 1500 miles) There is therefore little danger of ambiguity.

One letter grid reference repeat themselves in the same grid every 500,000 yards (about 300 miles) while references containing no letters repeat themselves every 100,000 yards (about 60 miles). Where however two grids meet, it may easily happen that;identical references on different grids occur very much closer than the above.

In laying out new grids for India and adjacent countries, lettering on adjoining grids has been arranged so that identical references shall be as far as possible. Even so, repetition may occur as close as 900 miles for a two letter reference and 150 for one letter reference. If no letters at all are used identical references may befound just across the grid junction line a few miles away. It is therefore always necessary to use letters as well as figures in the vicinity of a grid junction.

11. JUNCTION BETWEEN GRIDS:

A system of "butt junctions" between grids is now being used on all gridded maps published in Pakistan and India. A line is chosen along which the change from one grid to another is to be made. Both grids are then cut off along this line and placed togehter forming "but joint". All co-ordinates, map references etc. on one side of this junction line will be in terms of one grid; while as soon as this line is crossed, they will be in terms of other grid.

Contd..7.

NOTE — D

The grid bearing is the angle between grid North and that line joining two points which appear ~~straight~~ straight on the projection.

Certain technical troops of army such as Survey and Artillery, may, to preserve continuity temporarily extend their work interms of one grid beyond the junction line.

The factors regarding the selection of a particular junction line are

(i) Tactical

(ii) Technical, and are following :-

Tactical:- It is inconvenient to break from one system of co-ordinates to another in the middle of the battle.

Technical:- A change of grids is likely to lead mistakes in map references by careless map readers, so junction lines should be selected which will enable the danger of this to be minimised. Such mistakes as will occur, will probably arise from reading the co-ordinates of a line on the wrong grid.

Other factors are also to be considered.-

(a) There should be as much "stagger" as possible between lines meeting on opposite sides of it.

(b) Junction line should be along the edge of the sheets rather than the middle, so that the whole of the sheet is on the same grid.

(c) If a junction line be a grid line, it should be a line of the northern or eastern grid so that no south-west corners of squares are cut off on either grid.

(See Diagram XV & XVI)

12. LAYOUT OF INDIAN GRIDS:

An index of layout of old Indian grids has been shown in Diagram IV.). on page 7/1

A series of eight Lambert Grids has been designed to cover the whole of Pakistan, India and Burma. Their origins are as follows :-

Grid	I	-	Lat	32°30'	Long 68°00'
"	IIA	-	"	26°00'	" 74°00'
"	IIB	-	"	26°00'	" 90°00'
"	IIIA	-	"	19°00'	" 80°00'
"	IIIB	-	"	19°00'	" 100°00'
"	IV A	-	"	12°00'	" 80°00'
"	IV B	-	"	12°00'	" 104°00'
"	0	-	"	39°30'	" 68°00'

Contd..8.

NOTE — F

Length of side in grid yards= length in true yards and scale error
Log (Length im Grid yards) = log (Length in true yards) + log scale factor.

Fig-A

Layout and co-ordinate of
500,000 unit grid squars

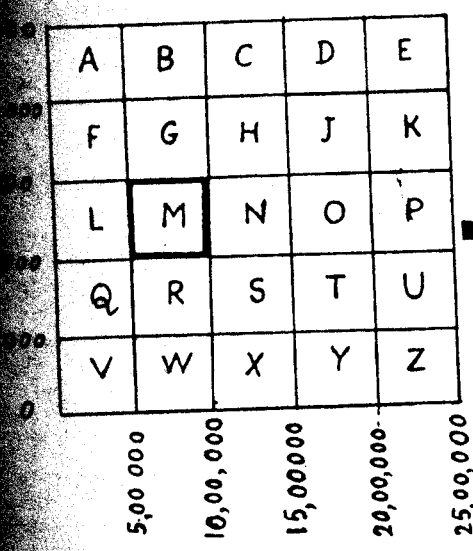
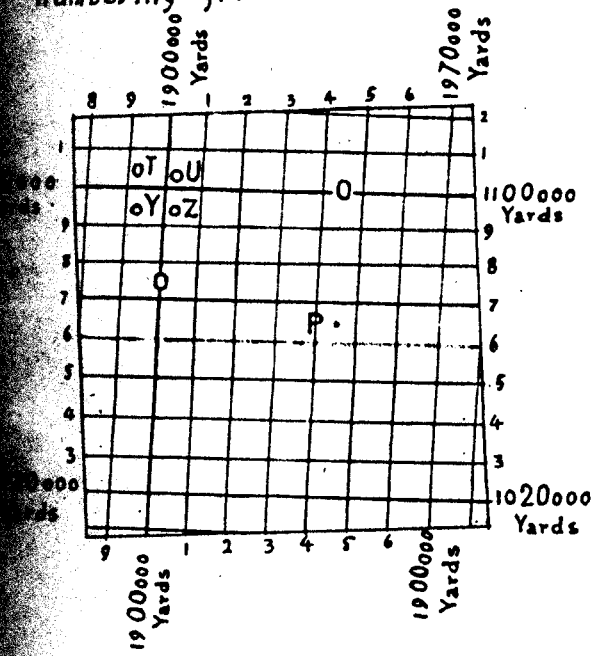


Fig-C

A typical 1/4 inch sheet (H-39-B) illustreating method of lettering and numbering grid lines



Grid reference of point P is oZ 4865 (to nearest 1000 yards)

Fig-B

Layout and co-ordinate of
100,000 squars in 500,000 sq (M)

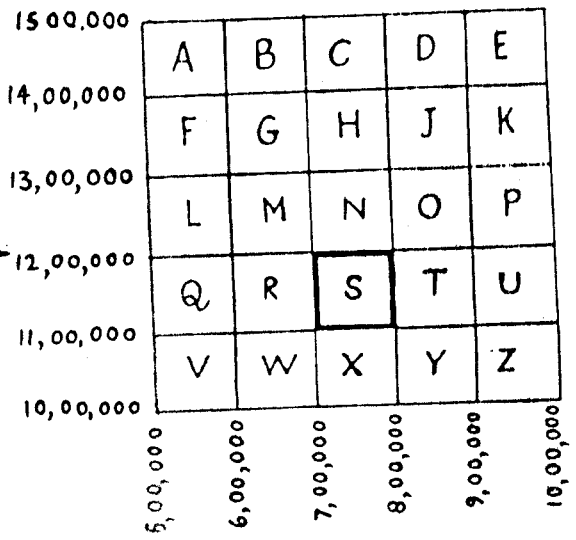
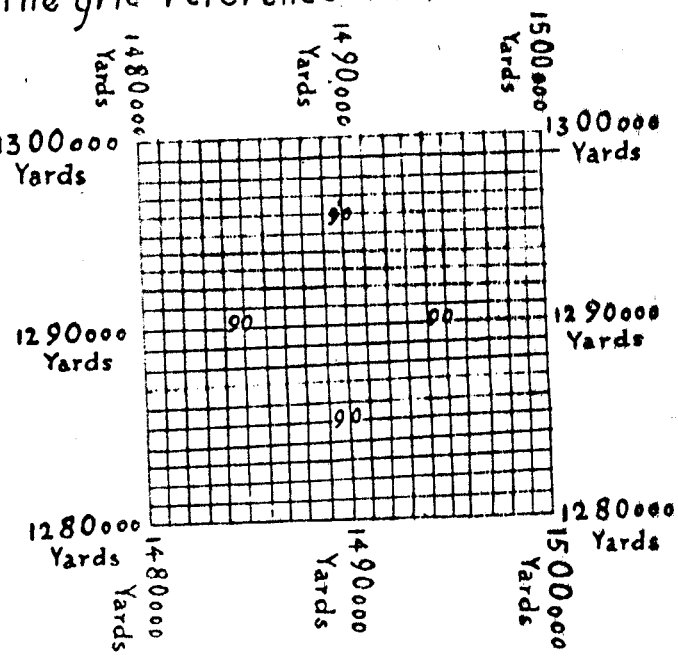


Fig-D

A typical 1/50,000 sheet 50 NP 88
The grid reference of P is NP 943837



Grid reference of point P is NP 043837 (to nearest 100 yards)

NOTE — E

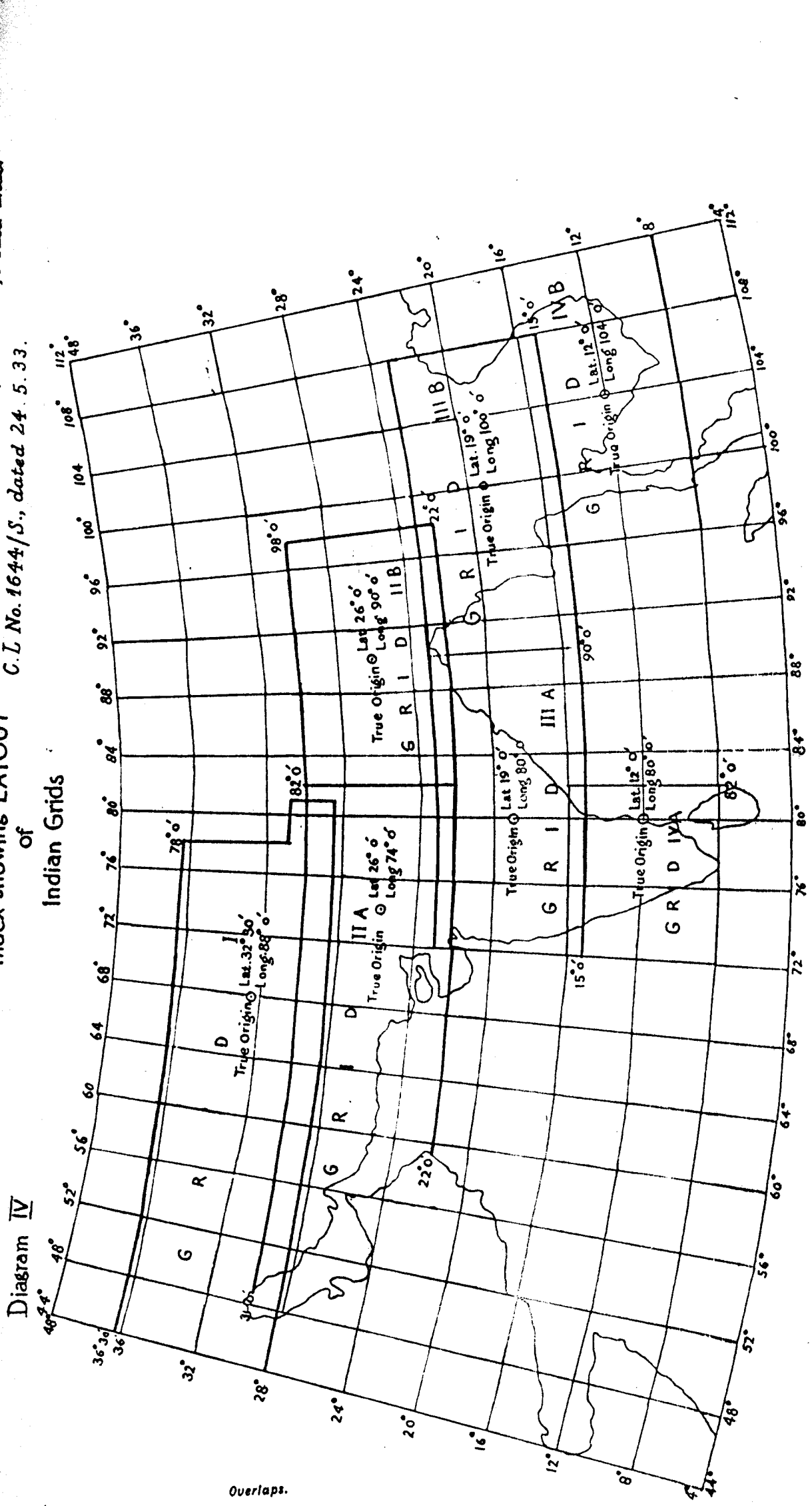
Grid bearings and true bearings are reconed clock wise from Grid North and True-North respectively. Azimuths are reconed clock wise from True-South.

Selection of the actual grid to be used, consult the index

Index showing LAYOUT of Indian Grids

showing limits of Grid Zones in peace times, issued under C.L No. 1644/S., dated 24. 5. 33.

Diagram IV



Overlaps.

The limit of 8° for the extent in latitude has been imposed by insistence of the R. A. on the scale error's not exceeding 1:800. To avoid inconvenience at places near latitudes common to two grids, the origins have been spaced only 7° apart giving an overlap of 1° in which co-ordinates may be expressed in terms of either grid without exceeding the 1:800 limit. The provision of these overlaps will enable the commander of a moving army to effect the change of maps from one grid to another for large portions of his force simultaneously.

7/1

It will be seen that the grids designated by the same number but with a different letter have origins on the same latitude; and the data for both 'A' and 'B' grids will be found in the same table.

The limits to which each grid may be extended are governed only by the inconveniences of a large scale error, if the extent in latitude is excessive, extension in longitude renders conversion difficult or inaccurate unless table of 8 figure logarithms are available, and the map users will probably complain of the awkwardness of a large convergence.

13. CHANGE OF GRID JUNCTION:

In partial modification of the Layout of Indian grid junction mentioned para 12 above and as shown in diagram IV, some changes of the grid junctions falling both in East and West Pakistan have been made vide Surveyor General of Pakistan's No. 7064/42-A-13, dated 3/11/51 (copy enclosed as appendix A) and No. 8423/42-A-3, dated 25/12/51 (copy enclosed as appendix B).

Necessary changes mentioned thereon have been shown in diagrams XIII, XIV.

14. APPEARANCE OF GRID LETTERS AND FIGURES ON MAPS:

The following are the main orders regulating the appearance of grid letters and figures on maps published by the Survey of Pakistan:-

(a) All gridded maps must have a "Grid Box" in the footnote or margins to explain how to read a grid reference. (See Figure A diagram V).

(b)(i) Both grid letters must appear somewhere in the body of all gridded maps so that they may be found even if the headings and footnotes have been cut off. (See Figure E & F of diagram V).

(ii) Where the corners of 100,000 unit squares appear in a sheet, the letters for each square will be put on the corners.

(iii) Where only a line between two 100,000 squares appears the letters will be close to it on opposite sides near the centre of the line.

Contd..9.

(iv) Where no 100,000 line appears the letters will appear near the middle of the sheet.

(v) Where a 100,000 unit line meets a grid junction line, grid letters will appear in both the corners thus formed and also opposite the end of the 100,000 unit line.

(c) Brackets need not normally be used for the 500,000 square letter; the exception being when it is alone and not in conjunction with a 100,000 letter.

(d) Every tenth grid line will have its co-ordinates from the false origin given in full, and two full values will be given on each side of the sheet.

(e) Figures relating to the grid will be in the upright type. In overlap areas where "ticks" of a secondary grid line are shown at the edges of the sheet the figures relating to those will be in the sloping type. No letters of the 2nd grid will be given but the values of every 10th tick will be given in full values will appear on each side of them being in the body of the sheet <u>not</u> border. (See diagram No.7).

(f) A grid junction line will be drawn twice the thickness of the 100,000 lines and appropriate notes such as

"Grid C (meters)"

"Grid B (meters)"

will be entered along it in bold type.

15. COLOURS OF GRID:

As desided in the all grid letters, numbers figures, grid box, and other grid in formations will be in purple. The 'ticks' of secondary grid and their values will be in black Grid Numbers appearing beyond the junction line along the edges of a sheet will appear in black.

16. SCALE ERROR:

The map on which grid lines form perfect squares contains inevitable distortions or errors of scale, the grid squares on the ground are not exactly of 1000 yard side. The squares on the other hand are almost exactly square although at a distance from the centre the outside side will be inevitably smaller than the side nearer the centre. These scale errors are given in the grid tables (Auxilary Table Part V).

Contd..10.

17. GRID CORRECTIONS:

The angle formed by the three points on the ground as measured by a theodolite will be very nearly but not exactly equal to the angle between the straight lines joining them on Lambert's projection or the angle calculated from their grid co-ordinates. The necessary corrections to real or observed directions to reduce them to grid directions are known as grid corrections and are given in grid Tables (Aux.Tables Part).

18. GRID NUMBERS:

A grid number is the numerical value of a grid line indicating the distance of that line from the false origin of the grid. All such numbers are shown in colours in which they should appear on a published map.

19. GRID LAYOUT OF MAPS:

There are two types layout of maps - (i) Spherical and (ii) Grid.

(ii) In which the sheet is bounded by grid lines. This layout is more convenient for medium and large scale maps of limited area.

20. GRID REFERENCE BOX:

It contains instructions for giving grid reference of details by giving reference of a selected point.It appears in the lower margin of maps. This box is printed in black and will be included in the grid plate.(See figure 'A' of diagram V).

21. GRID N O T E:

This is generally given when an overlapping grid are shown in the map and takes the form 'outting points of grid 111B which is in yards have been shown by ticks along the edges of the sheet in sloping type'.(See figure 'D' of diagram V).

22. OVER GRID:

In mapping an area within 25 miles of the junction of two UTM grid zones or the areas normally covered by other grids it is necessary to show an overlapping grid. This overlapping is shown by 'ticks' emanating from the edge in correct delineation. They are printed in black unless otherwise stated or in colours other than normal colours.No letter of the overlapping grid will be given but the value of every 10th tick will be given in full and two full values will appear on each side of them being in the body of the sheet, not border.

22a. SECONDARY GRID:

In some countries like U.S.A.sometimes Areas covered by the present UTM grid system were formally covered by other grid which are termed as "Secondary Grids".The secondary grid usually appears on the sheet.This is a temporary procedure, the purpose of which is to provide a common grid system on companion maps. Secondary grids may be deleted from the maps after all maps from a given area have the UTM grid as the major grid and all geodetic control and other mapping data have been converted to UTM grid co-ordinates.

The secondary grid is shown by inside ticks emanating from the edge of the mosaic in the correct delineation,printed and spaced at 1,000 intervals with the 10,000 unit ticks accentuated in weight.

of them being in the body of the sheet not border.

23. THE DECLINATION DIAGRAM:

(i) This diagram is usually shown in the top of the large scale sheets. It shows the relationship of the magnetic and true north to grid north for the major or main grid at the center of the sheet. Normally the diagram contains three pronges representing magnetic north, true north and grid north. The prong for magnetic north is surmounted by a half arrow or the capital letters "MN", the prong for true north is surmounted by a five point star or capital letters "TN" and the prong for grid north is surmounted by the capital letters "GN". See figure in diagram V.

The angles between the prongs as shown in figure ... in diagram V are usually exaggerated for clarity although approximate relative proportions should be maintained Area correcting the prongs for grid north and magnetic north and grid north and true north are indicated by dashed lines. opposite each are appears the value of the angle. These values appear with the declination diagram on the grid plate.

(ii) Declination Note:- Immediately below the declination diagram appears the declination note (See figure ... in diagram V).

24. CONVERGENCE:

The convergence of Mean grid North with True North is given in Aux. Tables, Part V. This should be extracted to the nearest minute for the central meridian of each sheet on the 1:250,000 and larger scales; and entered in the legend in the north margin on sheets of smaller scale than 1:250,000, this legend will not appear. On a map drawn with grid edges, the convergence and magnetic declination legend will appear thus:

"True North in this sheet is 3° 3' West of mean grid north"

Magnetic Declination about 2° 50' West of mean grid Nortn in 1931.

(Increasing by about 4' annually)

(See figure 'B' in diagrem V).

25. INDEX AND INTERMEDIATE GRID LINE:

(i) The major grid for 1:100,000 and large scale maps is indicated by solid lines at 1000 unit intervals. Each 10,000 unit line is accentuated in weight. The thick line is called the Index line and others are called intermediate lines.

(ii) Where a grid line conicides with the edge of a map, the grid line is omitted. The edge line is then labeled on the grid plate with the values of the omitted grid line.

Contd..12.

mples of Grid reference box

GRID I (Yards)

Grid references are given in thousands of yards East and North of the south-west corners of the lettered squares: thus the grid reference of is
(for grid letters see body of map).

GRID II B (Yards)

Grid references are given in hundreds of yards East and North of the south-west corners of the lettered squares: thus the grid reference of is
(for grid letters see body of map).

mple of Mag. declination ..... Magnetic Variation from True North about 0° 40′ West in 1963.
(Annual Change negligible).

mple of Convergence ..... Mean Grid North, in this sheet, is 0°43′ West of True North.

rid note ..... Cutting points of Grid III A which is in YARDS have been shown by ticks along the edges of the sheet, with values in sloping type

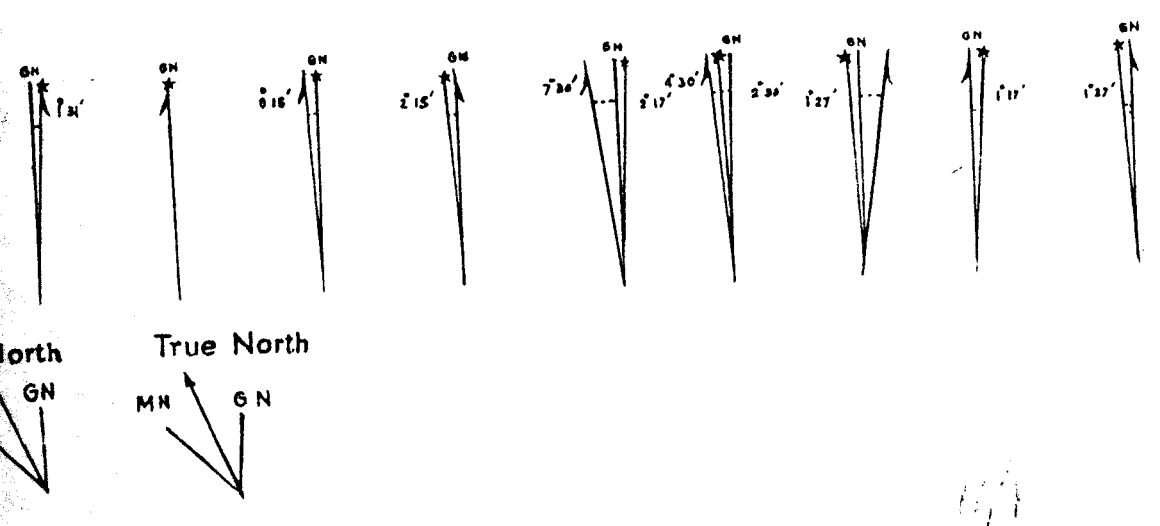
Grid letters (large size) .....

A B C D E F G H J
K L M N O P Q R S
T U V W X Y Z

Grid letters (small size) .....

A B C D E F G H J K L
M N O P Q R S T U V W
X Y Z

Different types of declination diagram



26. SCALE OF DRAWING:

The grid will be drawn on the scale of publication and as such the typing should be sharp, clean and clear as it will have no further scope of improvement after reduction.

27. MAGNETIC VARIATION:

(i) Vide DMP's CO No. I (Professional) 1964, the magnetic variation is shown to the nearest 10 minutes on all topo maps except where there is insufficient magnetic data when it will be shown to the nearest 30 minutes in accordance with para 281 of THB Chapter VI.

(ii) Its value and annual change should be obtained from latest 'Magnetic Variation Chart' or "Isogonic Chart".

(iii) When the "Annual Change" is less/then 5' " Annual Change negligible" should be inserted.

(iv) When the variation is "zero" and there is an annual change the heading should be worded as follows:

"Magnetic Variation from True North about 0° in 1966"

(Increasing by about 6' West/East annually)

(v) This will appear centrally between the longest line of central headings and sheet No.

28. C O R N E R S:

When a separate grid original is prepared, the corners should be inked up in black with ticks 1/4 inch long drawn immediately outside the edge and letters in blue, the following note in blue being made at the foot of the original.

"Reproduce ABCD to dimensions of the outline plate".

29. LINE NUMBERS:

Grid lines will be numbered at intervals along their length, as shown in the diagram VII positions of these numbers may be altered to avoid important detail and typing.

Figures in the body falling nearer the edges than 3/60" and others if necessary will be omitted. The figures '0' and '00' should be entered along these sheet edges which conicide with the meridian of the origin of computation, in such a way that their positions will agree with those of the adjoining sheet.

Contd...13.

219

1:250,000 and larger scale maps will often be folded in small map cases in field. It is, therefore, essential that in every 8"x 8" square of the sheet, there should be at least one set of Northing and Easting grid numbers.

In Survey of Pakistan Maps Canadian System of grid numbering is followed which consists of placing the grid numbers on the body of maps in rows. The grid numbers are placed immediately to the North and East of every thick Northing and Easting grid lines. For detail of grid numbering and lettering please see copy of GSG's No.5300/TI-2, dated 2-5-47 enclosed as Appendix 'C'.

30/ GRID LETTERS:

On the 1/M scale, grid letters will be placed in the centre of the square to which they refer. When a square falls across the edges of two or more adjoining sheets, the letter should be typed in the body of the sheet which contains the largest portion of the square and the borders of other sheets. (See diagram X).

31. ALIGNMENT OF GRID LINES:

Grid figures andletters whether in the body or border of maps, should be typed parallel to the grid lines to which they refer, but typing of spherical values, names etc. will be parallel to the spherical lines and not to grid lines.

32. THICKNESS OF LINE:

Grid lines will be ruled up in black before typing is commenced, and care should be taken that typing is not obscured by them. The fine lines should be drawn as fine as possible consistent with being absolutely continuous and black. The thick lines should be just sufficient thick to give clear contrast with the fine lines; on no account should they be broken for typing other than grid values.

The thickness of junction lines should be doublethe thickness of thick grid lines.

33. FULL CO-ORDINATE VALUES IN BORDERS:

(a) The full Co-ordinate values of thick grid lines will be entered in the borders on all scales except the 1/Million. Where only one thick line or no thick line falls across a border, full co-ordinate values should be added against suitable fine lines near the corners. In cases where the thick grid lines are conicident with the edges of the maps, the full co-ordinate value of the next line will be entered.

Contd...14.

In case where thick grid line does not reach the opposite edge of the sheet but cuts the adjacent edge of the sheet, the full value of the thick grid line will be entered in the border concerned as usual, But in the opposite border where the thick line does not appear the value of the next thin line will also not be entered. (DSG's No. T-11276/44-A-13 dated 6/10/66.)

(b) In the north and south borders full co-ordinate value will be typed to read from South to North where east of the true origin and from North to South where west of the true origin.

(c) The tops and not the bases of all figures should be in the same line.

34. SPHERICAL POSITION TO BE SHOWN ON GRIDDED MAPS:

(i) All grid originals should have spherical ticks of length 1/4-inch long marked in the 4-corners with their values.

(ii) Black ticks, 1/2-inch long, marking the position of intermediate 5 or 15 minutes lines, should be drawn in the margin projecting from the outer edge of the border. Spherical values should be entered in black. These ticks will not appear in the published map, but will be retained on the complete outline plate for the purpose of compiling mapping.

(iii) Before typing it will be necessary to rule lines of latitude across the sheet in blue, to ensure that typing is kept parallel to those and not to grid lines.

35. GRID ORIGINAL TO BE PREPARED SEPARATE:

According to the latest colour policy, the grid is to appear in purple as such a separate grid original will be prepared on publication scale on a blue print of the sheet on drawing paper. Grid should be drawn in black and imprinted in purple.

36. PLOTTING GRIDS ON SMALL SCALE MAPS:

In case where table of Grid is not available, and for all sheets on scale smaller than 1 inch to 1 mile, the the cutting points of the nearest 10,000 yard grid lines (100,000 yard lines in 1/M sheets) will be plotted from the sheet corners from appropriate grid tables.

Contd...15.

37. SHARP DRAWING AND TYPING ESSENTIAL:

Typing and line work on grid originals drawn on scale of publication should be particularly clean and sharp as there will be no reduction of scale to eliminate imperfections.

38. PLOTTING OF GRID LINES:

The following procedure will be adopted for the plotting of grids for 1:50,000 sheets:

(a) If a mosaic is prepared,

i) Project the spherical graticule, subdivide and rule up the 5' lines.

ii) From table 9 Grid plot (by arcs) the distances in yards of the nearest 1,000 yard grid lines in both directions from the four corners of the sheet.

iii) By interpolation in table 9 grid plot the distances of the 1,000 yard grid lines nearest to the 4 internal 5' lines.

iv) Rule up eight grid lines (Four east and West and four north and south), two arcs fixing each of which have been obtained in (ii) & (iii) above.

v) Subdivide between the lines already drawn, for the remaining grid lines.

vi) Check up subdivision for equality along the full length of each side and rule up the remaining lines.

(b) If there is no mosaic, the procedure detailed in sub-para (a) above should be carried out on the fair sheet before the drawing is commenced.

(c) In exceptional cases, owing to inequaliting in the internal graticule lines proceed as in (a)(ii) above: rule up the four grid lines and subdivide for the remaining grid lines instead of plotting them as in (a)(iii).

39. DETAIL PROCEDURE OF GRID LINE DRAWING:

(a) Materials and equipments required:-

i) One piece of drawing paper(130 lb. drawing paper vide para 466 of THB Chapter VI).

ii) Calibrated steel straight edge showing inches and centimeters

Contd...16.

iii) Beam Compass

iv) Engineering scale

v) Ruling Pen

vi) Crowquill Pen

vii) Straight edge

viii) Black ink, Pencil blue and black

ix) Auxiliary Table.

(b) Procedure (See diagram No. VI)

i) First locate the approximate centre of the sheet by means of diagonals .... (Figure 1).

ii) Draw a vertical line V-V' through O and then construct a horizontal line as perpendicular to V-V'. Extend the horizontal and vertical lines to the edge of the sheet. Comparatively more space to be kept at the bottom of the sheet for marginal information...(Figure 2).

iii) Set up beam compass at 1/2 the north-south length of the grid; at map scale strike off arcs A and B from point 'O' on line V-V'.(Fig.3).

iv) Determine the length at map scale of the east west dimension of the grid, and sewing arcs C,D,E, E', A,O and B .... (Figure 4).

v) With the bar beam compass set as it was for step 3, strike off arcs G.G',J.J', from the intersections C and D with line H-H'. The intersectioon of E and G, E' and G', J and F, J' and F' will be corners of the outermost limits of the grid pattern.....(Figure 5).

vi) Connect the corners with straight lines, making sure the lines pass through points A,B,C,D.(Fig.6).

vii) Complete the grid pattern by dividing the large squares into proper number of grid intervals ...(Figure 7).

viii) Test the grid pattern by setting the beam compass and checking the diagonals.(Figure 8).

ix) Assign grid values to the grid lines as as required against .... (Figure 9).

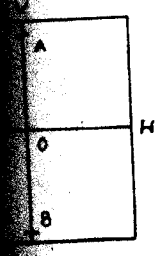
Contd...17.

VII

Detail method of grid drawing

1

2



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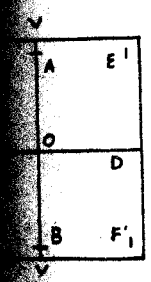

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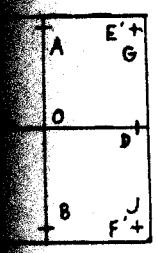

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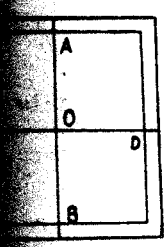

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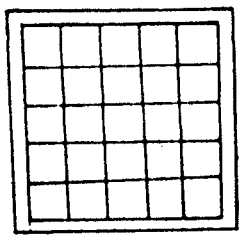

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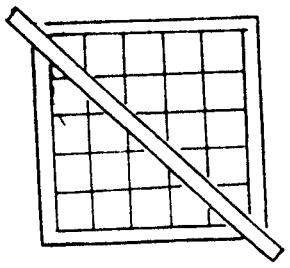

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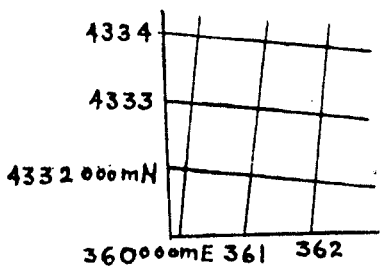

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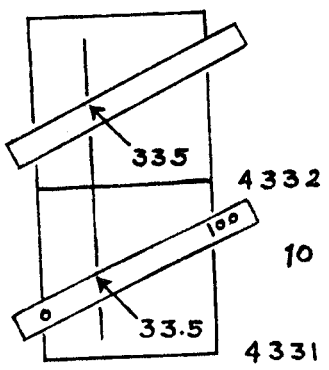

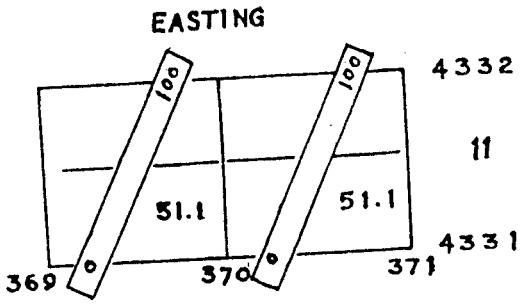

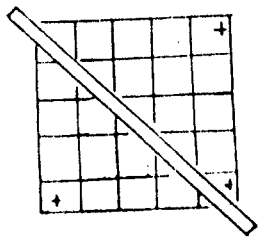

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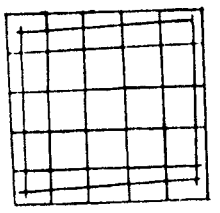

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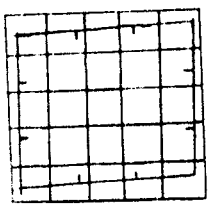

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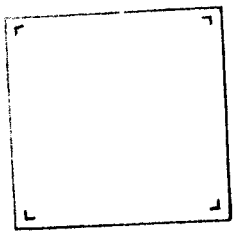

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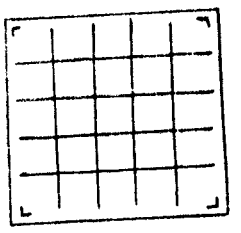

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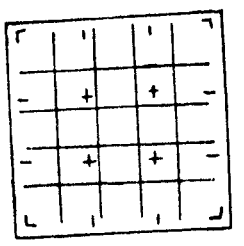


17

x) Plot the 4 corners of the projection and then divide each side into 5' minute intervals. The position of the intersections of the meridians with the limiting north and south parallels is plotted by the following grid co-ordinates obtained either from Auxilary Table Part V or by computation on 14 Mech. (See Appendix D & E).

Inter section of	Eastings	Northings
Corner A	- -	- -
" B	- -	- -
" C	- -	- -
" D	- -	- -

First determine the grid square in which the intersection falls and then plot the corners as shown in Figures 10 and 11.

xi) Connect the 4 corners with a thin blue pencil line .....(Figure 13).

xii) Locate 5' intervals by dividing each side into 3 equal parts .... (Figure 14).

xiii) Ink the registration ticks in 4 corners which will be 1/4 inch long and at right angles ....(Figure 15).

xiv) Ink all grid lines, First thick lines and then other then lines.....(Figure 16).

xv) Ink the projection ticks ...(Figure 17).

40. RE - I S S U E:

Most of the departmental sheet prepared in Survey of Pakistan are 100% gridded ans separate grid BPO already exist. To save time some sheet have been printed with grids in black so while correcting any of such sheets for re-issue, it should be seen that any typing that is fouled by the thick grid lines and their border values are shifted. The duffing out of the grid lines ticks and of the internal spherical lines, and accessory letters and figures will be done in the reproducing office. A separate grid original on the scale of publication should be prepared on a blue print of the outline sheet after it has been corrected for re-issue.

Contd...18.

41. GRID FORMULA:

See Auxilary Table Part V, and the Lambert Tables (grid B and C). Also see 'Notes on how to compute a Lambert or Transverse Mercator Grid' in the computation supplement to THB Chapter VIII and XII, a few simple formula for Lambert Grid are given below:-

Let M = meridian distance of extreme parallel from the central parallel.

m = meridian distance of any parallel from the central parallel.

R = radius of the earth (21 x 10^{0} ft.approx.)

c = normal to the spheroid at the Central parallel, terminated by the minor axis.

o = Latitude of central parallel.

Lo = Longitude of Central meridian.

L = Longitude of any meridian.

S = modified meridional distance.

Then (a) scale error X = $\frac{m^2}{2R^2}$ approx.

(b) Imposed scale error = $\frac{-m^2}{2R^2}$ usually

(c) Modified meridional distance from Central Parallel S = Fo(m ____ $\frac{m^2}{6R^2}$) approx.

Where Fo = Central Scale factor
= 1 - $\frac{m^2}{4R^2}$ usually.

(d) True meridional distance m = $\frac{xR}{3438}$ approx.

(e) Radius of central Parallel = Ro = cot

(f) Radius of any parallel = Ro - Sin.

(g) Chord from Central meridian = 2(Ro-S) Sin c/2

(h) Convergence C = (L-Lo) Sin .

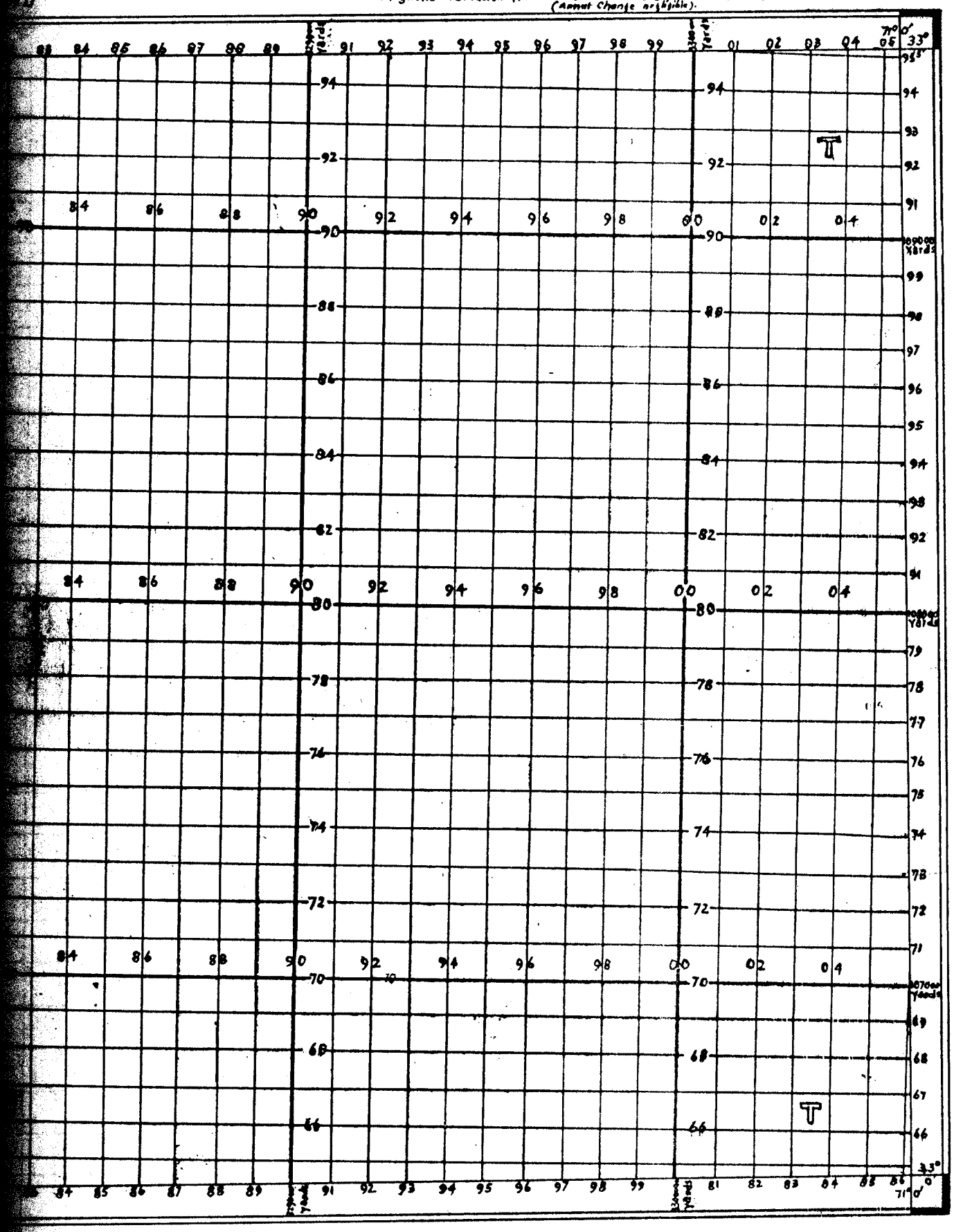
42. SIGNATURE ON GRID ORIGINAL:

The name of Sectional Officers and OC Unit etc. will be written in blue at the lower margin of the sheet but Section Officers and Officer-in-Charge of the Party or Drawing Office will sign in black with dates. As per para 467 of THB Chapter VI, Circle Directors need not sign on the grid original.

Grid I
SHEET No. K/16

Sample 1:-50,000 grided maps

Mean Grid North, in this sheet, is 0° 30′ West of True North.
Magnetic Variation from True North about 1° West in 1946.
(Annual Change negligible).

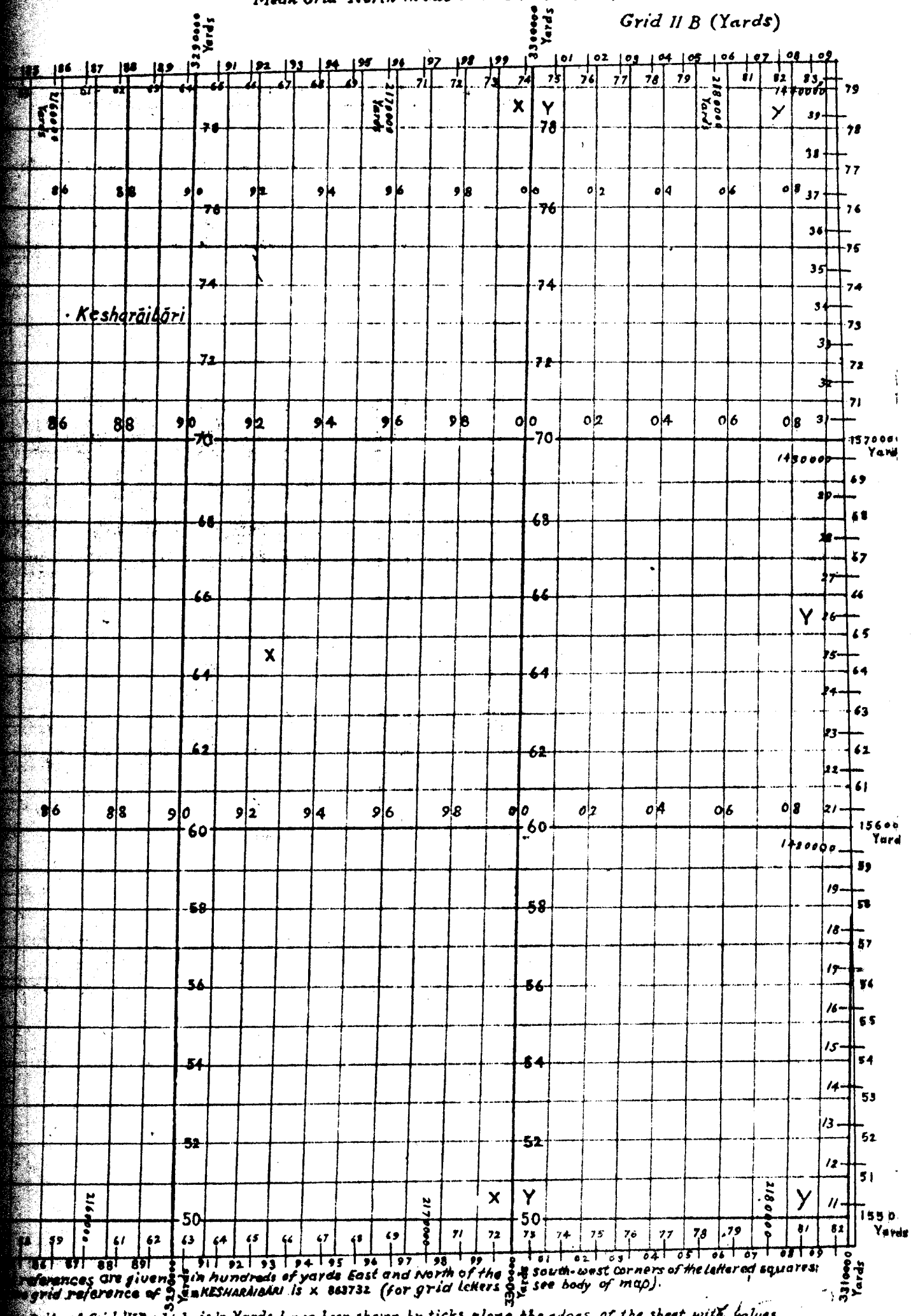


1912

Sheet No. 84 B/II

Sample 1:50,000 grided maps having secondary grid

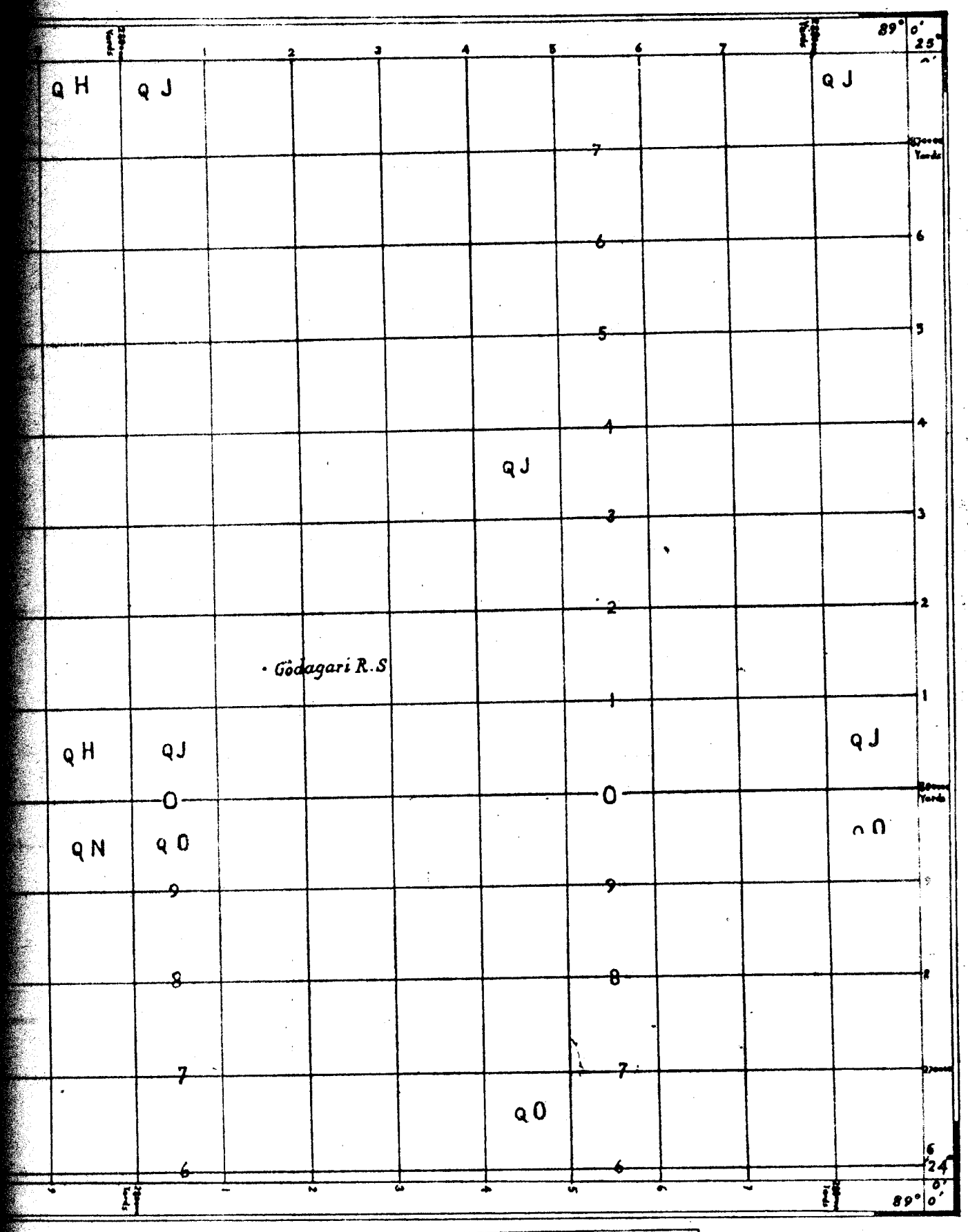
Mean Grid North in this sheet is 1° 09' East of True North



References are given in hundreds of yards East and North of the south-west corners of the lettered squares: e.g. grid reference of KESHARIABARI is x 863732 (for grid letters see body of map).

Points of Grid IIIB which is in Yards have been shown by ticks along the edges of the sheet with values ...ing type. Mean Grid North III B is 2° 22' west of true North.

Sheet No. 78 D

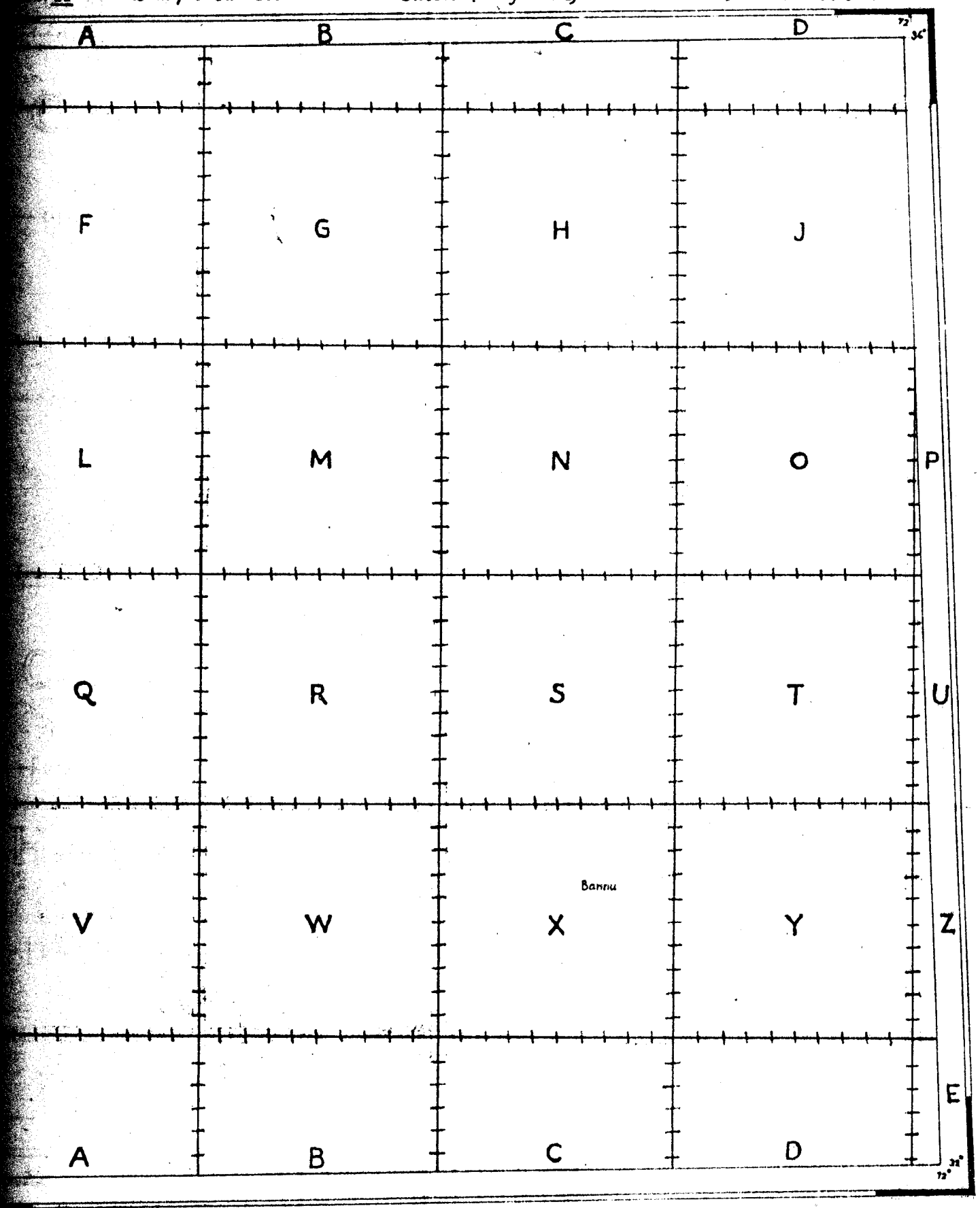


Grid references are given in thousands of yards East and North of the south-west corners of the lettered squares, thus the grid reference of GODAGARI R S is QJ 1614
(for grid letters see body of map).

X Sample One Million Gridded Sheets (Half scale)

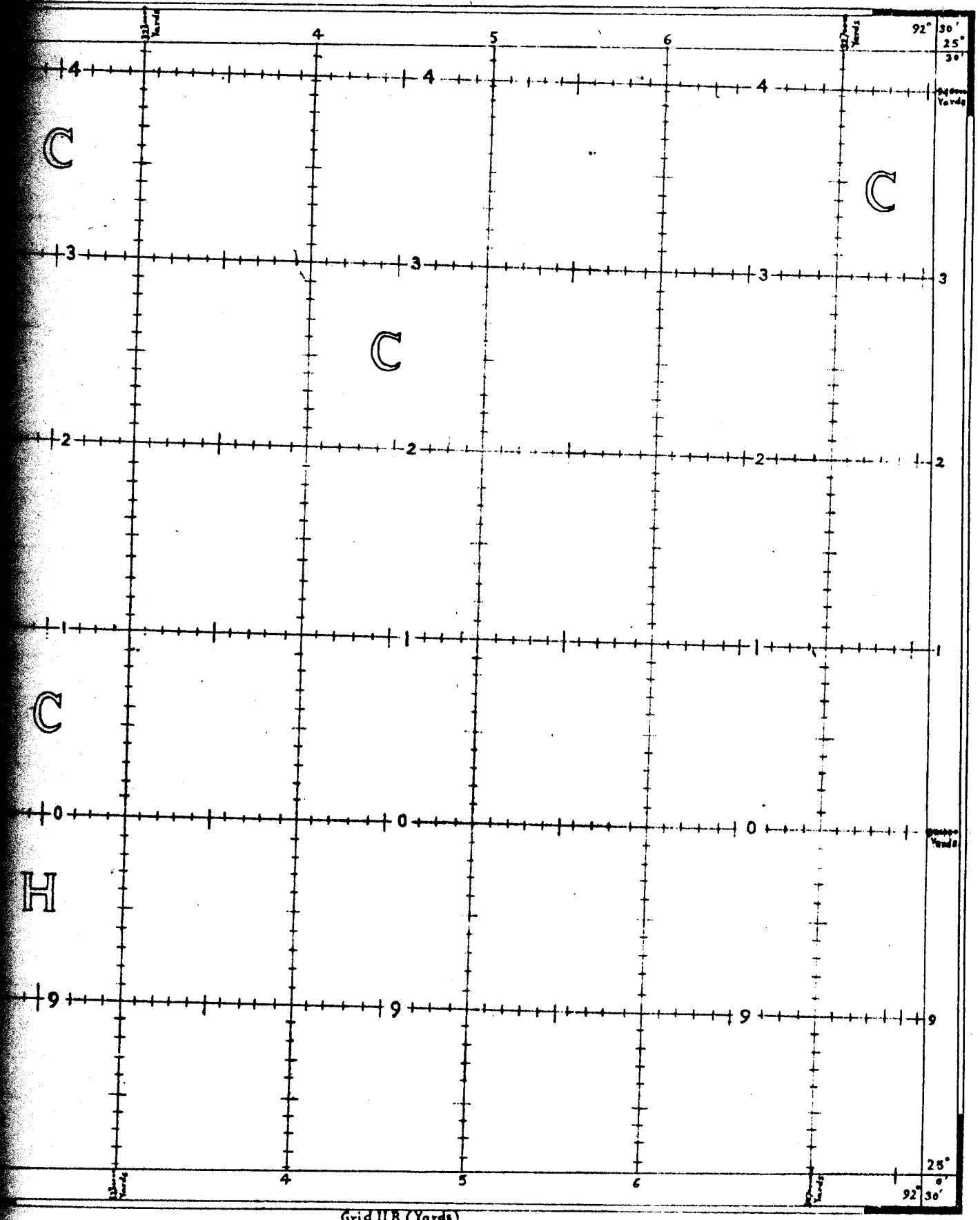
Type No 24

Sheet No. 38



Sample Half in Grided Sheet (half scale)

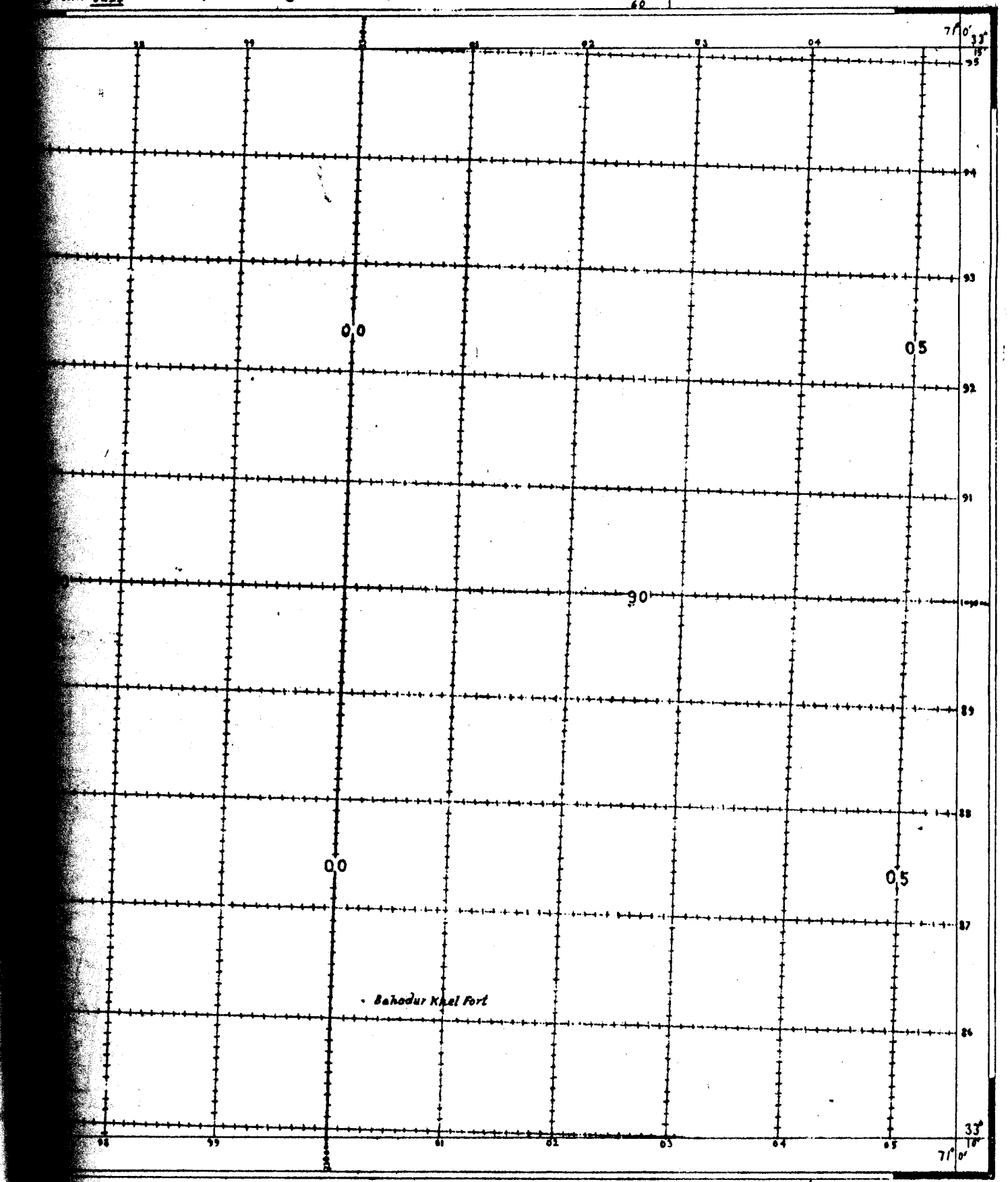
Magnetic Variation from True North about $\frac{3}{4}°$ West in 1946 No.83 $\frac{C}{SW}$



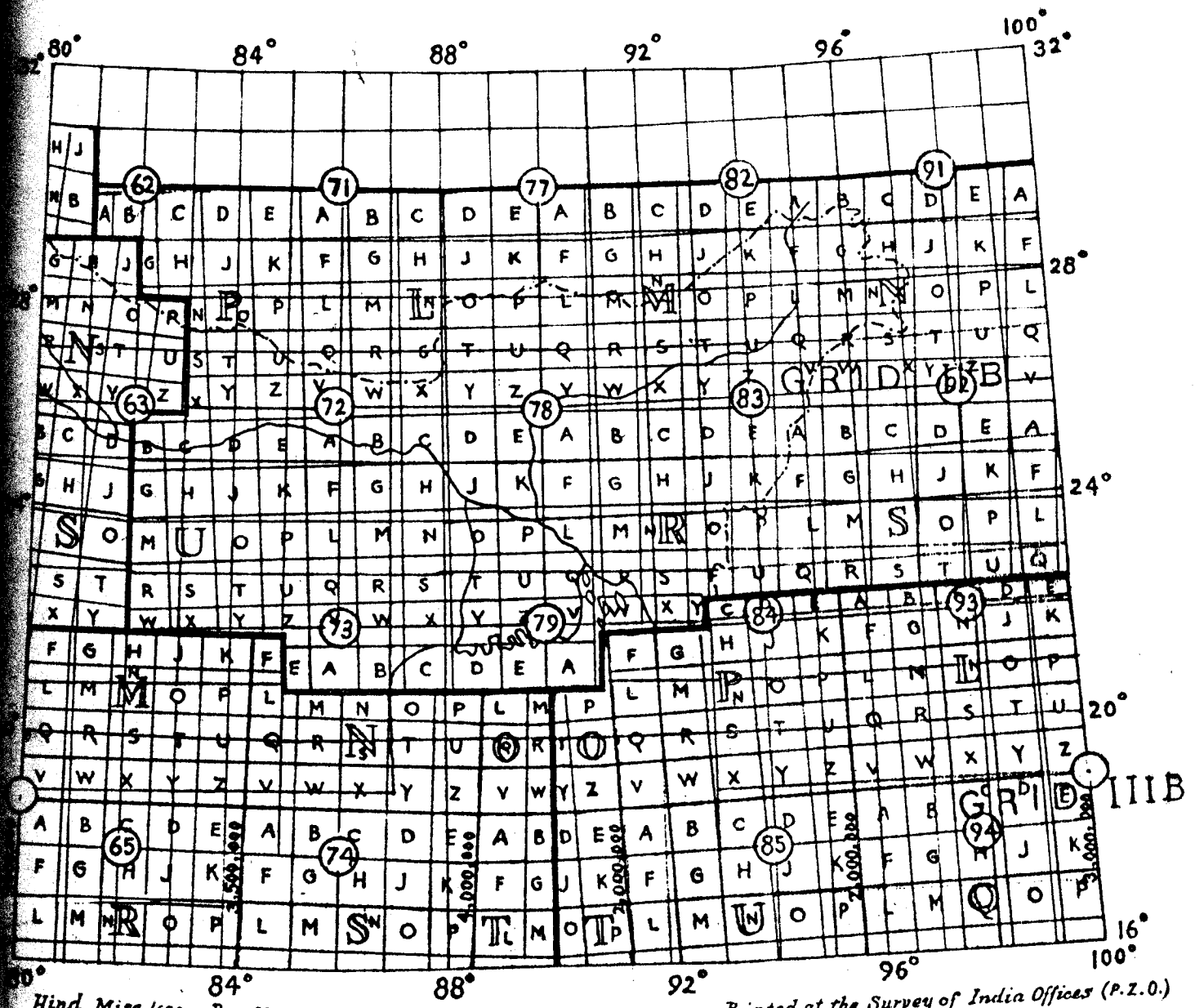
Grid IIB (Yards)

References are given in thousands of yards East and North of the south west corner of the lettered squares; thus the grid
(for grid letters see body of map)

gram XII *Sample Large scale grided sheets*



Indian Grid Junction 2nd Edition



Hind Misc./6780 Reg. No. 1532X. D.D.'44.

Printed at the Survey of India Offices (P.Z.O.)

APPENDIX A

No.7064/42-A-3
Surveyor General's Office
Block No. 40, OMH Lines
Karachi-4, dt. 3/11/51.

From
The Surveyor General of Pakistan.

To
1. The Deputy Director Map Publication,
Survey of Pakistan, Murree.

2. The Deputy Director East Pakistan,
Survey of Pakistan, Comilla.

Sub :- GRID JUNCTION:

In view of the disability of having all the maps of East Pakistan in one grid, it has been decided

(a) Junction of grid II B with III B between longitude 91°E, and 93° E will be at latitude 20°30' north, Above this latitude grid II B will appear in the body of the map.

(b) Maps where grid III B is required to be changed on account of (i) as grid II B, will show the ticks and value of the existing grid in the border of the sheets.

2. A diagram showing the location of this new junction is attached.

Sd/- Mohd. Najmuddin.
For Surveyor General of Pakistan.

Copy to :/ E-inC General HQs., Rawalpindi with reference to his No. 0664/8/EG, dt. 17th Sept.,51.

NOTE — G

Surveyors are primarily concerned with 3 types of computations (a) given the co-ordinates of two points, to find their distances and mutual bearings (b) given the co-ordinates of one point and the distance and bearing from another, to find the co-ordinates of the latter and (c) given the angles and one side of a triangle to find the other two sides.

The simple possible formula for these computations are -

β = bearing = $\tan^{-1} \delta E / \delta N$

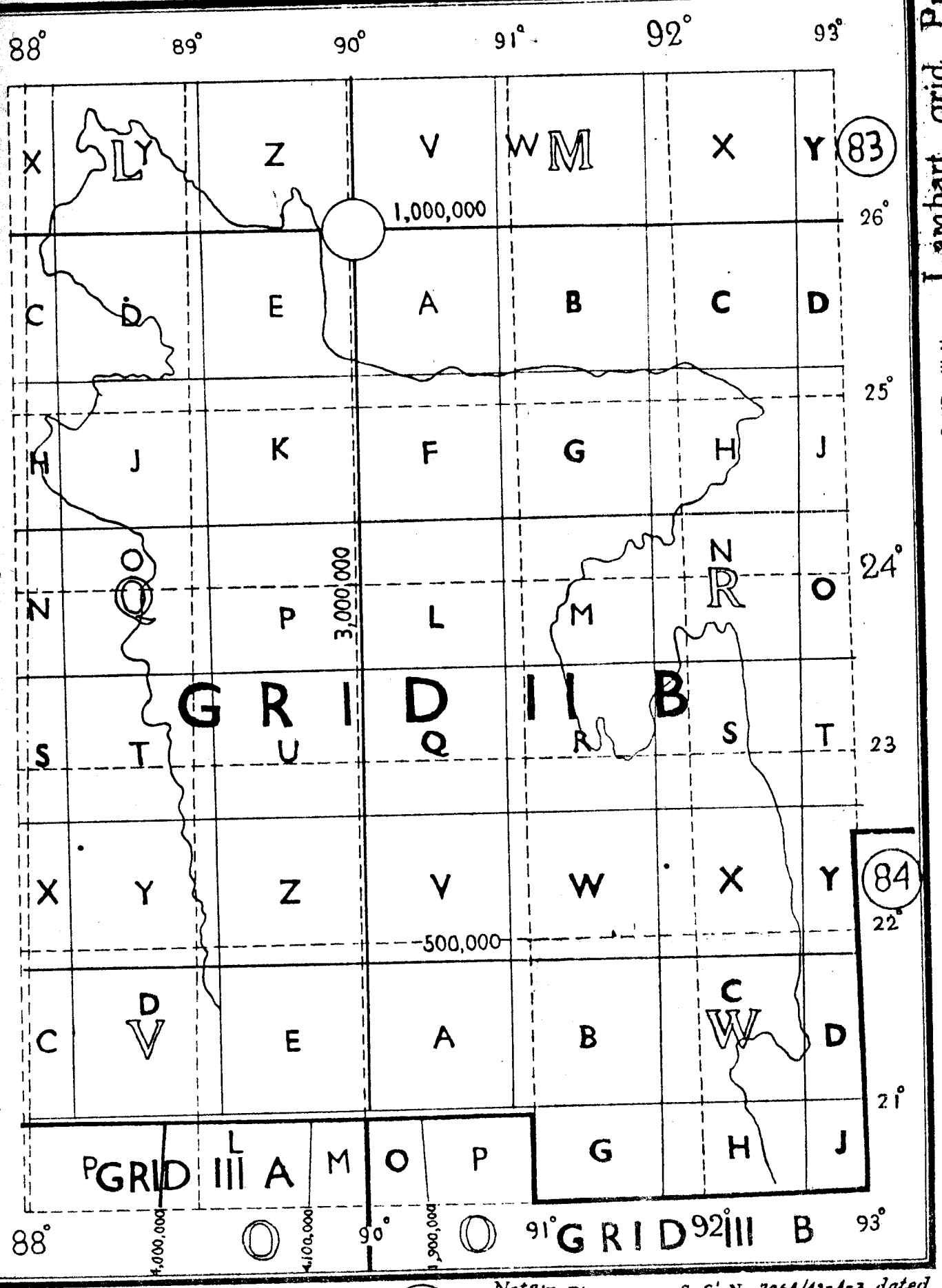
C = distance = $\delta E \operatorname{Cosec} \beta = \delta N \sec B$

$$\frac{\text{Sin A}}{a} = \frac{\text{Sin B}}{b} = \frac{\text{Sin C}}{c}$$

Where δE and δN are difference of eastings and northings respectively.

GRID JUNCTION IN EAST PĀKISTĀN

am XIII



Lambart grid Projection

WORLD POLYCONIC BAND III N.

Grid - projection —

REFERENCES. Origin of Grid II B .....
Latitude 26°-00' Longitude 90°-00'
Grid Junction line .....

Note:- Please see S. G's No. 7064/42-A-3 dated 3.11.51 Appendix 'A' for change of grid junction.

APPENDIX B

Telegram Pak Surveys Survey of Pakistan

Telephone 5511 Ext
5512/16

No.8423/42-A-3
Surveyor General's Office
Block No. 40 GHQ Lines
Karachi-4, the 29 Dec'51.

From
The Surveyor General of Pakistan.

To
The Deputy Director, Map Publication,
Survey of Pakistan, Rawalpindi.

Sub :- GRID JUNCTION:

The undermentioned modifications in the grid junction will be adopted in future.

(a) The junction of grid 'O' with grid I will now be at latitude 37° North.

(b) The junction of grid I with II A between longitude 66° E and 71°E will be at latitude 29° North.

2. Maps where grid O (or I) is required to be changed to grid I (or IIA) will show the ticks and values of the existing grid in the border of the sheet.

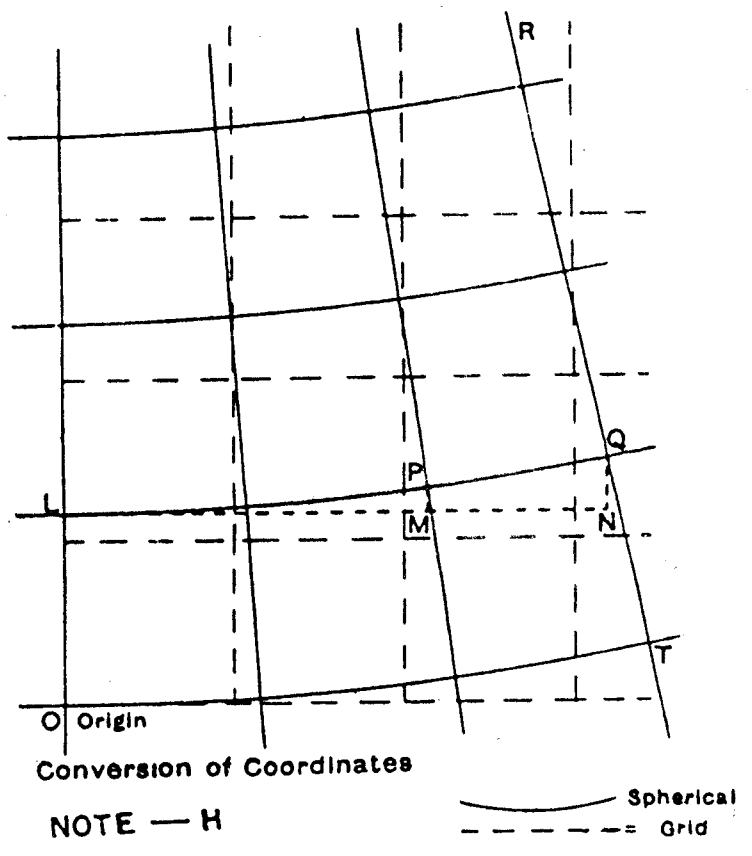
3. An index showing the locations of the new grid junction is attached.

Sd/- S.Q. Hasan,
for Surveyor General of Pakistan.

Copy to :-

1. The E-inC GHQ Rawalpindi with reference to his No. 0664/8/EG,dated 7/11/51.

2. The Deputy Director East Pakistan, Comilla.

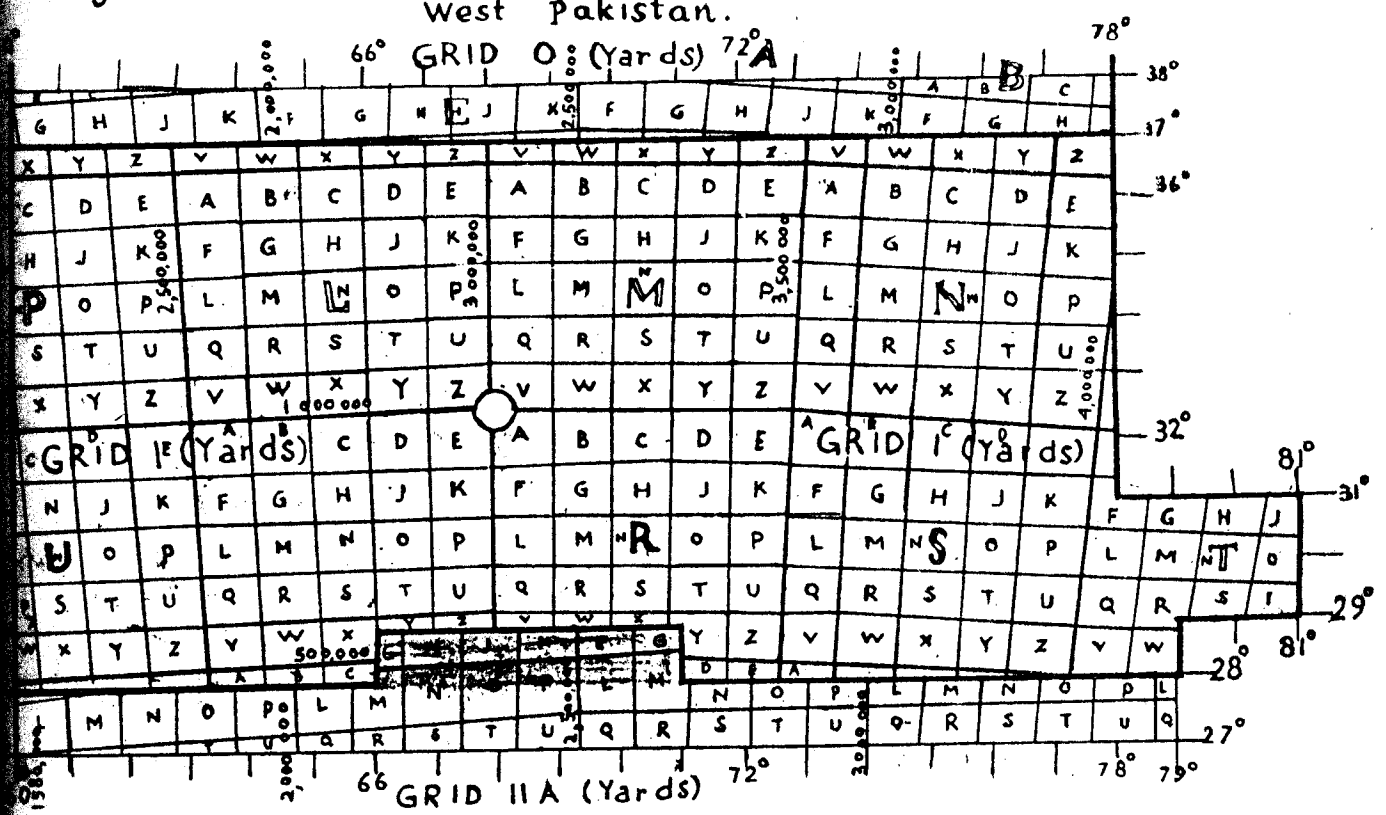


Conversion of Coordinates

NOTE — H

Diagram showing change of Grid Junction and letters

Diagram XIV IN West Pakistan.



References:- *Origin of grid I (Yard)*

{ *Latitude* 30° 30′
{ *Longitude* 88° 0′

Grid junction shown thus ..... ———————

Note:-

Please see S.G's No. 5423/42-A-3 dated 29.12.51 appendix 'B' for change of grid jnnetion.

(COPY)

APPENDIX C

AMENDMENT TO GSGS(India) Dated 27 July, 1944. (Grid Numbering and Lettering).

GSGS No.5300/TI-2 Dated 2 May,'47.

1. Para 2 ADD Maps of 1/4 and larger scales will often be folded in small map cases in the field. It is therefore essential that in every 8" x 8" square of the sheet, there should be at least one set of Northing and Easting Grid Numbers.

2. Delete Para 5 and put instead:

5. The Canadian system of Grid Numbering consists of placing the Grid numbers on the body of the map in rows. The Grid numbers are placed immediately to the North and East of every thick Northing and Easting Grid Lines.

In addition :

On Quarter-inch.

An extra row of numbers is placed along each, 50,000 yd/Metre Grid line.

On Half-inch.

Rows of numbers are placed along each 20,000 Yd/Metre Grid line (i.e. each Northing line corries a number):-

Midway between the 0 and 10,000 Easting line.
20,000 " 30,000
40,000 " 50,000
60,000 " 70,000
80,000 " 90,000

On one-inch.

As the Grid lines are close, only the even thousand grid lines are numbered.

On 1/100,000.

As the grid lines are close,, only the even thousand grid lines are numbered and the numbers are only written along the thick Grid lines bearing even numbered tens of thousands.

On 1/25,000.

An extra row of numbers is placed along each 5,000 Yd/Metre line.

Samples are attached showing how the numbering system is applied to eadh scale. Other scale will be treated in similar style, the test being that there is a row of grid gifures in any 8" x 8" square of the face of the map.

3. Delete para 7 & 8.
4. Re-number para 9,10,11 as, 8 & 9.

Sd/- JFF Lathbury,
Lt Col RE
for D. Survey. India Command.

Distributions:

(1/2", 1" and 1/25,000) Would recipents kindly add the extra rows of grid numbers to the samples already forwarded so as to make them agree with above text.

D.Mil.Survey, War Office etc. etc. ---------

Mach.

SURVEY OF PAKISTAN

APPENDIX - D

SECTION COMPANY. DATE

Machine Deduction of Grid Co-ordinates from Spherical

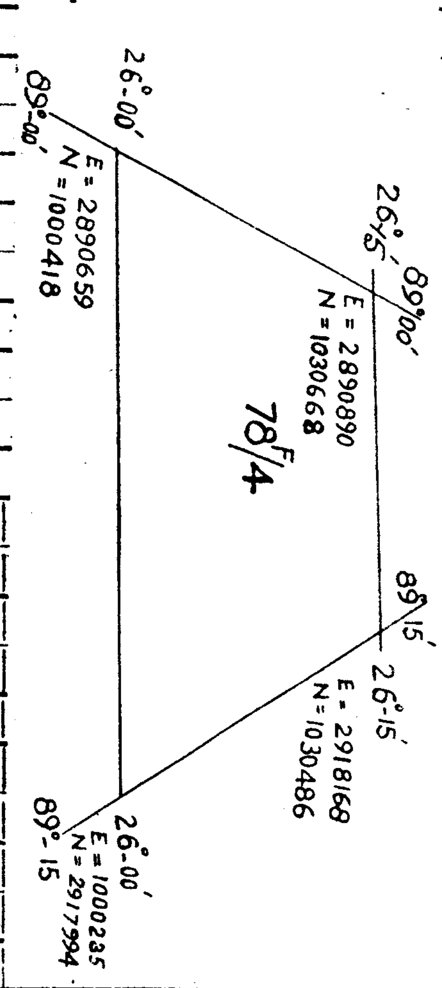
Grid $\begin{cases}\lambda_0 \\ L_0\end{cases}$

Formulæ:— $\begin{cases}(1)\ E_P = E_K\,\Delta L'' + F_E N_{2K} + E_0 \\ (2)\ N_P = N_{1K} + N_{2K}\left(\dfrac{\Delta L''^2}{10^6} + F_N\right)\end{cases}$

SPHEROID

METRES OF YARDS

No.



	Point P				
2	Latitude of P = λ_P	26° 15′ . ″	26° 15′ . ″	26° 00′ . ″	26° 00′ . ″
3	Longitude of P = L_P	89 00 .	89 15 .	89 00 .	89 15 .
4	$\Delta L = L_P - L_0$	−1 00 .	−0 45 .	−1 00 .	−0 45 .
5	$\Delta L''$	− 3 600 ·	− 2 700 ·	− 3 600 ·	− 2 700 ·
6	$(\Delta L'')^2 \times 10^{-6}$	12 · 960	7 · 290	12 · 960	7 · 290
7	F_N for ΔL (i)	+ ·004	+ ·002	+ ·004	+ ·002
8	Sum = line 6 + line 7 = (a)	12 · 964	7 · 292	12 · 964	7 · 292
9	F_E for ΔL_T (i)	+ 2 · 262	+ 1 · 708	+ 2 · 262	+ 1 · 708
10	Interpolation for $(\Delta L - \Delta L_T)$ secs. (i)	− 0·	− 0·	− 0·	− 0·
11	Sum = F_E for ΔL (ii)	− 2 · 262	− 1 · 708	− 2 · 262	− 1 · 708
12	N_{2K} for λ_T (iii)	32 ·20 082	32·20 082	32·26 457	32·26 457
13	Interpolation for $(\lambda_P - \lambda_T)$ secs. (iii)	− ·00 455	− ·00 455	− ·0	− ·0
14	Sum = N_{2K} for λ_P	32·19 627	32·19 627	32·26 457	32·26 457
15	E_K for λ_T (iii)	30 ·292 352	30·292 352	30·352 317	30·352 317
16	Interpolation for $(\lambda_P - \lambda_T)$ secs. (iii)	− ·004 283	− ·0 04 283	− ·0	− ·0
17	Sum = E_K for λ_P	30·288 069	30·288 069	30·352 317	30·352 317
18	$E_K \times \Delta L''$ = (line 17 × line 5)	− 109 037 · 0	− 81 777·8	− 109 268·3	− 81 951·3
19	$N_{2K} \times F_E$ = (line 14 × line 11)	− 72 · 8	− 55·0	− 73·0	− 55·1
20	Sum = E_P	− 109 109 ·8	− 81 832·8	− 109 341·3	− 82 006·4
21	Constant E_0 (to make all Eastings positive)	3 000 000·0	3 000 000·0	3 000 000·0	3 000 000·0
22	Sum = E_P (Easting of P)	2 890 890 ·2	2 918 167 ·2	2 890 658·7	2 917 993·6
23	N_{1K} for λ_T (iii)	1 028 234·2	1 028 234·2	1 000 000·0	1 000 000·0
24	Interpolation for $(\lambda_P - \lambda_T)$ secs. (iii)	+ 2 016 ·8	+ 2 016 ·8	+ .	+ .
25	Sum = N_{1K} for λ_P	1 030 251·0	1 030 251·0	1 000 000·0	1 000 000·0
26	N_{2K} × (a) = (line 14 × line 8)	417·4	234·8	418·3	235·3
27	Sum = N_P (Northing of P)	1 030 668 · 4	1 030 485·8	1 000 418 ·3	1 000 235·3

(i) From Table 10 Grid., ΔL_T is the tabular entry next smaller than ΔL. (ii) Change sign if ΔL (line 4 or 5) is negative. (iii) From Table 1 Grid., λ_T is the tabular entry next smaller than λ_P.

Computed by Sd/ S Salman Date 26/11/66.

Checked by Sd/ N. I. Majumdar Date 26/11/66

Mc No. 331 MB'50-1800.

APPENDIX 'E'

Grid Co-ordinates to the nearest yard of the corners of 30' squares (i.e. of standard 1/2 inch sheets) are given in Aux. table Part V. It will generally be necessary to obtain the grid coordinates of the corners of the 15' square on 1:50,000 scale sheet. In interpolating these values small corrections are necessary and these are tabulated at the end of each table or as under :-

(a) INTERPOLATION FOR 15' CORNERS:

i) For interpolation along a parallel:

If N1, N2, E1, E2 are the tabulated northings and eastings of the corners 15' east and west of the point P; and if $\triangle$ L degrees is the longitude of P minus that of the origin then

$$Np = \frac{N1 + N2}{2} - x$$

$$Ep = \frac{E1 + E2}{2} + 0.009x \times \triangle L$$

ii), For interpolation along a meridian:

If N3, N4, E3, E4 are the tabulated northings and easting of the corners 15' north and south of the Point P; and if $\triangle$ L degrees is the longitudes of P minus that of the origin

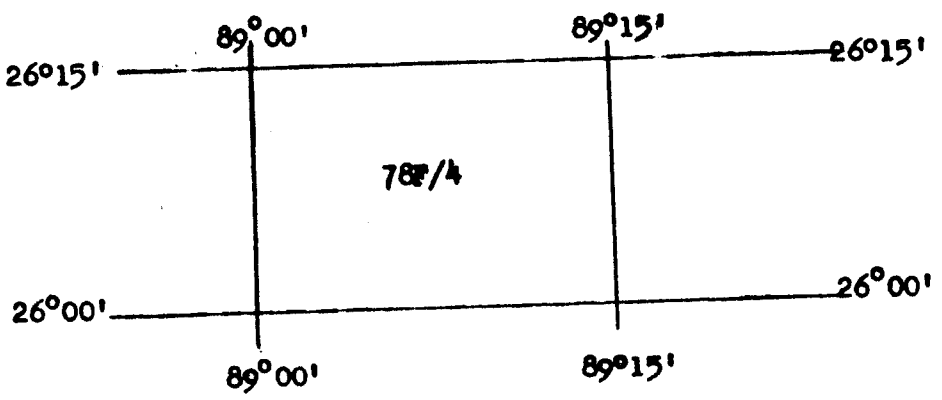
$$Np = \frac{N3 + N4}{2} - y$$

$$Ep = \frac{E3 + E3}{2} - 0.008y \times \triangle L$$

x,y for each latitude are tabulated. If the co-ordinates of the Central Point of a 1/2" sheet must be applied in succession. / are required, both the above sets of formula

Example:-

It is required to find the grid co-ordinates (grid 11 B) of sheet No. 78 F/4 bounded by 26°00 N, 26°15' N, 89° 00' E and 89° 15'



Contd...24.

The following are the tabulated values:-

L / λ	89°00'		x	y
26°00'	E1 2890659 N1 1000418	E 2 2945329 N2 1000104	26	+1
26°30'	N1 2891122 N1 1060920	E 2945560 N 1060607	26	+1

For the point = 26°00', L = 89°15'

$$\triangle L = (89°15' - 90°00) = -0°45' = -0°75$$

$$N5 = \frac{N1 + N2}{2} - x \;,\; E5 = \frac{E1 + E2}{2} + .009x \times \triangle L$$

$$= \frac{1000418 + 1000104}{2} - 26 = \frac{2890659 + 2945329}{2} \times 009 \times 26 \times 0.75$$

$$= 1000261 - 26$$

$$= 1000235 - \qquad = 2917994 \times 0.234 \times -0.75$$

$$= 2917993.825$$

$$= 2917994.$$

It is then necessary to find the co-ordinates of the point $\lambda = 26°30'$ L = 89° 15' although this is not a corner of the required sheet

$$N6 = \frac{N3 + N4}{2} - 26, \qquad E6 = \frac{E3 + E4}{2}$$

$$= \frac{1060920 + 1060607}{2} - 26 \qquad = \frac{2891122 + 2945560}{2}$$

$$+ 0.009 \times 26 \times .75$$

$$= 1060737.5 \qquad = 2918341 - .2515$$

$$= 2918340.75$$

Contd...25.

The following are the tabulated values:-

L / λ	89°00'		x	y
26°00'	E1 2890659 N1 1000418	E 2 2945329 N2 1000104	26	+1
26°30'	N1 2891122 N1 1060920	E 2945560 N 1060607	26	+1

For the point = 26°00', L = 89°15'

$\triangle$ L =(89°15' - 90°00) = -0°45' = -0°75

$$N5 = \frac{N1 + N2}{2} - x \text{ , } E5 = \frac{E1 + E2}{2} + .009x \times \triangle L$$

$$= \frac{1000418 + 1000104}{2} - 26 = \frac{2890659 + 2945329}{2} \times 009 \times 26 \times 0.75$$

= 1000261 - 26

= 1000235 - = 2917994 x 0.234 x -0.75

= 2917993.825

= 2917994.

It is then necessary to find the co-ordinates of the point λ= 26°30' L = 89° 15' although this is not a corner of the required sheet

$$N6 = \frac{N3 + N4}{2} - 26, \qquad E6 = \frac{E3 + E4}{2}$$

$$= \frac{1060920 + 1060607}{2} - 26 \qquad = \frac{2891122 + 2945560}{2}$$

$$+ 0.009 \times 26 \times .75$$

= 1060737.5

= 2918341 - .2515

= 2918340.75

Contd...25.

The point λ = 26°15', L = 89°15' (N7 E7)
may then be found by interpolation along the meridian between these points

$$N_7 = \frac{N5 + N6}{2} - y \qquad E_7 = \frac{E5 + E6}{2} + 009y \times \Delta L$$

$$= \frac{1000235 + 1060738}{2} - 1 \qquad = \frac{2917994 + 2918341}{2}$$

$$= 1030486 \qquad = .009 \times .1 \times -0.75$$

$$= 2918168$$

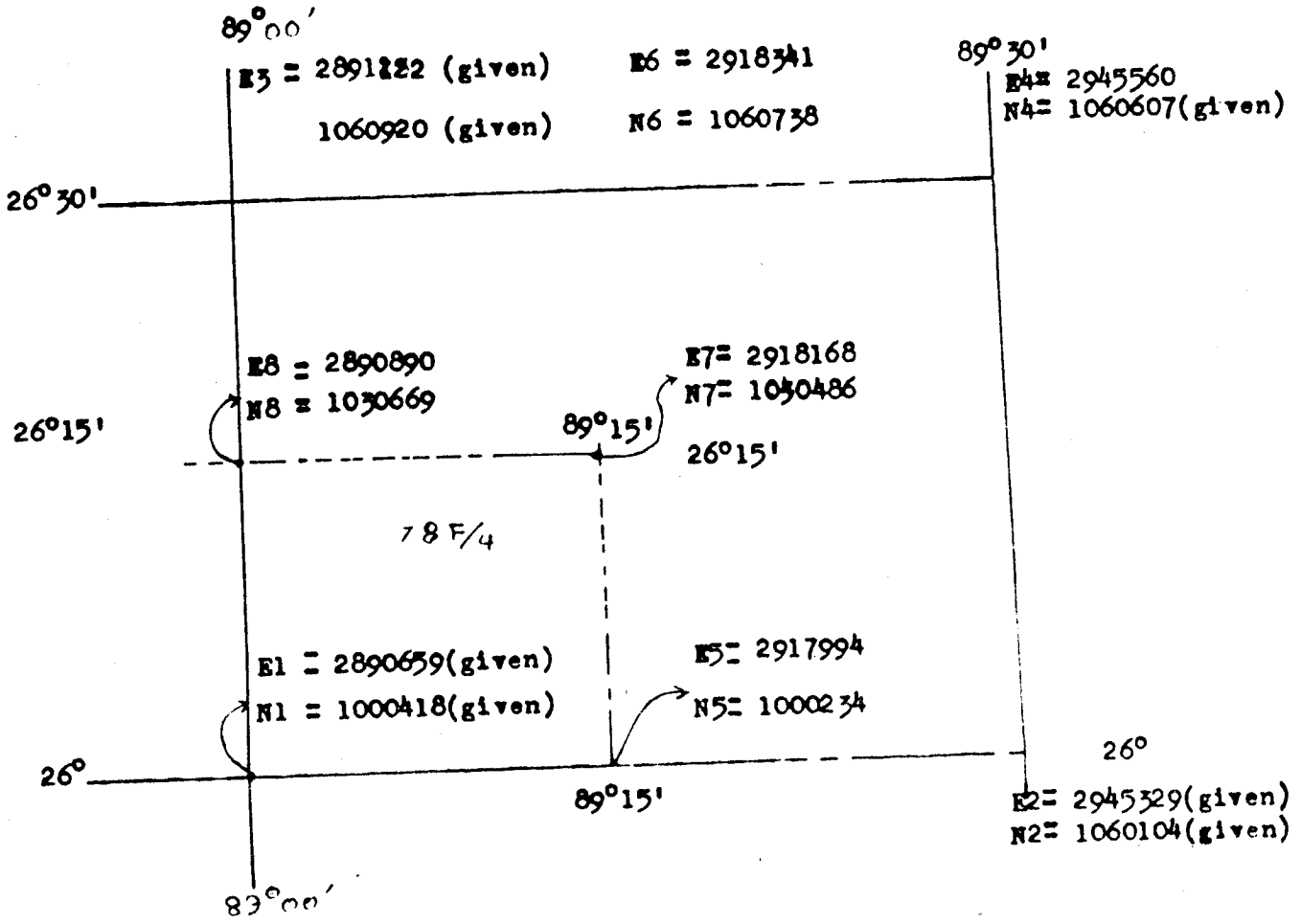
The fourth point λ = 26°15', L = 89°00
can be found out by interpolation along the meridian
L = 89°00'

$$N8 = \frac{N1 + N3}{2} - 1 \qquad E8 = \frac{E1 + E3}{2}$$

$$= \frac{1000418 + 1060920}{2} - ; \qquad = \frac{2890659 + 2891122}{2}$$

$$= 1030669 \qquad = 2890890$$

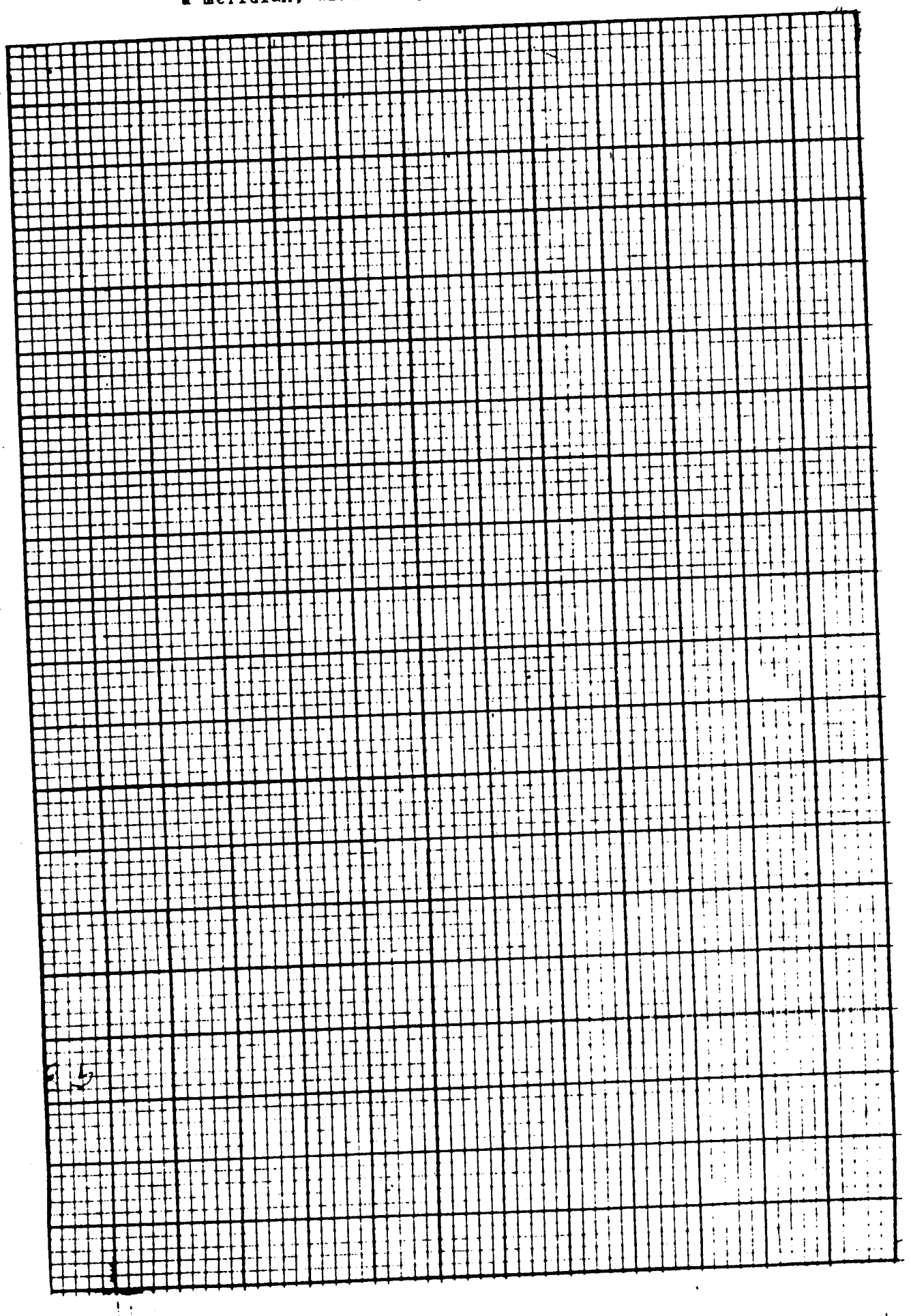
See the co-ordinates below:-



Contd...26.

8C

(b) For interpolation inside 15' square to obtain 5' intersection, it will nearly always be sufficiently accurate to use a direct interpolation. If unusual accuracy is required for large scale work it may necessary to put in the correction for interpolation to northing, along a parallel. For mid point of the 15' parallel the correction is $\frac{x}{4}$, where x is the tabulated value; for either 5' intersection with the parallel, the correction is $\frac{2x}{9}$. The corrections to easting and to northing along a meridian, will always be negligible.



APPENDIX 'F'

SURVEY OF PAKISTAN
DEPUTY SURVEYER GENERAL'S OFFICE
JEJGAON INDUSTRIAL AREA
DACCA 28.

No. I-11276/ 44-A-13. Dated 6th October, 65.

From
S. Q. HASAN, ECQE.,
DEPUTY SURVEYER GENERAL.

To
OC No 2 Do
OC NO 4 party
OC NO 6 party
OC NO 2 ph Office
OC NO 1/2 EPWAPDA Survay party.

Sub:- FULL VALUES OFGRID LINES APPEARING IN THE MARGIN OF SHEETS.

Rules as under already exist for entering grid values in the border of the sheets.

Full coordinate value in borders:

a) The full coordinate values of thick grid lines will be entered in the borders on all scales (except the 1/Million. Where only one thick line falls accross a border, full coordinate values should be added against suitable fine lines near the corners. In cases where the thick grid lines are coincident with the edges of the maps, the full coordinate value of the next line will be entered.

b) In the north and south borders full coordinate values will be typed to read from south to north, where east of the true origin, and from north to south, where west of the origin.

c) The tops, and not the bases, of all figures should be in the same line:

2. The above rules are simply amplified further as follows:

i) Except the portion underlined as at (a) above full grid values against fine lines will not be entered in the border.

ii) In cases where thick grid line does not reach the opposite edge of the sheet but cuts the adjacent edge of the sheet the full values of the thick grid line will be entered in the border concerned as usual. But in the opposite border where the thick line does not appear the value of the nexty thin fine will also not be entered.

Sd/- S.Q. Hasan
DEPUTY SURVEYOR GENERAL
SURVEY OF PAKISTAN, DACCA.

A P P E N D I X - G

THE UNIVERSAL TRANSVERSE MERCATOR GRID

GENERAL

1. DEFINITION

a. A grid is a system of coordinates on the earth's surface expressed in linear units. It is also the system of squares representing the coordinate system on a map.

b. A spheroid is an assumed size and shape of the earth, used for computing geodetic positions.

2. SPHEROIDS

(a) This is designed both for the map user and the map maker. For the benefit of the latter, a brief discussion of the spheroid is inserted at this point, for use especially in connection with the system of reference.

a. So long as calculations are made in E, N coordinates or in terms of distance and bearing, there is no need to know the exact form of the earth. But if it is required, for example, to express a length measured along the Equator as a difference of longitude, then it is necessary to have the length of a degree of longitude at the Equator; this in turn means knowing a, the earth's equatorial radius, since

$$a \div \frac{180}{\pi} = \text{length per degree of equatorial longitude.}$$

In the same way, other conversions require a knowledge of the polar radius b. From a and b can be derived the flattening, f, which is defined by the equation

$$\frac{a - b}{a} = f.$$

The quantities a and f are generally considered to define a spheroid.

Among the spheroids in present use are several for which Transverse Mercator tables are being prepared by the Corps of Engineers. These spheroids, with the accepted values of their dimensions, are listed below :

TABLE 1

Name	a (International meters)	I/F
International	6,378,388,0000	297,000 000
Clarke 1866	6,378,206,4000	294.978 698
Clarke 1880	6,378,249.1450	293.465 000
Everest	6,377,276.3452	300.801 700
Bessel	6,377,397.1550	299.152 813

(b) In Afganistan, India, Pakistan, Burma, Ceylon, Thailand Malay etc Everest spheroid is used.

The fundamental defining parametes of the Everest spheroid are

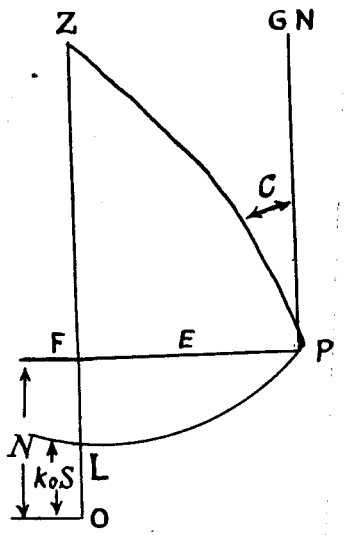
$$\text{Flattening } f = \frac{1}{300.8017}$$

Equatorial semi-axis a = 20,922,931.80 Indian feet which was reduced to meters by considering the relation 1 Indian foot = 0.30479841 meters as exact

Therefore a = 6,377,276.34518 meters

3. NOTATION

The elements of the Transverse Mercator projection are illustrated in Figure 1.



P = the point under consideration

F = the foot of the perpendicular from P to the central meridian

O = the origin

OZ = the central meridian

LP = the parallel of the latitude of P

ZP = the meridian of P

OL = Ko S, the meridional are from the equator

LF = the ordinate of curvature

OF = N, the grid northing

FP = E', the grid distance from the central meridian

GN = Grid north

C = the convergence of the meridians; i.e. the angle at P between true north and grid north

In Figure 1, P represents a point in the northern hemisphere, and east of the central meridian. By inverting the diagram, overturning it, or both, the figure can be made to represent the situation in either hemisphere or on either side of the central meridian.

4. SPECIFICATIONS

The Universal Transverse Mercator grid has the following specifications :

a. Projection : Transverse Mercator (Gauss-Kruger type), in zones 6^{0} wide (See diagram)

b. Spheroid: Clarke 1866 in North America; for other areas see Plate 1.

c. Longitude of origin: Central meridian of each zone.

d. Latitude of origin: O (the Equator)

e. Unit: Meter

f. False northing: 0 meters (10,000,000 for Southern Hemisphere)

g. False easting: 500,000 meters

h. Scale factor at the central meridian : 0.9996

i. Zone numbering : Starting with 1 on the zone from 180 W. to 174 W. and increasing eastward to 60 on the zone from 174 E. to 180 E.

j. Latitude limits of system :

North : 80 N.

South : 80 S.

k. Limits of zones and overlap : The zones are bounded by meridians whose longitudes are multiples of 6° W. or E. of Greenwich. On large-scale maps and in trig lists an overlap of approximately 25 miles on either side of the junction is provided for engineer surveyors and for artillery survey and firing. This overlap is never used, however, in giving a grid reference.

5. POLAR AREAS

In the North and South Polar Stereographic grids will be used. These will extend from the poles to $79^{\circ}30'$ N or $79^{\circ}30'$ S, thus providing a 30' overlap on the Universal Transverse Mercator.

6. CONFORMALITY

The Transverse Mercator is a conformal projection; that is, angles measured on the projection or computed from the grid coordinates closely approximate their true values; at any point length corrections are the same in all directions. Conformality is an important advantage for all users of the numerical values of the grid, whether gunners, surveyors, or mathematicians.

7. GENERAL

The preferred as well as the easiest method for constructing the Transverse Mercator graticule and grid for a map sheet is to plot the grid first, and from this, plot the graticule. The reason for this choice is that the grid is a sample system of squares which is the same, except for position, for all maps at a given scale anywhere. Once it has been constructed, the graticule can be plotted from the coordinates of the intersections of meridians and parallels. When this is done, the graticule will be on the same Transverse Mercator projection as the grid. As compared with the older method of constructing a separate graticule, on its own central meridian, for each sheet, this method gives a true representation of the projection, which is slightly out of scale to true distance at any point. The scale differences, although measurable at the compilation stage while the material is still on a stable medium, are not measurable any longer in the printed sheet since they are masked by the very much larger errors of paper

corners as centers, and these first grid lines may be drawn tangent to each pair of arcs. It is more convenient, however, to measure these distances directly on the graticule neat line; and this is sufficiently accurate provided the declination of the secondary grid from the neat line is not more than 3^{0}. (When the declination is greater than 3^{0}, the distance must be divided by the cosine of the declination and the result measured on the neat line.) By connecting the points, or, as the case may be, the tangents, the large grid rectangle is obtained. The rest of the grid lines are obtained by subdividing this rectangle into the proper number of intervals.

12. MAKE-SIZES

There are two ways of specifying the size at which a sheet should be reproduced. The first, and simplest, can be applied if the grid is shown on the copy for reproduction. It consists simply in giving the make-sizes in terms of the grid rather than the graticule; for example, by putting an exactly ruled grid on the ground-glass of the camera. The final grid is often on a separate drawing; consequently the grid drawing is brought to reproduction size first, and then, using the same camera setting, all other copies are photographed; or else all other copies are photographed to the size of the sheet corner ticks on the reduced image.

A second method is to compute the dimensions of the neat lines by the Pythagorean Theorem, as follows :

a. The length L of any side is expressed by the equation $L = \sqrt{\Delta E^{2} + \Delta N^{2}}$ where ΔE is the difference is easting coordinates, and ΔN is the difference in northing coordinates between the end-points of the side.

b. The lengths thus obtained are the true dimensions of the Transverse Mercator projection based on the central meridian of the grid zone. Due to the properties of this projection, for standard size sheets these lengths of sheet lines will vary within the same latitude band by amounts up to a maximum of 0.03 inches at any standard scale, depending on the distance of the sheet from the central meridian of the zone. However, the grid squares will always remain true squares at the proper size.

--oOo--

APPENDIX H

LAMBERT GRID FOR INDIAN SUB-CONTINENT

The Lambert Rectangular Grid was adopted by Survey of India in 1929 and professional paper No. 26 on Lambert Projection and its application to griddings was revised by removing the theoretical portions and adding the actual practical working of the system for use by those who are concerned with this side of survey.

2. Survey of India, in the begining, desired that all references will be prepared in spherical terms. But, army faced difficulties in gunnery relating to fixing of their batteries, computing their ranges and in finding out directions. Such a system cannot be drawn on a sphere and grid system was then introduced with considerable labour.

3. Seven grid system was introduced with seperate grid origins to cover the whole of the then India and Burma, with a view to accommodate scale factor differing from unity by more than 1:800.

4. Definition of grid : Although a system of equal squares cannot be drawn on the earth's surface, but such a system can easily be drawn on a map whose edges fit together. Such a reference system is called grid and it is named after the projection of the map on which it is drawn.

5. The best reference system is a set of "squares" or rectanges ruled on the map, with reference to which the positions of points are described by ordinary East and West or "X" and "Y" co-ordinates.

6. The system of map references, now, being used in our maps, is that of "Modified British Grid". The reference system, being used, is mainly a set of equal squares drawn on a plane surface but such a system cannot be drawn on a sphere.

7. A Lambert grid consists of equal and perfect squares. But when represented on its own Lambert projection, it will not do so on any other projection. On any other orthomorphic projection small squares will be correctly shaped, but their size will vary from place to place. In particular, when the grid is drawn on the polyconic maps of the Survey of India, which are everywhere very nearly true to scale, the squaree will appear square but they may differ from their reputed sizes by as much as one part in 820.

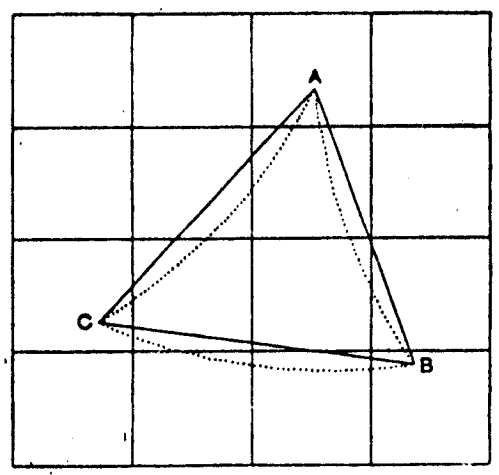
8. For a clear understanding of the Lambert grid it is necessary to be familiar with the Lambert projection. A projection is any orderly system by which the meridians and parallels of the spheraid are represented by straight or curved lines on a plane map.

9. Anyone is at liberty to devise and name any new system which may occur to him, but various well established systems have certain

advantages. From the grid point of view a most important desideratum is that the projection should be orthomorphic; that it to say meridians and parallels should everywhere cut at right angles, and at any point the scale along the meridians should be the same as the scale along the intersecting parallels, so that in any small area, a map on the projection should give an undistorted picture of the earth's surface. It is too much to expect this in large areas, for a plane representation of any considerable part of a spheroid must be distorted. But if the projection is orthomorphic every small area is itself represented without distortion, although different small areas may be at different scale.

9. Computation on the Grid - The Lambert Grid consists of true squares when exhibited on a map drawn on Lambert projection (with the same central parallel). Since the projection is orthomorphic each small grid square will represent an almost perfect square on the ground: but these squares on ground will not all be equal. For if grid squares in the latitude of the standard parallels represent 1,000-yard squares on the ground, it is clear that in central latitudes 1,000-yard grid squares will represent squares with sides of rather more than 1,000 yards, and that beyond the standard parallels they will represent smaller squares. Thus although the squares are called 1,000-yard squares, they are not actually so. They represent thousands of a new unit, a "grid yard", whose length varies with latitude:

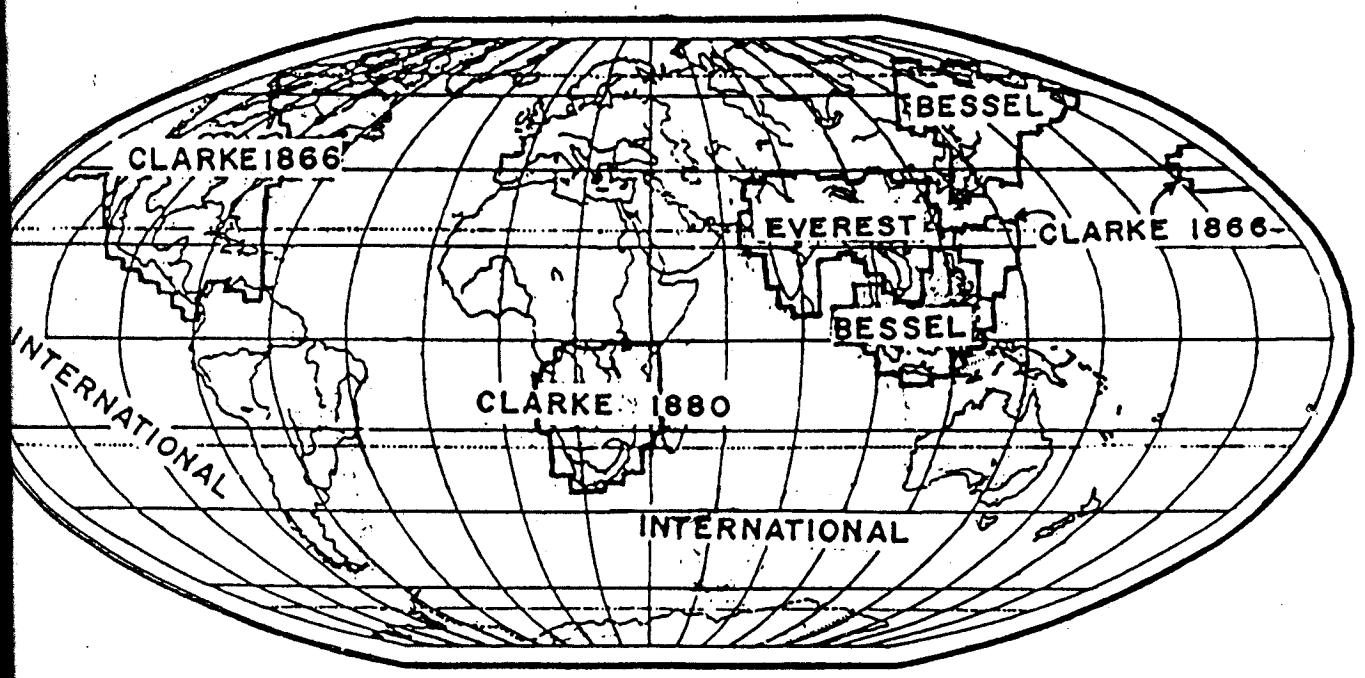
In exactly the same way, a "grid angle" does not exactly equal a true angle. If ABC are three points on the ground, the straight lines (rays of light) joining them from a triangle with certain angles*. If these points and their joining lines are plotted on the projection, the lines which are straight in nature will appear slightly curved, and the triangle formed by the three points as projected will have angles different from those of the real triangle (see fig. 4). If the sides of the triangle are very short, the two triangles are similar, for the projection is orthomorphic; but the orthomorphic property only holds rigorously in a small area, and the ordinary triangles of minor triangulation are large enough for the difference to be appreciable, especially at some distance from the central parallel of the grid.



10. The method of calculating directly in grid terms in this - All measured angles and distances are first converted grid angles and distances and are then deducted to grid co-ordinates and grid distances.

11. For the range of a gun the R.A., need true yards, but they are prepared to neglect an error of 1:800, which is the greatest difference between true and grid yards in an 8^{o} grid.

OJECTIONS COVERING DIFFERENT PARTS OF THE WORLD AS IT STANDS TODAY



43. NOTES ON PROJECTIONS NOW BEING USED IN SURVEY OF PAKISTAN:

(a) SIMPLE CONICAL PROJECTION:

The rules for constructing this projection are as follows (see fig.1):-

Select any parallel QQ (latitude λ_o)passing centrally through the area under consideration. Let PP be the Earth's axis,QR a tangent and QS a normal meeting the axis at R and S respectively. The length of QS (known as ν_o)is required for many purposes,and tables for it exist (Table 1 of the Auxiliary Tables,4th edition). Then the system of the projection is that the parallel QQ is represented by a circle of radius QR ($= \nu_o \cot \lambda_o$). The meridians are represented by the radii of this circle,so spaced that two meridians such as PC and PD separated by a difference of longitude of Δ L are represented on the projection by two radii which include an angle C'R'D' of Δ L sin λ_o. Other parallels are represented by concentric circles separated from the central parallel by their true meridian distances; thus on the projection A'C' equals the true distance AC measured along the Earth's surface. The projection as described above may be represented on a map at any conveniently reduced scale (e.g.,at 1 inch to one mile).

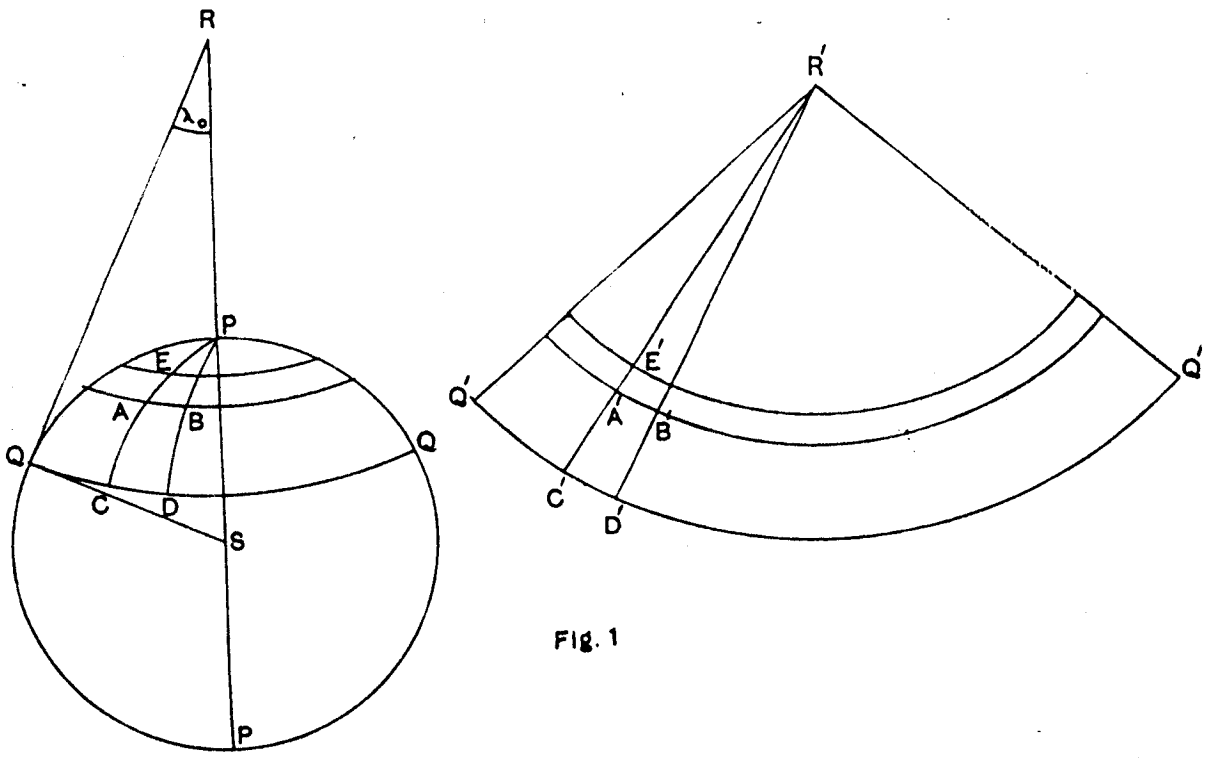


Fig. 1

(b)SIMPLE CONICAL PROJECTION IS NOT ORTHOMORPHIC:

This simple conical projection is not orthomorphic. Whereas north and south lines such as A'C' and B'D' are true to scale,east and west lines such as A'B' are not; all distances such as A'B' are too large on the projection, except those like C'D' on the central parallel,which are correct. The scale error in a east or west direction increases rapidly at a distance from the central parallel,so that the projection is suitable for a belt of small extent in latitude, but of indefinite extent in longitude.

(c)CONICAL ORTHOMORPHIC PROJECTION:

The simple conical projection can be improved in two obvious ways. In the first place it is easily made orthomorphic Instead of making A'C' on the projection equal to the true meridian distance, it is so modified that at any point its scale error is equal to that of the intersecting parallel. Calculation shows that if m is a true meridian distance * from the central parallel,and S is this modified distance,

$$S = m + \frac{m^3}{6 \rho_o \upsilon_o} + \text{smaller terms} \quad \ldots \quad \ldots \qquad (2)$$

where is the radius of curvature of the meridian in the central latitude (see Table II of Auxiliary Tables,4th edition The projection is then orthomorphic.

(d) STANDARD PARALLELS AND LAMBERT CONICAL ORTHOMORPHIC PROJECTION.

The second modification is as follows:- As it stands, the scale is correct on the central parallel,and is too great elsewhere. Suppose the extent of the projection to be such that the scale error is K (e.g.,1:1000) at the extreme edges.Then if the scale of the whole is reduced by ½K (1:2000) the reputed scale remaining unchanged,the scale error in the centre will be 1:2000 too small,at the edges it will be 1:2000 too large,and at two intermediate parallels,called standard parallels it will be correct.The maximum scale error has consequently been halved.

The projection modified as above is called "Lambert's conical orthomorphic projection,with two standard parallels".

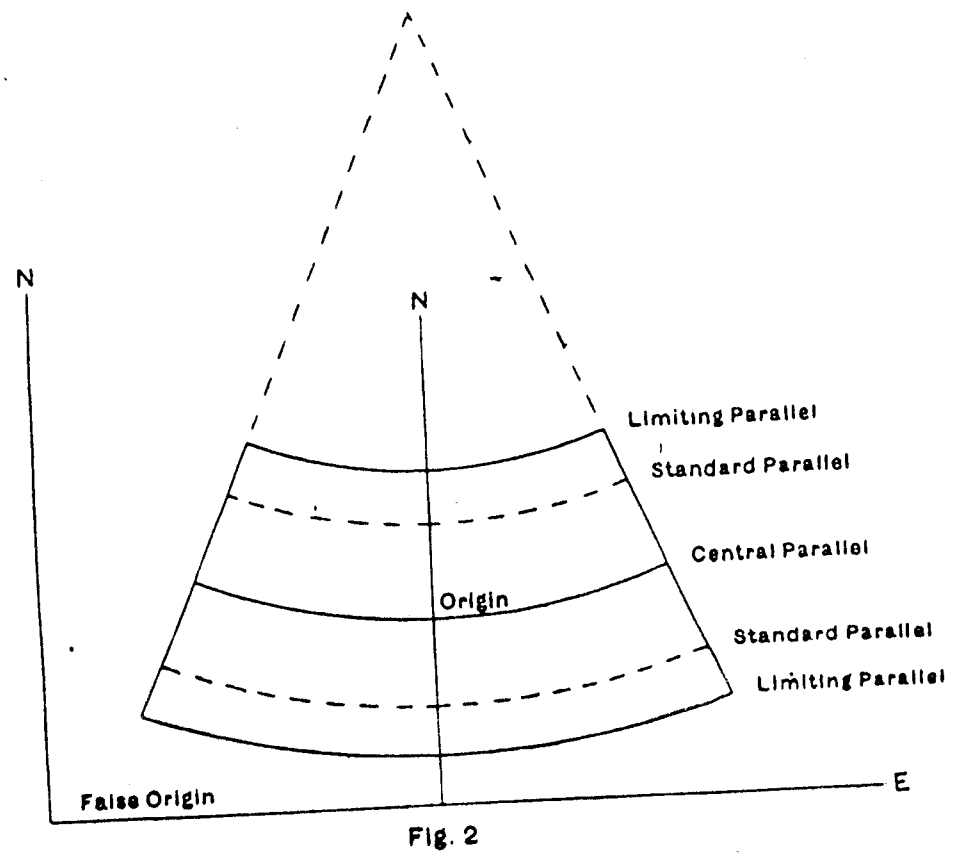


Fig. 2

(e) SCALE ERROR.

Halving the scale error is all to the good, but the utility of the projection is not increased thereby as much as might be thought at first sight. A simple error of scale is a very easy thing to deal with: what inconveniences surveyors is a rapidly changing scale error, with which is associated a narrowing of the area over which the orthomorphic property holds with any specified degree of accuracy. And this trouble is not remedied by the introduction of the two standard parallels.

If this reduction of scale is not employed the scale error in any latitude is

$$(A'E' - AE)/AE \quad \text{(see fig.1)}$$

$$= \frac{A'E'}{AE} - 1$$

$$= \frac{dS}{dm} - 1$$

$$= \frac{m^2}{2\rho_o \upsilon_o} + \text{smaller terms (from (2))}$$

$$= \frac{m^2}{2R^2} \text{ approximately, where R is the Earth's mean radius} \quad \ldots\ldots (3)$$

---

* Positive for a point north of the origin.

If a projection is intended to cover a belt of (say) 8° of latitude, the greatest scale error will be $\frac{(4 \times 69)^2}{2(3960)^2} = 1:412$

Then if an error of - 1:824 is imposed on the whole, the error in the centre will be - 1:824, at the edges it will be + 1:824, and the standard parallels will be in such latitudes that $m^2/2R^2 = 1/824$ or m = 2°.83 north or south of the central paralle.

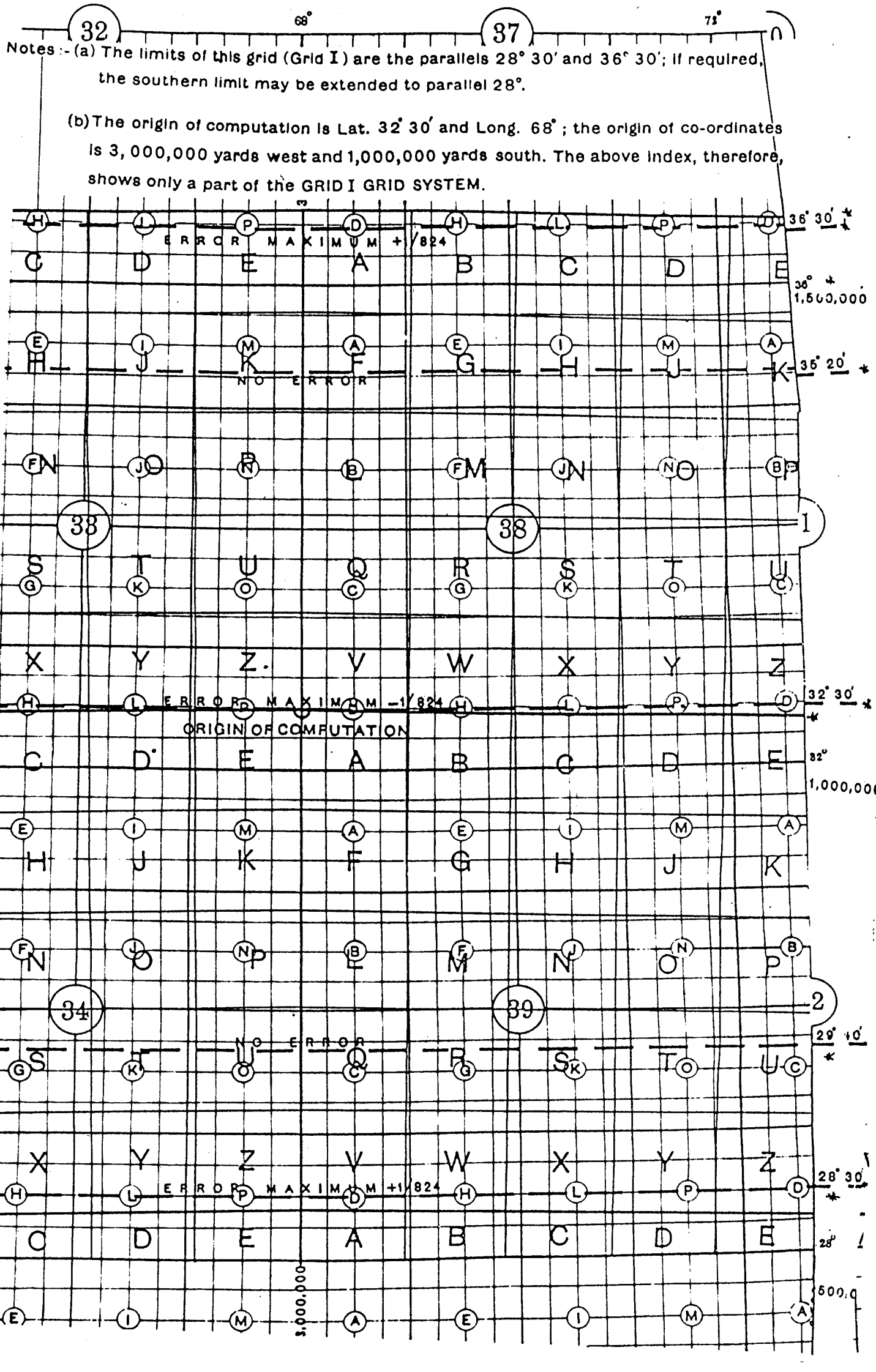
To summarize, it is seen that the Lambert projection is orthomorphic, in central latitudes the scale is too small, and in outer latitudes it is too large."

(f) LIMITTING PARALLELS.

It must be realised that the so-called limiting parallels are not hard and fast limits. The projection and grid can be used beyond these limits, but the scale error increases more and more rapidly as m increases. The limiting parallels are only definite in so far as they mark the point where the scale error is equal and opposite to the central scale error.

APPENDIX I

Index illustrating a part of GRID I GRID SYSTEM (in black) with reference to Survey of India Sheets (in red)



Notes :- (a) The limits of this grid (Grid I) are the parallels 28° 30′ and 36° 30′; if required, the southern limit may be extended to parallel 28°.

(b) The origin of computation is Lat. 32° 30′ and Long. 68° ; the origin of co-ordinates is 3,000,000 yards west and 1,000,000 yards south. The above index, therefore, shows only a part of the GRID I GRID SYSTEM.

APPENDIX J

GUIDE for preparation of GRID ORIGINALS

Note:-(1) In this grid system, a 500,000-yard square is divided into twenty-five 100,000-yard squares and lettered from A to Z (excluding the letter I).
On the millionth scale each of these 100,000-yard squares is shown with sides subdivided into tenths by ticks. On the $\frac{1}{4}$-inch and $\frac{1}{2}$-inch scales these squares are further divided into a hundred 10,000-yard squares and, on the latter scale, shown with sides subdivided into tenths by ticks. On the 1-inch scale each 10,000-yard square is again divided into a hundred 1,000-yard squares. The index above illustrates a part of Grid I; the names of other grids in the system will be notified in due course.

Note:-(2) A grid original will normally be prepared on scale of publication on a 130 lb. d. p. blue print of the complete outline plate. For items to appear on a grid original, for the two thicknesses of grid lines to be used, for figures and letters to be completed in body and border etc., see samples on this guide.
In addition, grid reference footnote and diagram of incidence of grid letters are to be completed, vide specimens on this guide. For this purpose black and blue prints will be supplied for completion appropriate to the sheet concerned. These, with the co-ordinate gauge, the exact positions of which should be marked in blue on the grid original, will be pinned up by P.L.O. before photography.

Note:-(3) The full co-ordinate values of all thick grid lines will be entered in the border on the 1-inch, $\frac{1}{2}$-inch and $\frac{1}{4}$-inch scales. In addition, on the $\frac{1}{2}$-inch and $\frac{1}{4}$-inch scales full co-ordinate values of the fine lines nearest the corners will be entered; but where the value falls less than $1\frac{1}{2}$-inches from the corner, the next line should be selected. On the 1-inch scale, full co-ordinate values of fine lines are not required at corners.

Note:-(4) Letters and figures in the body of the grid should, as far as possible, be placed symmetrically, but their positions may be altered to avoid important detail or to take advantage of an open space. Figures in the body may be omitted where necessary but approximately thirty should appear in the body of each 1-inch sheet. Those in the body falling nearer

Note:-(4) (contd.) the edge than $\frac{3''}{60}$ should be omitted. Thick grid lines should be broken to clear typing or important detail.

Note:-(5) The convergency of Mean Grid North with True North will in future be given in table 44 B of the Auxiliary Tables, but may at present be found on page 48 of Professional Paper No. 26 (Provisional Issue). This convergency must be extracted for the centre meridian of each sheet on all scales to the nearest one minute.

Notes:-(a) The grid name should be entered $\frac{35''}{60}$ clear above the sheet number and $\frac{5''}{60}$ to the west of eastern edge of the sheet, care being taken not to foul the F.O.U.O. note on sheets already published.

(b) The co-ordinate gauge will appear $\frac{8''}{60}$ clear above the grid system name and $\frac{15''}{60}$ east of the extreme border line.

(c) East of the origin of computation, full co-ordinate values in the north and south borders should be typed from south to north, and west of the origin of computation from north to south, all full co-ordinate values should be typed in the direction of the co-ordinate lines to which they refer.

(d) The expression '15 D.O.', etc. means the number given to that particular type in No.1 D.O.'s type list, the numbering in which is the same as that in the Type Table.

(e) Type numbers and dimensions quoted are for scale of publication.

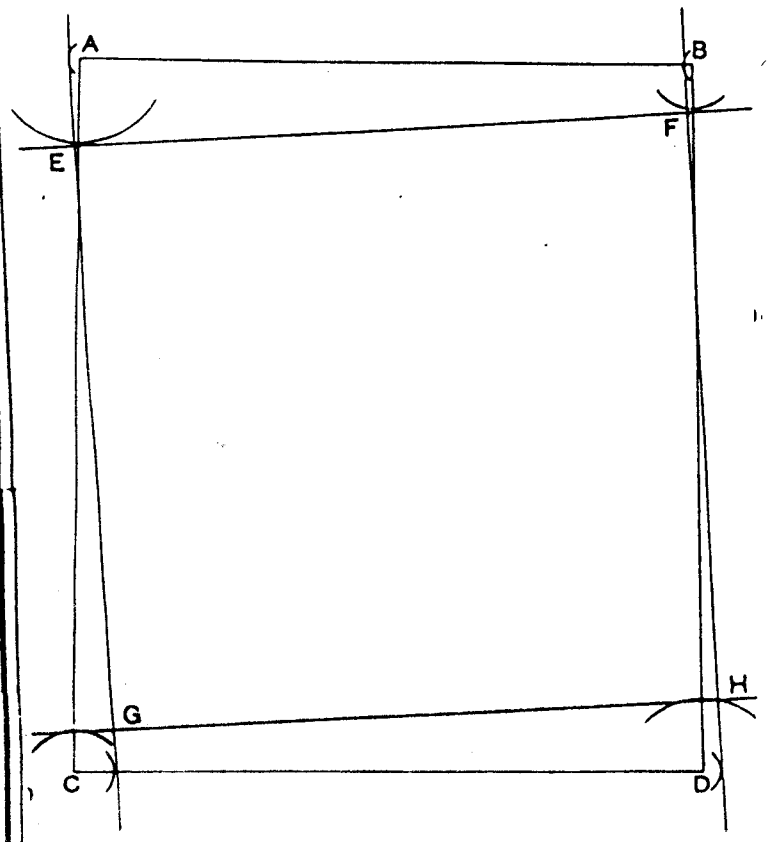
THE LAMBERT GRID FOR INDIA

HOW TO PLOT GRID LINES

APPENDIX K

Case I. When the spherical values of the cutting points of 10,000 yard grid lines with meridians and parallels are available, the cutting points will be plotted from diagonal scales of latitude and longitude drawn in blue on the fair sheet, and the grid completed by joining the cutting points, sub-division being made as required between cutting points.

Case II. When only the grid co-ordinates of the corners of spherical sheets are available the instructions for plotting given below will be followed.



Let A B C D be the graticule of the sheet to be gridded. From the given rectangular co-ordinates of the spherical corners of the sheet, ascertain the grid lines falling closest to each graticule side. Then enter the grid lines as follows. Suppose E G is the grid line to be inserted. With A as centre, and radius equal to the distance of A from the grid line (east or west), describe an arc of a circle. Similarly with C as centre, and radius equal to the distance of C from the same grid line (east or west), describe an arc of a circle. Carefully place a straight edge so as to touch both these arcs of circles simultaneously, and draw the common tangent E G, which is the grid line required. In order to do this accurately, particularly in the case when the two circles lie on opposite sides of their common tangent, as in E G, it is best, first of all, to place the straight edge touching the arcs of circles as above, and to draw two fine dots at the points of contact as nearly as they can be judged by eye. The dots must be exactly on the circumferences of the circles. Then join up the two dots.

In a similar manner, the other grid lines E F, F H and G H are obtained. The right-angular figure E F G H is then sub-divided into the necessary number of squares and the gridding of the sheet completed.

Scale of Map	Class of Grid lines	
	Thick	Fine
1″ Sheets	Multiples of 10,000 yards	Multiples of 1,000 yards
$\frac{1}{2}$″ Sheets	Multiples of 100,000 yards	Multiples of 10,000 yards
$\frac{1}{4}$″ Sheets	Multiples of 100,000 yards	Multiples of 10,000 yards
$\frac{1}{M}$ Sheets	Multiples of 500,000 yards	Multiples of 100,000 yards

A L P H A B E T I C A L INDEX.