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Digitizing Geographic Data with Gridot: A GENERALIZED PROGRAM for DRAWING OVERLAY GRIDS in VARIOUS MAP PROJECTIONS

R. G. Edwards and R. C. Durfee

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Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy $6.00 ; Microfiche $2.25

ORNL/RUS-17

Contract No. W-7405-eng-26

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R. G. Edwards and R. C. Durfee

Regional Environmental Systems Analysis Program
Regional and Urban Studies Department
Energy Division
and
Computer Sciences Division

Work supported by the National Science Foundation RANN
Program under NSF Interagency Agreement No. AAA-R-4-79
and
The Regional Energy Studies Program
Division of Biomedical and Environmental Research
Energy Research and Development Administration

SEPTEMBER 1976

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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FOREWORD

The Regional Environmental Systems Analysis (RESA) Program at ORNL was sponsored by the National Science Foundation from 1971 through 1975. ERDA's Division of Biomedical and Environmental Research is presently continuing portions of the research. The purpose of the program has been to develop and communicate to the planning and management community an improved basis for forecasting the environmental impacts of public and private decisions (such as land use) in order to improve environmental and energy resource management. The research strategy was to develop and validate a hierarchy of computer models to assist in the analysis of relevant, economic, physical, ecological, and social processes in a 16-county region of East Tennessee.

The research was grouped into five major research activities:

1. *Socioeconomic* analysis to develop systematic procedures for forecasting changes in population and employment for a geographic region consisting of an urban core with substantial rural fringes.
2. *Land Use* analysis to develop the basis for spatially allocating regional population and employment forecasts and to determine related land utilization.
3. *Ecological* analysis to develop measures of the burden placed on the ecological system by spatially distributed activities, and the resulting impact on the environmental quality of the system.
4. *Sociopolitical* analysis to describe the impact of decisions on the society of the region and to consider management strategies and political processes of response.
5. *Data Management and Computational Systems* to support the land use and ecological analysis activities.

Although the principal focus of the work is on a 6500-square-mile region in eastern Tennessee, the approach is designed to be applicable to other regions. The work described in this report is one study in the Data Management activity. Other reports being issued in the RESA Program final documentation are listed on the following pages. For a complete list of all documents produced during the entire five-year RESA Program see *Reflections on Regional Environmental Systems Analysis*, ORNL/RUS-26, by C. W. Craven, *et al.*

Activity and Title	Author(s)	Document No.
General		
1. Reflections on Regional Environmental Systems Analysis	C. W. Craven, Jr., et al.	ORNL/RUS-26
Socioeconomic Analysis		
1. Projecting Direct Regional Employment in Export Base Recreation	C. R. Kerley	ORNL/RUS-7
2. MULTIREGION: A Simulation Forecasting Model of Regional (BEA Economic Area) Population and Employment	R. J. Olsen, et al.	ORNL/RUS-25
Land Use Analysis		
1. Some Pitfalls of Land Use Model Building	A. H. Voelker	ORNL/RUS-1
2. A Cell-Based Land Use Model	A. H. Voelker	ORNL/RUS-16
3. Indices, A Technique for Using Large Spatial Data Bases	A. H. Voelker	ORNL/RUS-15
4. A User's Guide to a Subregional Land Use Allocation Model	P. A. Lesslie	ORNL/RUS-13
5. An Application of the Delphi Method to Regional Land Use Forecasting	O. L. Ervin	ORNL/RUS-21
Ecological Analysis		
1. Regional Ecological Studies	D. E. Reichle	ORNL/RUS-24
Sociopolitical Analysis		
1. A Federal Revenue Sharing Model for Tennessee	C. R. Schuller R. A. Hiltunen	ORNL/RUS-10
2. User's Manual for a Program to Forecast Local Political Jurisdictions' Shares from General Revenue Sharing	R. A. Hiltunen C. R. Schuller	ORNL/RUS-4
3. A Public Budget Model to Simulate the Impact of the Construction of Energy Facilities on Local Public Finances	R. A. Hiltunen C. R. Schuller	ORNL/RUS-9
4. Simulation of Political Interaction in Regional Systems	S. L. Yaffee R. A. Hiltunen	ORNL/RUS-23
5. A Generalized Public Budget Analysis	C. R. Schuller	ORNL/RUS-22

Activity and Title	Author(s)	Document No.
Data Management and Computational Systems		
1. Geographical Data Systems		
Part I: Overview and Concepts	R. C. Durfee R. G. Edwards	
Part II: Application to the Environmental Analysis of Strip Mining in Appalachia	R. C. Durfee R. G. Edwards M. J. Ketelle	ORNL/RUS-27
2. Digitizing Geographic Data with GRIDOT: A Generalized Program for Drawing Overlay Grids in Various Map Projections	R. G. Edwards R. C. Durfee	ORNL/RUS-17
3. REGRID: A Generalized Grid-to-Grid Transformation Procedure	R. G. Mashburn R. C. Durfee R. G. Edwards	ORNL/RUS-18
4. CATCH: Computer Assisted Topography, Cartography, and Hypsography - Part I: MAPROJ A Subroutine Package for a Number of Common Map Projections	T. C. Tucker L. J. Campbell	ORNL/TM-3790
5. CATCH: Computer Assisted Topography, Cartography, and Hypsography - Part II: ORGRAT - A General Subroutine for Drawing Graticules	R. L. Stephenson	ORNL/TM-3790
6. CATCH: Computer Assisted Topography, Cartography, and Hypsography - Part III: PERSPX - A Subroutine Package for Perspective and Isometric Drawings	T. C. Tucker	ORNL/TM-3790
7. CATCH: Computer Assisted Topography, Cartography, and Hypsography - Part IV: SEESIJ - A Subroutine Package for Determining the Visibility of Objects throughout a Region	T. C. Tucker	ORNL/TM-3790
8. CELNDX: A Program to Compute Cell Indices	D. L. Wilson	ORNL/RUS-14
9. An Application of the ORRMIS Geographical Digitizing and Information System Using Data from the CARETS Project	C. R. Meyers, Jr. D. L. Wilson R. C. Durfee	ORNL/RUS-12

ACKNOWLEDGMENTS

The authors wish to express their appreciation to T. C. Tucker of the Computer Sciences Division for his development of the various map projection routines[1] and for his involvement with an earlier version of the GRIDOT program. Appreciation is also extended to S. L. Yaffee of the Energy Division, who provided encouragement and program checkout as one of the original users of this version of the GRIDOT program in the Maryland Power Plant Siting Project.

DIGITIZING GEOGRAPHIC DATA WITH GRIDOT: A GENERALIZED PROGRAM FOR DRAWING OVERLAY GRIDS IN VARIOUS MAP PROJECTIONS

R. G. Edwards and R. C. Durfee

ABSTRACT

The GRIDOT computer program draws overlay grids on a Calcomp plotter for use in digitizing information from maps, rectified aerial photographs, and other sources of spatially distributed data. The options of the program facilitate use of the overlays with standard maps and map projections of the continental United States. The overlay grid may be defined as a latitude-longitude grid (geodetic grid), a Universal Transverse Mercator Grid, or one of the standard state-plane coordinate system grids. The map for which the overlay is intended may be in an Albers Equal Area projection, a Lambert Conformal projection, a Polyconic projection, a Transverse Mercator projection, a Universal Transverse Mercator projection, or any of the standard state-plane projections.

1. INTRODUCTION

1.1. Overview of the Use of the Program

Over the past four years the Regional Environmental Systems Analysis (RESA) Program at ORNL has been involved in the study of regional environmental problems. One of the primary goals of this program has been to simulate and analyze the spatial distribution and ecological effects of activities within a region. The analysis has involved the development of a series of regional models which represent socioeconomic, land-use, ecological, and sociopolitical activities. During the design and implementation of these models, it became apparent that large amounts of geographic information had to be collected and manipulated both external and internal to the models. The technique chosen for storing spatially distributed information (e.g., land-use, topography, transportation networks, etc.) was a rectangular array of cells defined by a grid system. Each cell of the study region was assigned values representing the raw variables being measured. This technique was applicable for modeling and statistical analysis, since the investigator could treat the spatial functions in terms of universally defined spatial units.

The most common sources of geographical data are various types of maps (e.g., topographic maps, road maps, land-use maps, soil maps, etc.) and aerial photography. The process of assigning values from these maps to each cell in the grid (usually called digitizing) is greatly aided by having a transparent overlay on which the appropriate grid system has been drawn. In this way the grid system appears to be an additional raster on the map itself. The purpose of the GRIDOT program, discussed in this report, is to produce such overlays using a pen-and-ink plotter (such as a Calcomp plotter).

Because maps are a two-dimensional distorted representation of the three-dimensional spheroidal shape of the earth, there are a variety of commonly used map projections, each minimizing a particular type of distortion. Likewise, there are a variety of coordinate systems, some corresponding to particular map projections, for establishing a grid system to be overlaid on top of a map. Some coordinate systems are measured in feet, others in meters, and still others in degrees of latitude and longitude. The GRIDOT program has been designed so that the common map projections and coordinate systems are available to produce a grid at any map scale. Figure 1 represents a typical grid overlay using a Maryland state-plane projection and coordinate system. Notice that two types of tic marks are drawn on the latitude and longitude borders (latitude tics just inside the border, state-plane tics just outside) so that the overlay may be easily registered on top of the base map. The state of Maryland uses a standard cell numbering scheme which numbers 2,000-ft cells from north to south and west to east, starting at an origin at the extreme northwest corner of the state. The GRIDOT program has cell labeling options which accommodate row and column labelings in various directions and by various increments. The regularly spaced raster of cells is determined by the height and width of the cells, which may be given as (1) latitude-longitude increments in degrees, minutes, seconds, (2) northing-easting increments in meters, or (3) northing-easting increments in feet, whichever is appropriate to the coordinate system being used. The reader unfamiliar with the commonly used terms "northing" and "easting" is referred to Section 3.2 of this report. The current map projections supported are (1) Polyconic, (2) Universal Transverse Mercator (UTM), (3) Albers Equal Area, (4) Lambert Conformal, and (5) state-plane projections (for states in the continental United States).

This report is primarily intended to describe how to use the GRIDOT program with emphasis on the preparation of input cards (Section 4). Several additional sections are included as a further aid to understanding the use of grid systems. These sections are briefly mentioned in the following paragraph.

The plotting of an overlay grid is only the first step in the process of digitizing and storing geographical data. The second step is actually choosing the way in which the data is to be stored, and then transferring it from the map into machine-readable form. This is quite an important step because the storage technique chosen will determine what types of analyses may be performed in the future and to what detail. The recording of the data in machine-readable form will determine labor costs, which can be quite expensive if cumbersome manual techniques are used. Thus a separate section (Section 6) is included to discuss the techniques of digitizing data from grids. For certain types of data, such as geology, there are some efficient ways of coding the data so that the manual effort is kept to a minimum. In addition, a novice user may not be acquainted with or aware of the importance of map projections and map coordinate systems. A large data collection effort in a non-standard coordinate system can render the information virtually useless in the future, when it is to be analyzed (not just mapped) with other data in standard coordinate systems. Thus Section 3, in addition to providing an overview of the program, introduces the reader to the concept of map projections and coordinate systems. Several sample problems are given in Section 2 so that the reader will be acquainted with some of the input options before reading the detailed description in Section 4. The output, both printer and plotter, is discussed in Section 5. Sections 7 and 8 are included for the system analysts who may desire more detail concerning the operation of the program or future improvements that may be added. For example, the capability of plotting a polygonal outline, such as a county boundary, on top of the grid would enable the technician to digitize only information needed for a particular county.

The usefulness of this program has been quite obvious in working with a number of different study regions in which new data had to be collected and merged with existing machine-readable data already available in various grid systems. The GRIDOT program, especially when combined with the REGRID program,[2] is a valuable tool for providing consistent and spatially compatible geographical information to analysis, modeling, and geographical display programs.

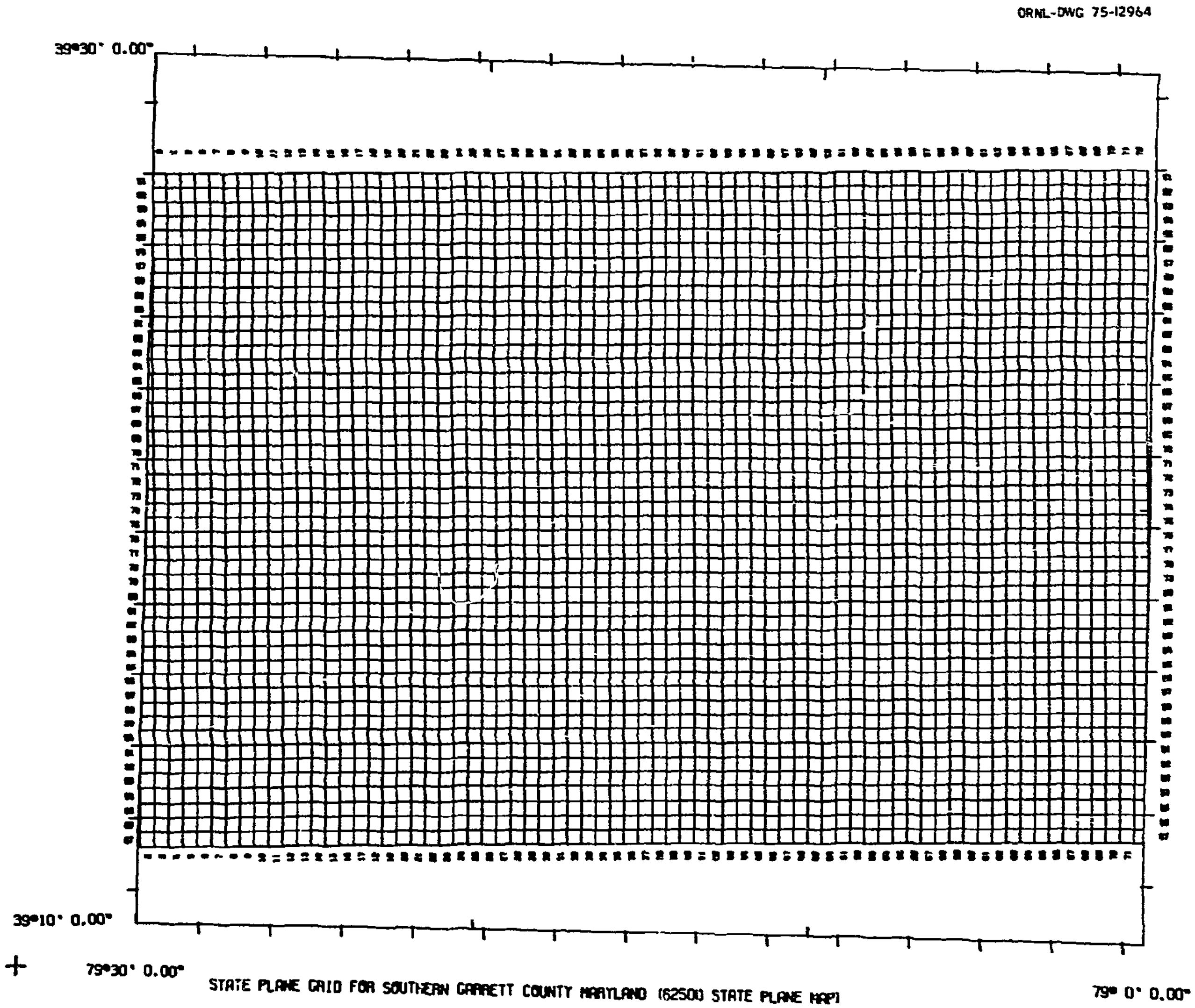

Fig. 1. A Grid Overlay for a Portion of Garrett County, Maryland, Using a State-Plane Grid System (Scale = 1/62,500, Cell Size Approximately 90 Acres).

1.2. Relationship to the ORRMIS Information System

The GRIDOT report is just one of several reports being published as a result of the geographical information system work done in conjunction with the NSF-RESA project at ORNL and being used by the DBER regional studies program. Most of these reports describe particular computer programs that were developed as a part of a total information system, entitled the Oak Ridge Regional Modeling Information System[4] (ORRMIS). In explaining the functional concepts and the role of these computer programs, especially GRIDOT, within the ORRMIS system, it would be of interest to review the history of the NSF-RESA program at ORNL. (Those readers interested only in the use of the GRIDOT program itself should skip to Section 2.) The original program was organizationally divided into four discipline areas: socioeconomic projection analysis, land-use allocation analysis, ecological impact analysis, and sociopolitical analysis. Under the land-use project much of the computational effort was directed towards the digitization and display of geographical information coupled with the building of data manipulation and analysis software that was to be directly usable by simulation models. As interaction with local and regional planning agencies took place, it became apparent that these users were as interested in the data bases and data management systems as they were in the simulation models. At the same time it became apparent that some of the other components of RESA, in particular the ecological analysis project, were needing and using the same tools being developed for the land-use project. Thus a fifth discipline area, data management and information systems, evolved as an off-shoot from the land-use project.

Out of this fifth project grew the ORRMIS system, which encompassed most of the information software for the processing of spatially distributed land-use and ecological data. The system which evolved from this unique research environment, as compared to the development of other information systems, was oriented towards providing an analysis capability rather than a collection of massive data bases. The original intent was to build a self-contained system with a command language to control computational and display capabilities that would meet all users' needs. However, this idea changed over time, and the philosophy which emerged was to build a modular system in which new functions could be added to solve new and unanticipated problems. Thus the resulting ORRMIS system is composed of a wide variety of routines and programs which are combined to solve spatial and time-dependent problems. These combinations have resulted in the creation of formal ORRMIS subsystems, with each subsystem meeting a particular class of needs. Although the type and structure of these subsystems change as new concepts and new software are created, the current ORRMIS subsystems are shown in Figure 2. There are now approximately 45 different programs and routines in ORRMIS.

The greatest amount of effort has gone into the Geographical Data Subsystem due to the spatial nature of regional environmental problems. This particular subsystem may be broken down into the basic components shown in Figure 3. The GRIDOT program plays a very important role in the first component, digitization of raw data. The technique by which raw data, whether in the form of maps, aerial photographs, tables, etc., are digitized may be broken into (1) manual techniques, (2) automated techniques, or (3) a combination of both.[4] The GRIDOT program is useful in all three cases. The manual use of gridded overlays is discussed in detail in Section 6. Gridded overlays are also useful with semi-automated techniques where, as one example, an x-y digitizer table is used to record land-use information on a grid basis. The operator simply positions the cursor (pointer) at the center of each cell in the GRIDOT-prepared overlay which contains a particular land-use and pushes the button which causes the machine to record the land-use of the cell. In the case of automated techniques, the ORRMIS digitization system[3] required that successive 35-mm pictures be taken of each internal section of a map so that the 35-mm film could be scanned with a flying spot scanner. The specification of each section was greatly aided by preparing section masks with early versions of the GRIDOT program and then overlaying them on the maps.

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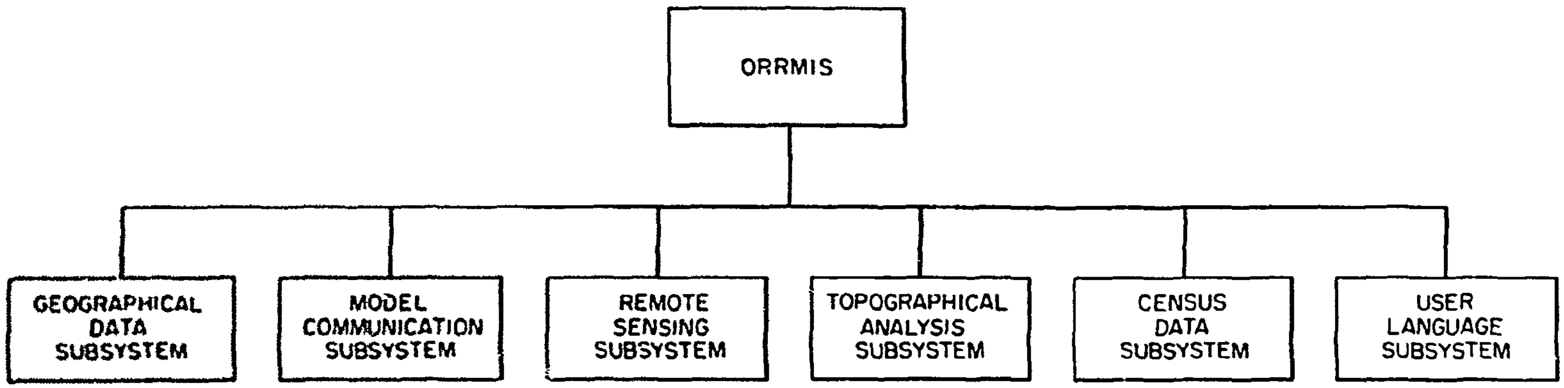

Fig. 2. ORRMIS Subsystems.

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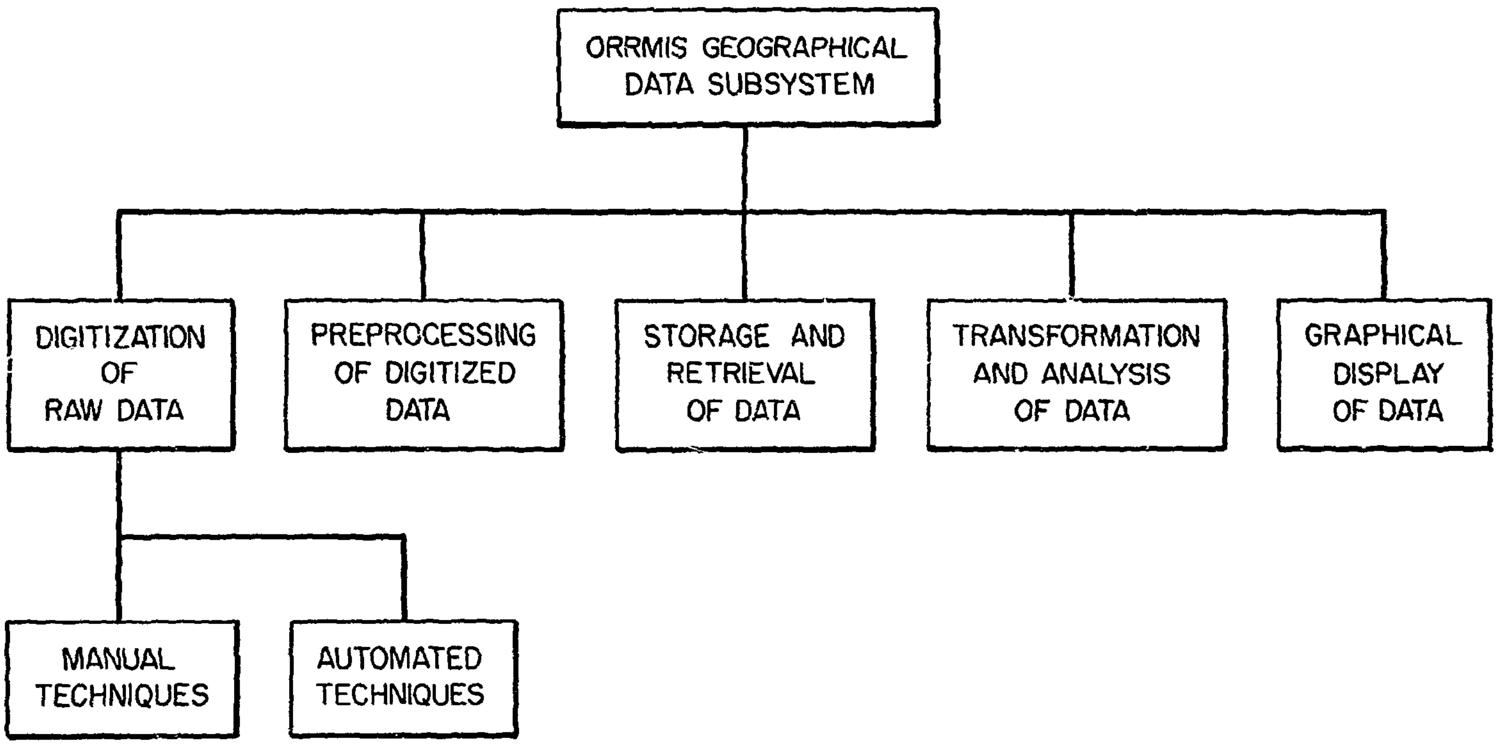

Fig. 3. The ORRMIS Geographical Data System.

The GRIDOT program also plays an important role in the fifth component of the Geographical Data Subsystem, graphical display. Procedures developed for use in the GRIDOT program are also used in producing the final graphical maps needed to display output variables. For example, GRIDOT has the ability to determine the minimum number of plotter line segments needed to represent a constant latitude-longitude (or northing-easting) line with the proper curvature, in a particular map projection. This same ability is useful in the production of the final maps. In the extreme case, GRIDOT with a few modifications could be used to produce an output map by simply replacing the tic mark at the center of each cell with symbols, or numbers representing different data values.

In the processing of geographical information, it has become obvious that computer cartography is a very necessary and difficult part of the problem. GRIDOT is one of the pieces of the ORRMIS system which provides a generalized cartographic capability for processing gridded data.

1.3. Applications Using Overlay Grids

This section presents five different projects using overlay grids for obtaining geographical data from maps or aerial photographs in order to show a variety of applications in which GRIDOT was found useful. From these examples the reader can see the variety of grid systems, map projections, scales, and map sizes which must be accommodated for handling a wide range of data. Table 1 presents (1) the project for which the grid overlay was used, (2) the type of data being collected, (3) the area involved, (4) the map projection used, (5) the grid coordinate system used, and (6) the scale of the overlay.

In the RESA project, land-use data such as transportation corridors, residential areas, churches, schools, etc., were digitized using geodetic cells of a constant latitude and longitude increment. The Maryland Power Plant Siting project digitized a number of natural and cultural variables for Maryland and the surrounding states using a 2,000-ft cell in the Maryland state plane coordinate system. One of the projects with the Soil Conservation Service is digitizing soil information from published surveys in Henry County on a geodetic grid of 1.19-acre cells. The Coal project is using land-cover and geological information at several different scales with both the Polyconic and Universal Transverse Mercator systems.

Table 1. Applications Using Overlay Grids.

	Project	Type of Data	Geographical Area	Map Projection	Coordinate System	Map Scale
1.	Regional Environmental Systems Analysis Project	Land-use Data	East Tennessee Development District	Polyconic	Latitude-Longitude	1/24,000
2.	Maryland Power Plant Siting Project	Seismicity Endangered Species, Roads	Eight Counties in Upper Maryland	Maryland State-Plane	Maryland State-Plane	1/62,500
3.	Maryland Power Plant Siting Project	Interstates and Highways	States Surrounding Maryland	Transverse Mercator	Maryland State-Plane	1/250,000
4.	Soil Conservation Service Project	Soil Type, Soil Slope	Henry County, Tennessee	Polyconic	Latitude-Longitude	1/15,840
5.	Coal Extraction Effects Project	Land-cover Data, Strip Mines from ERTS Imagery	East Tennessee	Universal Transverse Mercator (UTM)	Universal Transverse Mercator (UTM)	1/250,000

2. SAMPLE PROBLEMS

Sections 2.1 through 2.3 present three typical types of grid overlays which may be produced with the GRIDOT program. For each case the data form (from which data cards were punched) and the map overlay from the Calcomp plotter are shown. Although the data restrictions and parameters are not described until later in the report, it is assumed the reader would benefit from seeing the form of the data, examples of the various options, and the plotted output. Each of the samples is drawn for a TVA map, the northeast portion of Tennessee N1 16-3 (Harriman. Tennessee).

2.1. Geodetic Grid Overlay with Grid Intersections

This example (Figure 6) is a grid of cells 3 minutes in latitude and longitude (a geodetic grid), defined by small plus signs at the corners of the grid cells. Latitude and longitude tic marks just inside the border of the overlay define the 0-minute, 15-minute, 30-minute, and 45-minute latitudes and longitudes. Outside the border are tic marks for UTM coordinates that are multiples of 50,000 meters. The original scale of the plot was 1/125,000. The cell numbering origin is at the southeast corner. The data for this example appear in Figures 4 and 5. Figure 6 is the map overlay.

2.2. UTM Grid Overlay with Grid Lines

Figures 7 through 9 show the data and resulting grid overlay for a 2,000-m UTM grid for the example area. In this example the UTM coordinates of the center of each cell (divided by 1,000) have been used for the row and column identifiers of the cells. Fifteen-minute tic marks appear just inside the overall border. Also, the entire grid lines. as opposed to grid line intersections, have been drawn.

2.3. State-Plane Grid Overlay with Grid Lines and Cell Center Marks

The grid system for this example (data in Figures 10 and 11) is a 20,000-ft Tennessee state-plane grid, with each grid line drawn out in full, and with plus marks at the center of each cell. The gridded area (Figure 12) has been restricted to the eastern 3/4 of the original map. Cell numbering is from north to south and west to east. The extra row and column of cell index numbers (at the top and at the right) are to aid in digitizing data, as described in Section 6.3.

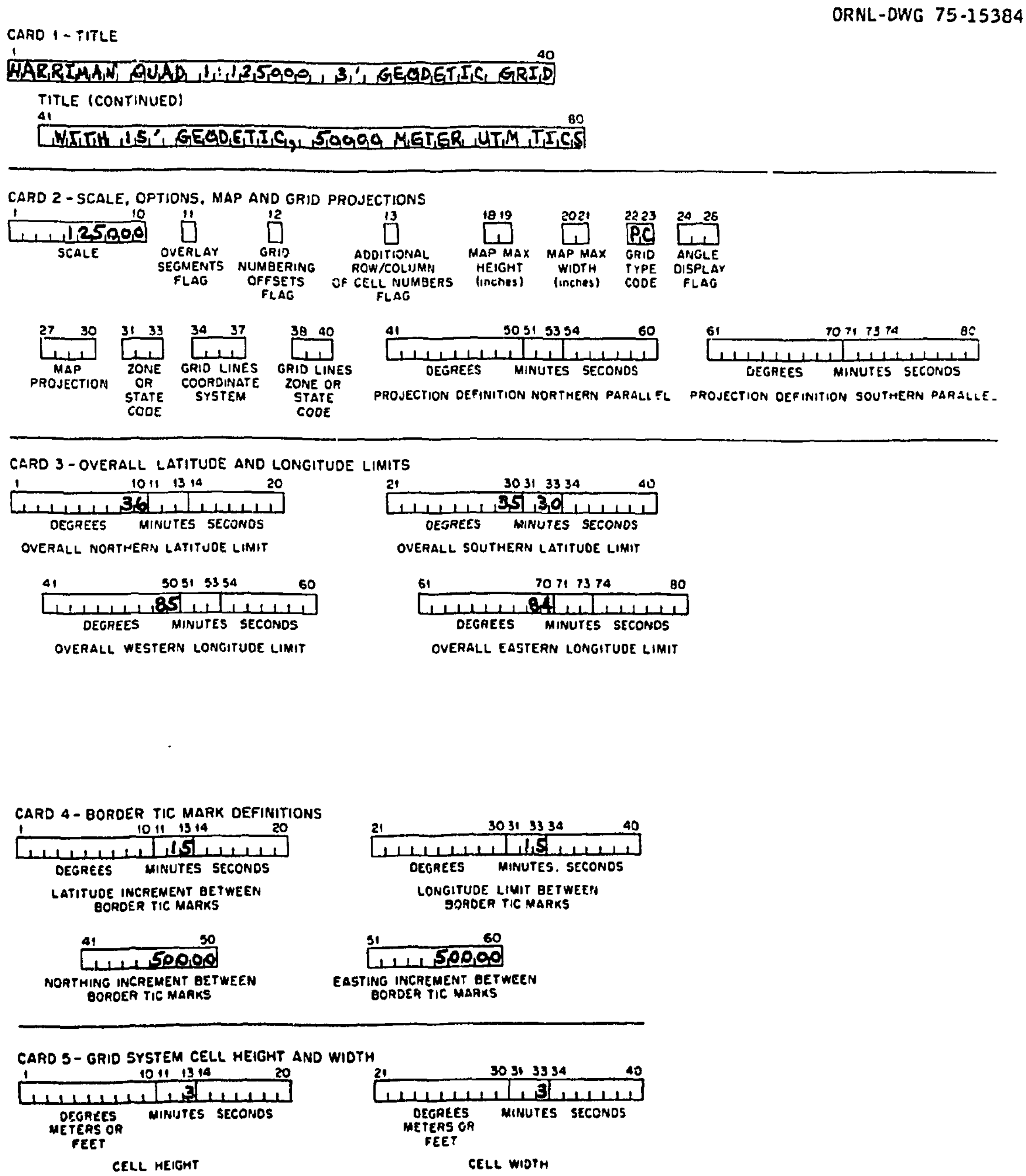

Fig. 4. Data for the Three-Minute Geodetic Grid Example (Cards 1-5).

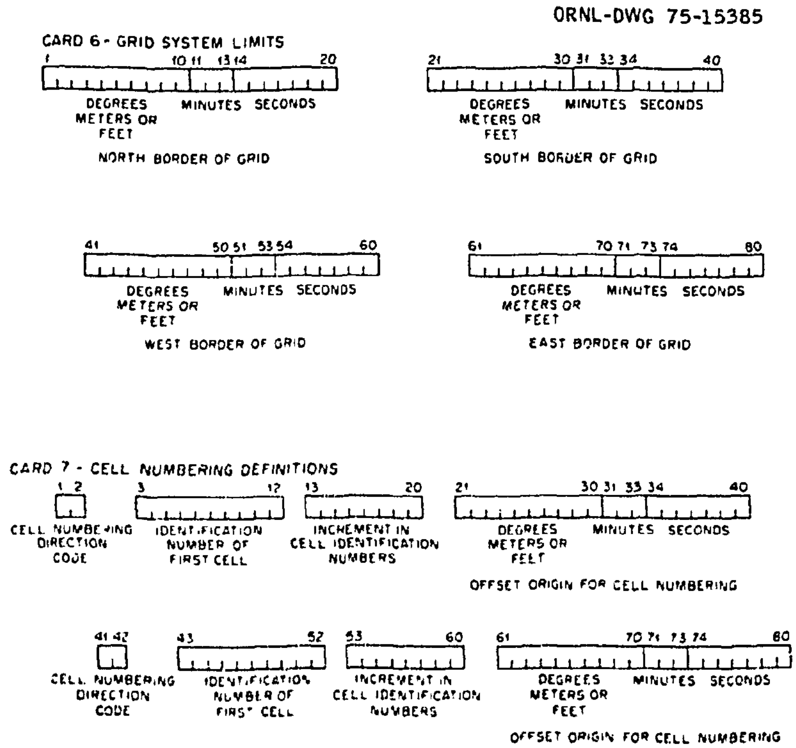

Fig. 5. Data for the Three-Minute Geodetic Grid Example (Cards 6-7).

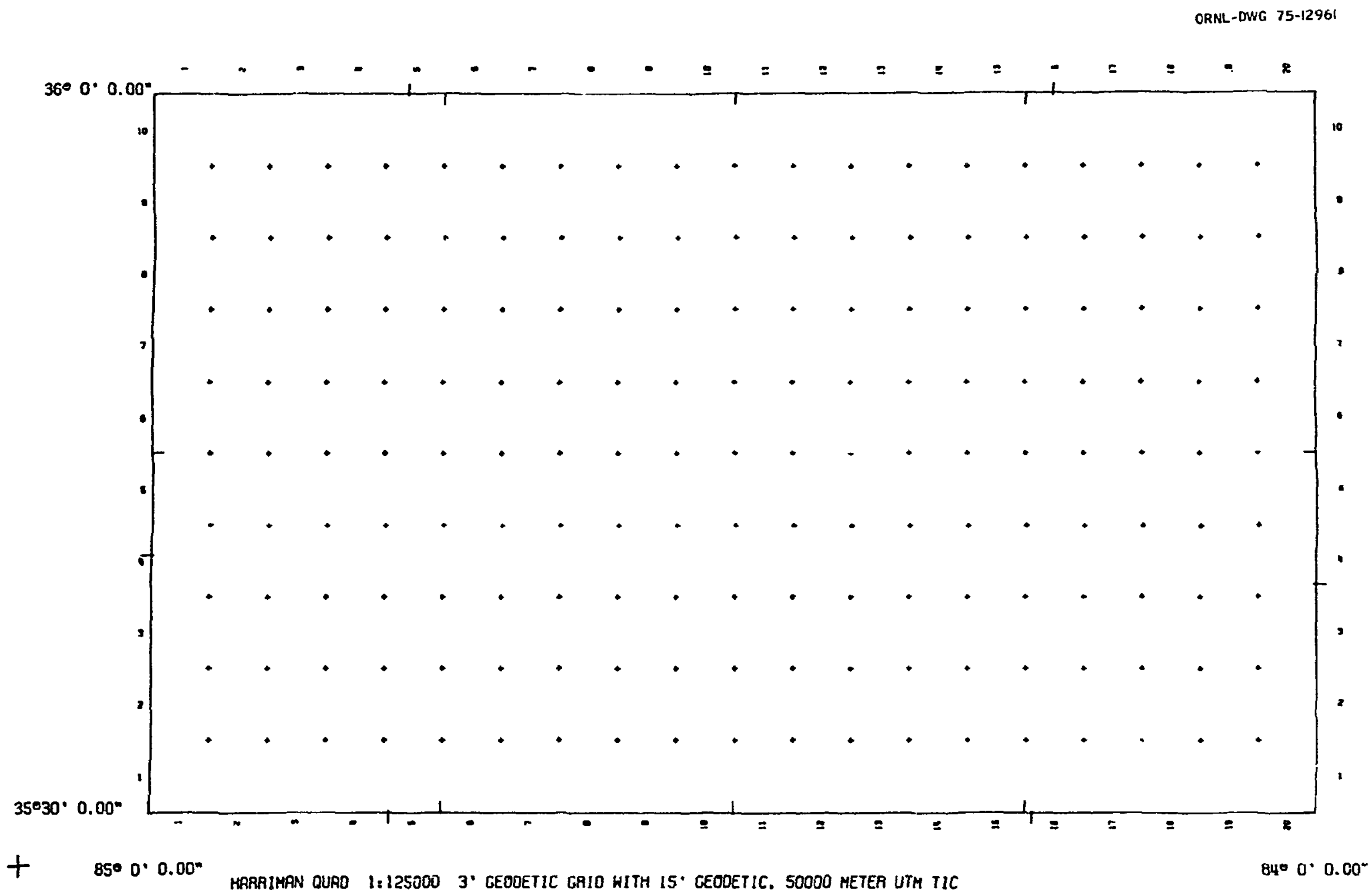

Fig. 6. Map Overlay for the Three-Minute Geodetic Grid Example.

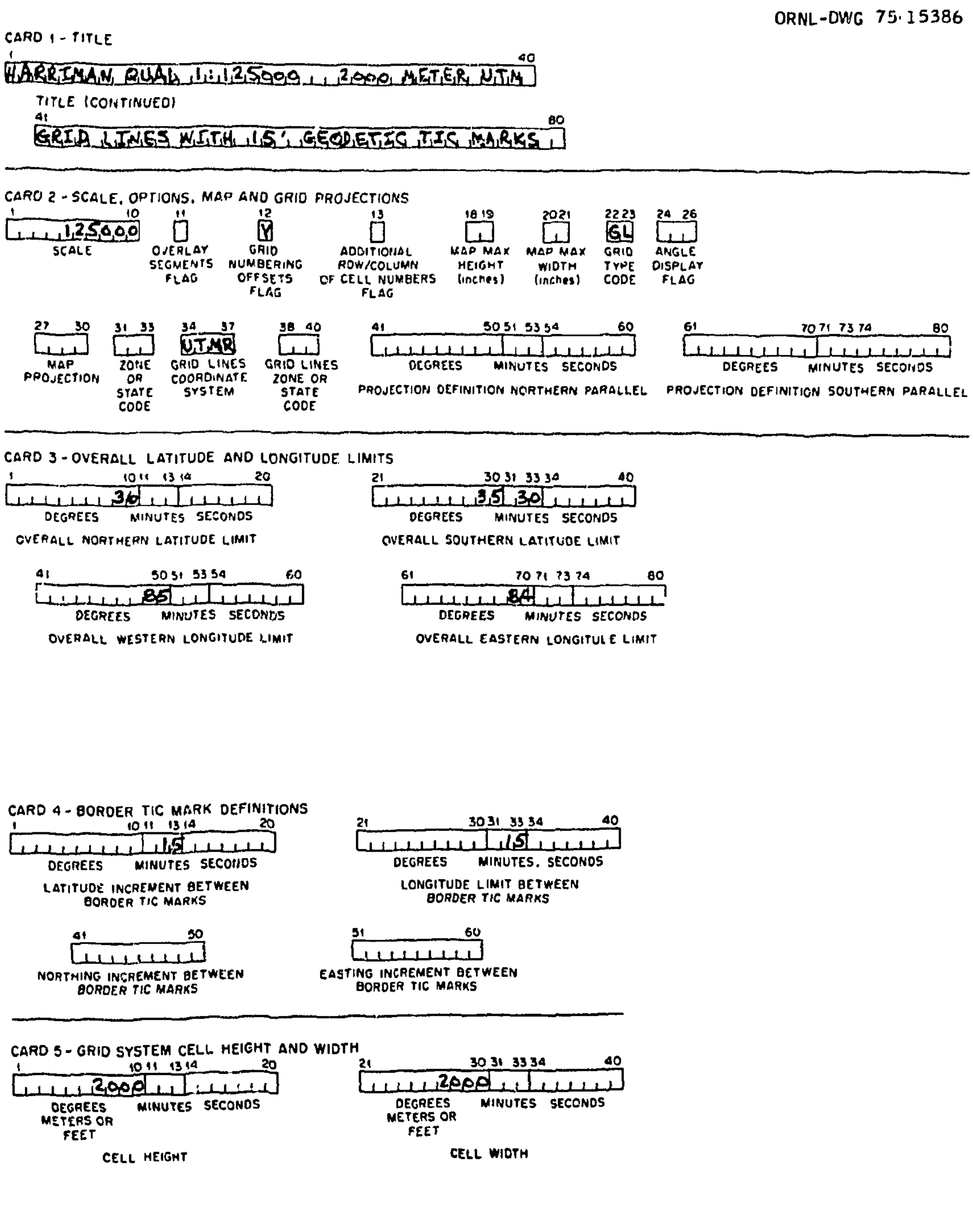

Fig. 7. Data for the 2,000-m UTM Grid Example (Cards 1–5).

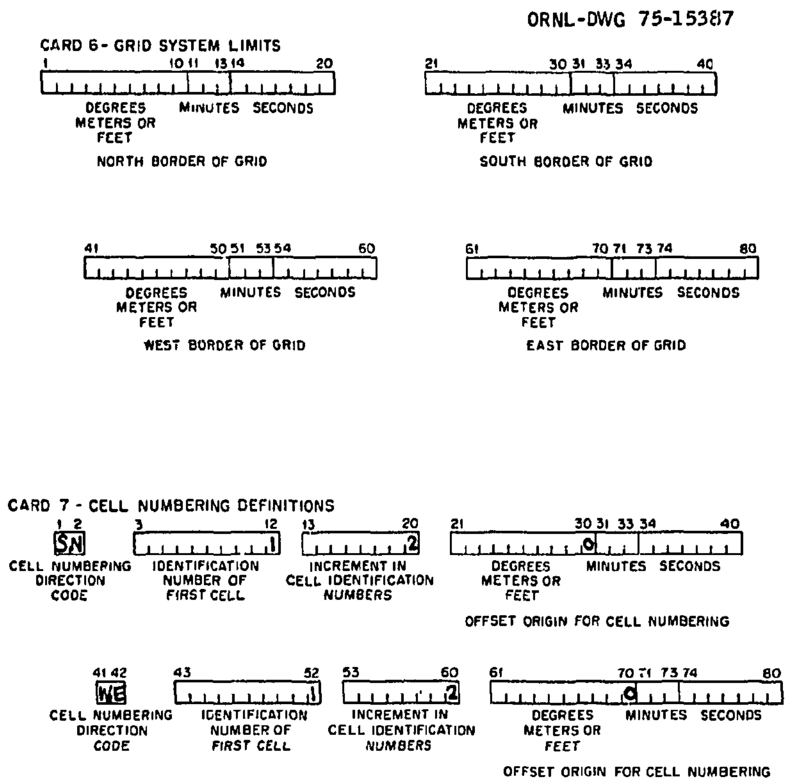

Fig. 8. Data for the 2,000-m UTM Grid Example (Cards 6–7).

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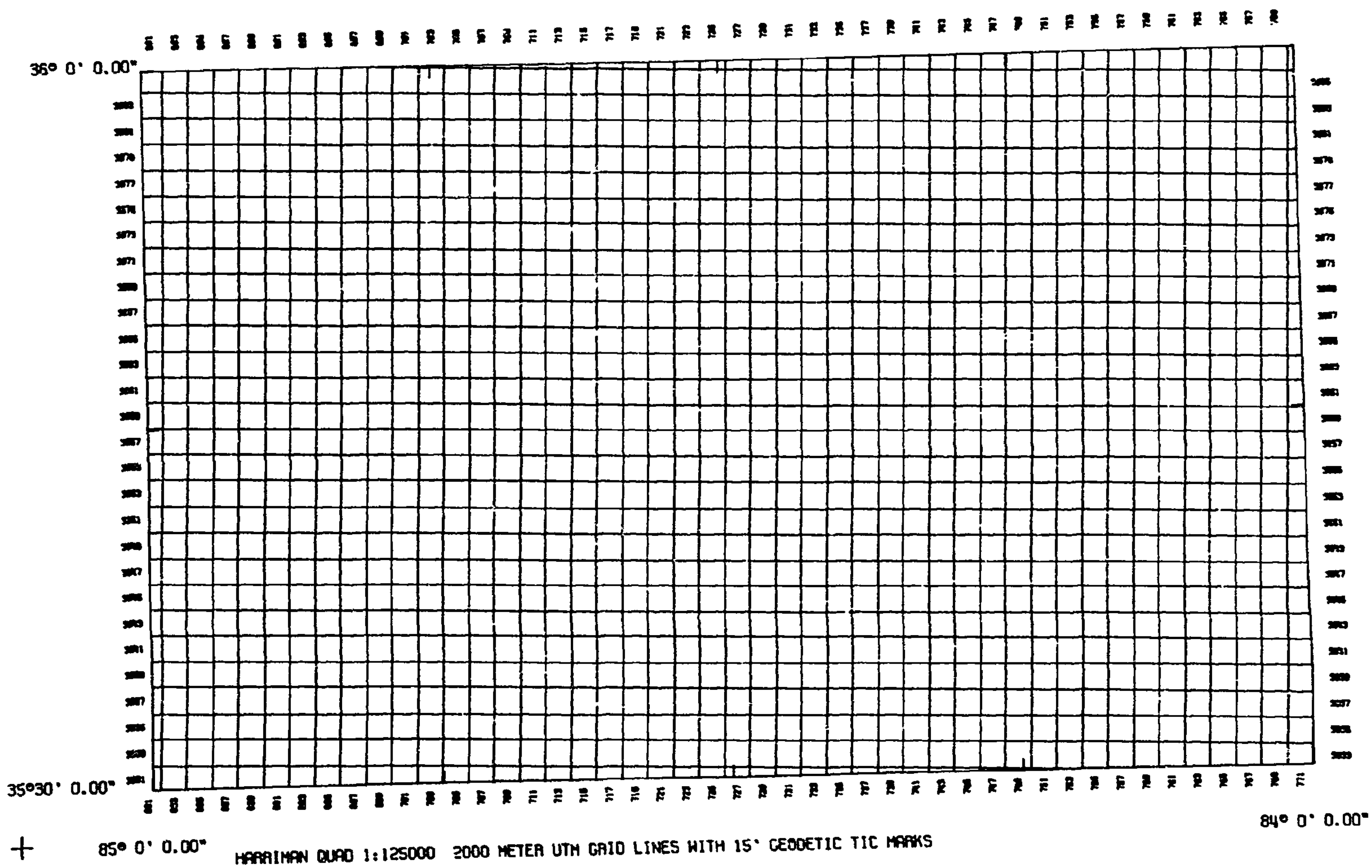

Fig. 9. Map Overlay for the 2,000-m UTM Grid Example.

ORNL-DWG 75-15388

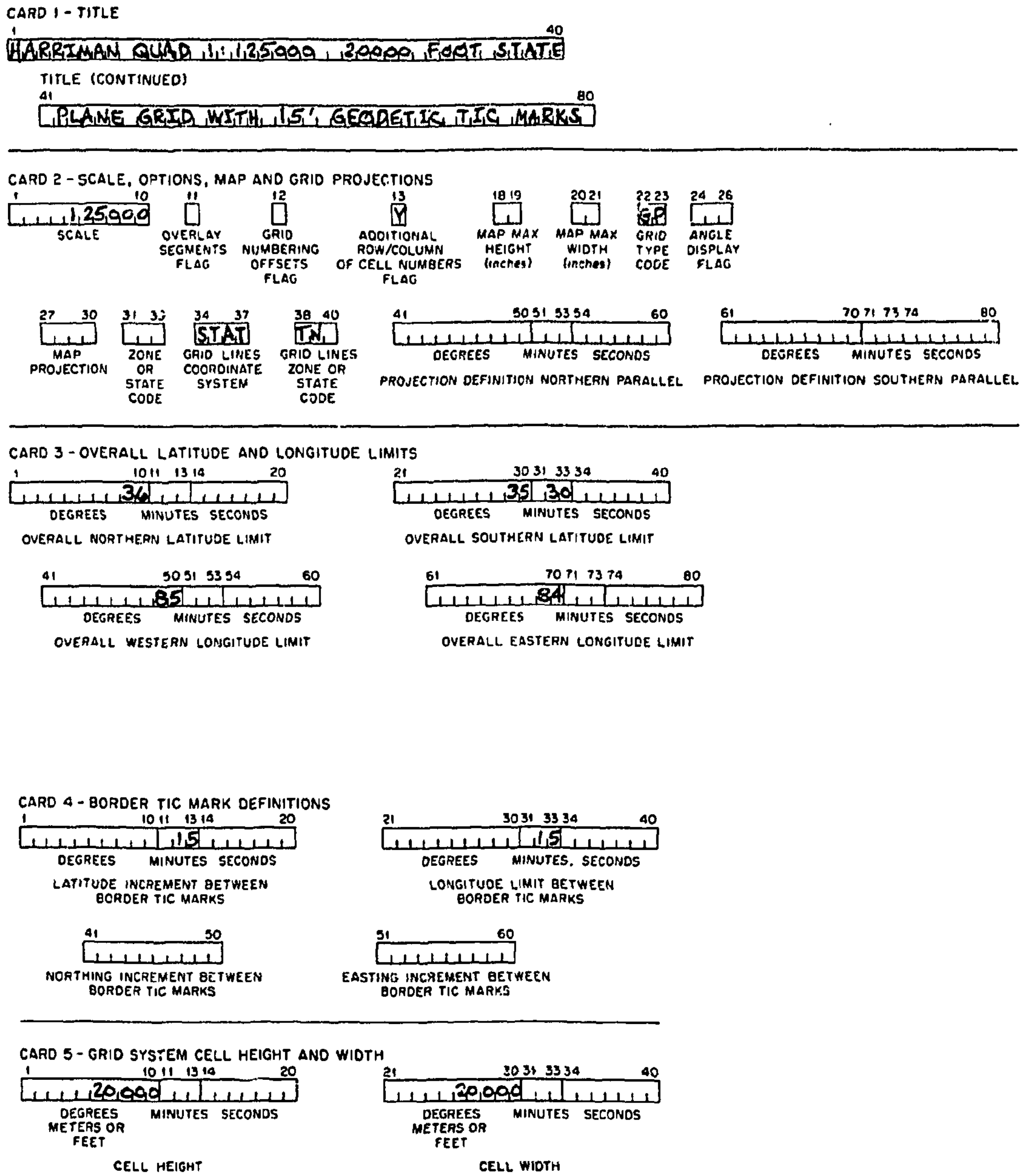

Fig. 10. Data for the 20,000-ft State-Plane Grid Example (Cards 1–5).

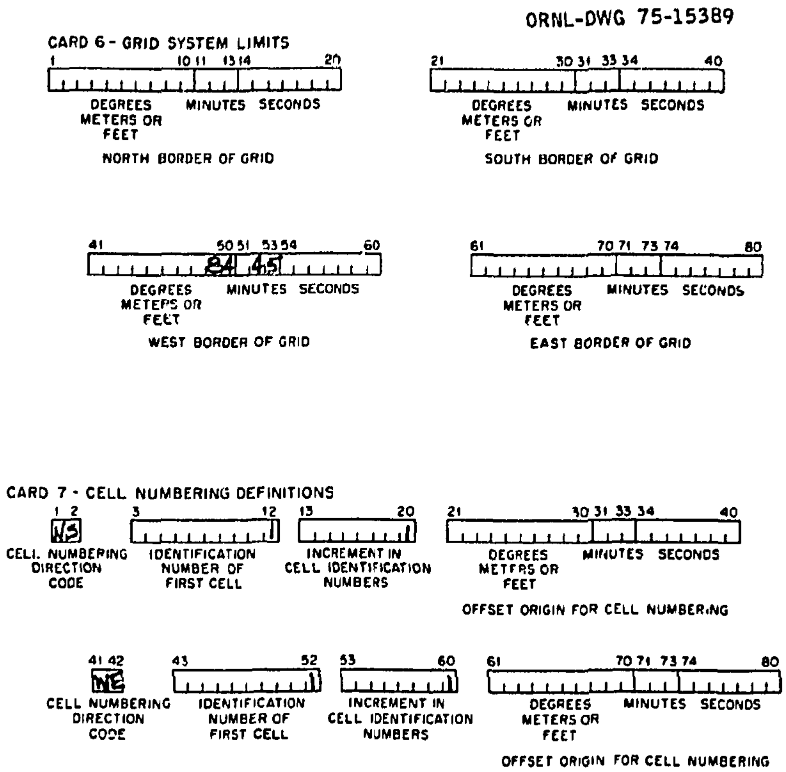

Fig. 11. Data for the 20,000-ft State-Plane Grid Example (Cards 6-7).

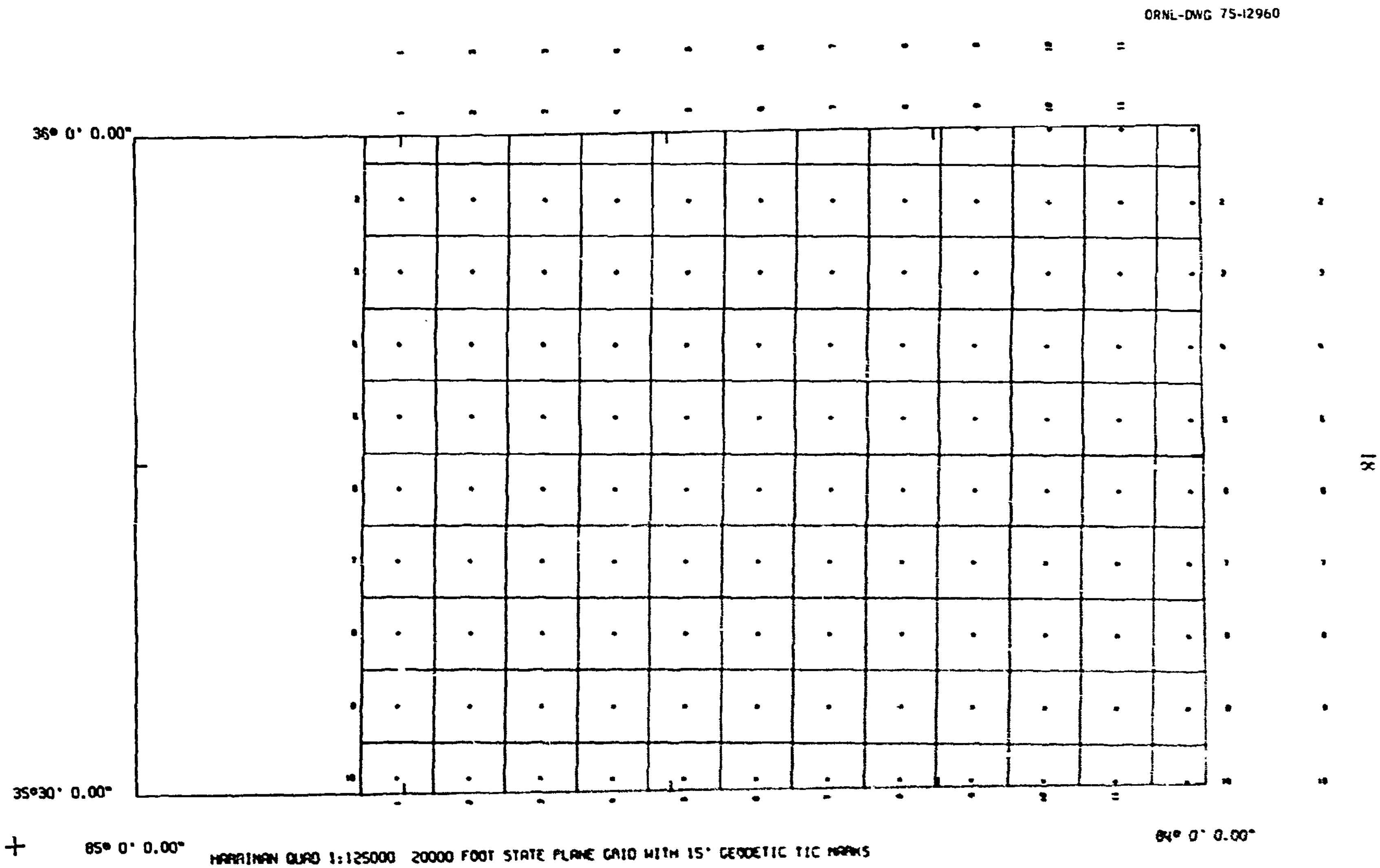

Fig. 12. Map Overlay for the 20,000-ft State-Plane Grid Example.

3. GENERAL FEATURES OF THE PROGRAM

3.1. Map Projections and Grid Coordinate Systems

Before describing the detailed input requirements for the GRIDOT program (Section 4), the general features, capabilities, and available options will be discussed. Specific nomenclature used throughout the report will be defined. The two terms "map overlay projection" and "grid coordinate system" will be used quite frequently. Since maps are two-dimensional representations, some sort of projection is necessary to represent any given portion of the earth. The projection may be as simple as projecting the earth's surface onto an enveloping cylinder (as in the mercator projection) or cone (as in a conic projection), cutting the cylinder or cone, and rolling it out flat. These simple projections have been generalized and standardized so that practically all maps published today use one of a half-dozen well-known projections. For example, the Lambert Conformal projection is used on many Rand McNally maps; the National Geographic Society commonly uses an Albers Equal Area projection; the U.S. Geological Survey uses either a Polyconic projection or a Transverse Mercator projection. If latitude and longitude lines are projected from the earth's surface onto the map, most of them will appear curved, the curvature being more distinct as the area becomes larger.

The term "grid coordinate system" refers to the method of dividing an area of the earth into a lattice of cells. One common method is to define cells using latitudes and longitudes so that every cell has the same latitude increment in height, and the same longitude increment in width. For example, a latitude could be defined by dividing the area bounded by latitude 39° to 40°, longitude 78° to 80° into cells 1 minute of latitude high, 2 minutes of longitude wide, thus producing a 60-row by 60-column grid. This system works very well for small regions, since the latitude-longitude lines for areas up to 15' are virtually straight lines. In digitizing larger areas the curvature of the latitudes becomes noticeable, making the drawing (by hand) of additional latitude-longitude lines a time-consuming and error-prone task. Alternatively, a grid system consisting of a series of regularly spaced horizontal and vertical lines could be drawn directly on the map. Such a system could be drawn as an overlay and used from map to map, so long as the maps have the same scale and use the same projections. Even if the scale changes but the projection remains the same, generating the grid involves drawing a rectangular grid perhaps with a different horizontal and vertical increment. The problem comes when data must be digitized from a map that uses a different projection from the desired coordinate system. The problem of transforming the rectangular grid of the original projection to the new projection can be thought of as projecting the grid lines of the original projection back onto the earth, then projecting these curves onto the new projection. (See Figure 13.)

In the terms used in the GRIDOT program, the projection in which the grid lines appear as a rectangular lattice of straight lines is called the "grid coordinate system" projection. If the cells are defined by a lattice of latitudes and longitudes, the grid coordinate system is called a "latitude-longitude grid system." The map projection which the overlay is being prepared for is called (simply) the "map projection." As an example, many USGS 7 1 2-minute quad maps use a Polyconic "map projection" and the UTM tic marks around the edges refer to a superimposed UTM "grid coordinate system."

In the GRIDOT program the user may specify (1) a latitude-longitude grid system, (2) a grid system of rectilinear lines in a Universal Transverse Mercator (UTM) projection, or (3) a rectilinear grid in one of the state-plane systems. One of the standard map projections may be specified along with the chosen grid coordinate system.

A further discussion of map projections as related to the true representation of the earth's surface is given in Section 3.3. The novice user should read that section in order to be aware of pitfalls that arise in the study of large geographical regions.

ORNL DWG 75-6571

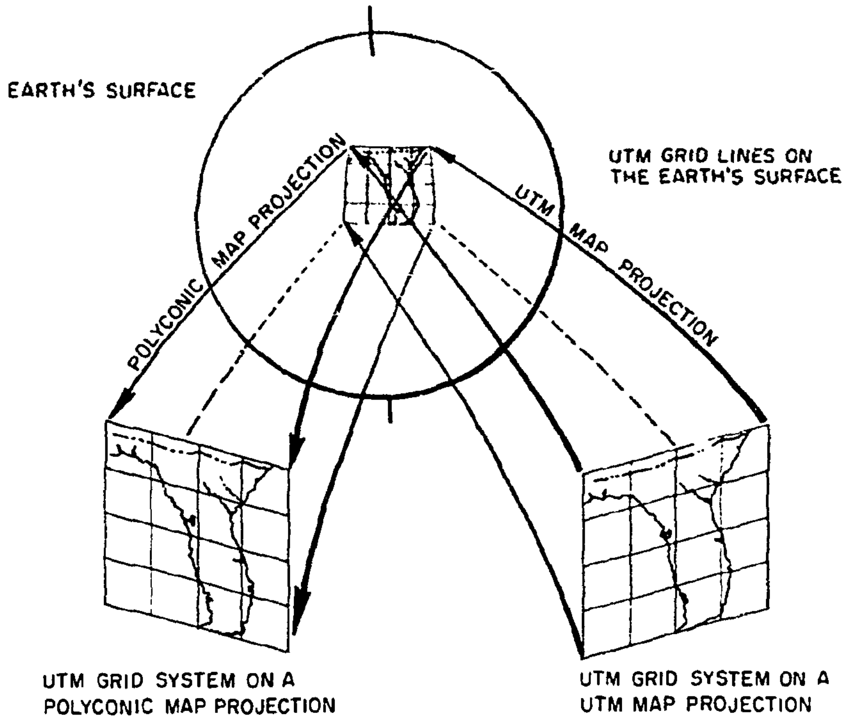

Fig. 13. Transferring UTM Grids to a Polyconic Map.

3.2. Northings and Eastings

In Section 3.1 the technique of drawing a rectangular grid over a map to define a lattice for digitizing data was discussed. The horizontal and vertical distances in the two-dimensional map projection are given in metric units (meters for a UTM grid) or English units (feet for state-plane grids) corresponding to distances on the ground for a one-to-one projection (map scale = 1/1). The cell heights (or widths) can be determined by multiplying the map scale by the vertical (or horizontal) distances measured on the map with a ruler having the appropriate units, meters or feet. However, the grid lines are referenced to a standard origin depending on the projection being used, and thus absolute distances may be referred to as well as relative distances such as cell height and width. The absolute position of the horizontal grid lines is called a "northing" and represents how far north the grid line is from the horizontal grid line origin. The absolute position of the vertical grid lines is called an "easting" and represents how far east the grid line is from the vertical grid line origin. The northing-easting origin conventions for the UTM projections and the legally defined state-plane system are widely accepted. The northing and easting grid lines of the UTM grid system (measured in meters) and one or more state-plane grids (measured in feet) appear as tic marks around the edges of many U.S. Geological Survey maps. The overlays produced by the GRIDOT program provide an option that will draw tic marks around the border of the overlay for either a UTM grid or one of the state-plane grids.

3.3. The Relation of Map Projections to the Earth's Surface

In using a map to determine distances from one point to another, such as the distance from one grid line to the next, the user should be aware that any map contains slight distortions with respect to the surface of the earth. This is because no projection of a three-dimensional surface onto a two-dimensional plane can preserve distances, angles, and areas simultaneously without distortion. However, all projections are defined so that at least one line or curve on the map will measure true distance as compared to the corresponding line on the face of the earth. For example, the Universal Transverse Mercator projection is defined by intersecting a horizontally placed cylinder with the earth's surface where the radius of the cylinder is slightly smaller than the radius of the earth. The cylinder therefore intersects the earth at two different curved lines which are parallel to and equidistant from the standard central meridian. For example, the central meridian for UTM Zone 16 is 87^0 west longitude. A UTM zone is 6^0 wide so that Zone 16 extends from longitude 84^0 to 90^0. This is shown in Figure 14. Along these two lines of intersection any distance measured and rescaled from a Zone 16 UTM map will be identical to true earth distance on the ground. As one moves away from these two intersecting lines, the map distance is not equal to true ground distance. Moving in towards the central meridian, the map would understate the true ground distance while moving out away from these two intersection lines overstates the true distance. The distortion from true scale is usually less than 0.1% within a UTM zone.

Thus, in order to minimize distortion in representing the earth's surface, UTM projections are based upon a series of standard zones set up around the earth, each defined by a cylinder oriented to the standard meridian of the particular zone. Each zone has its own unique grid system definition. When attempting to match grid systems from adjacent zones, the user is faced with a mismatch problem as shown in Figure 15. To alleviate this problem, users many times extend one UTM zone over into a neighboring zone so that the entire area of interest is defined by a single grid system.

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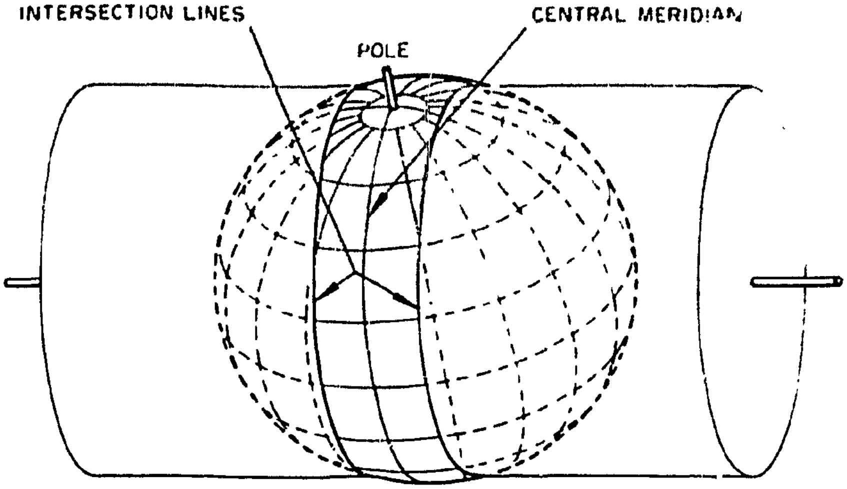

Fig. 14. The Transverse Mercator Projection.

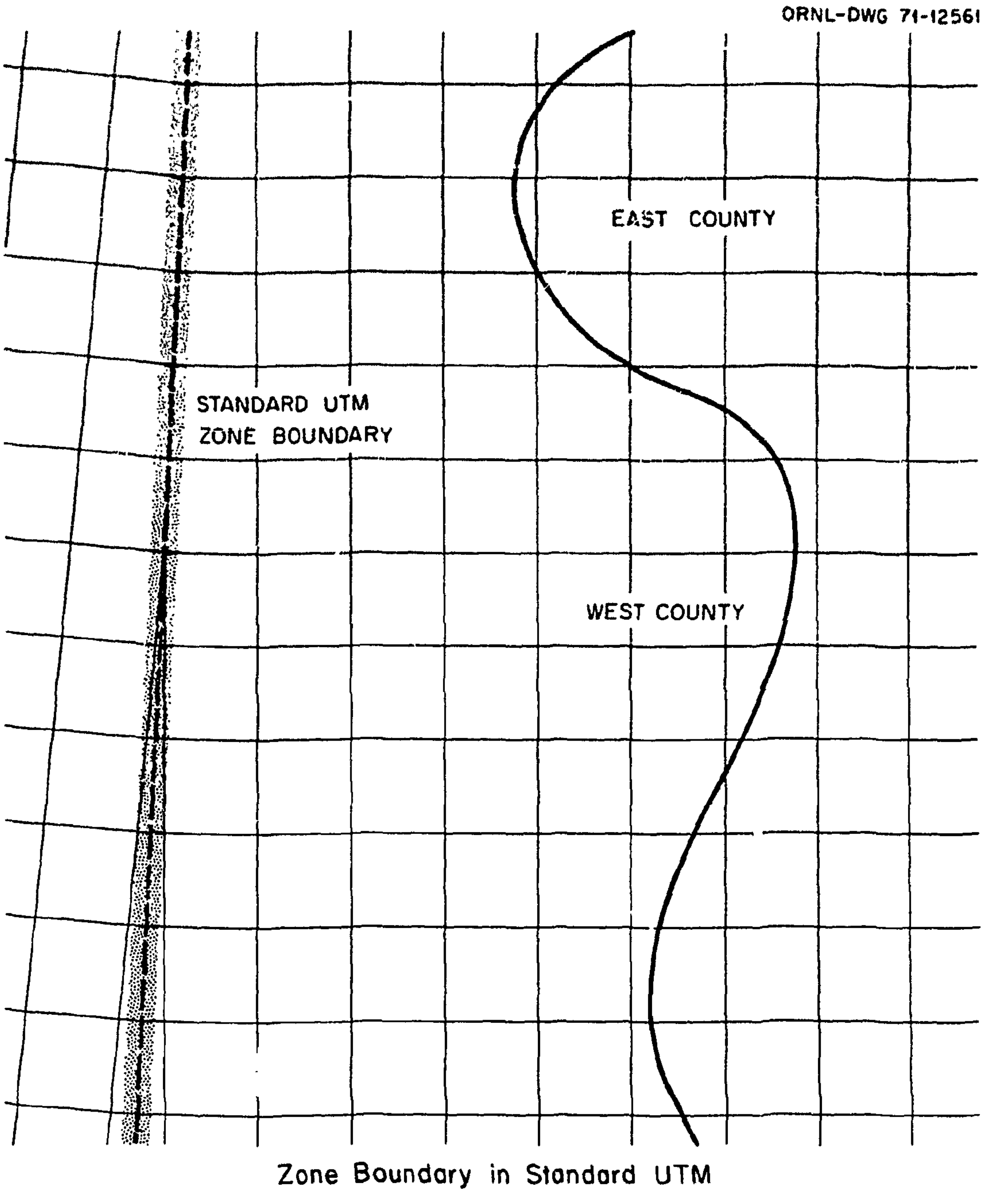

Fig. 15. Zone Boundary of a Universal Transverse Mercator (UTM) Zone.

3.4. Overall Latitude-Longitude Limits and Overall Grid Limits

The user of the GRIDOT program is assumed to be working with maps drawn between two latitude limits and two longitude limits, called the "overall lat-lon limits." These overall limits are the primary registration lines for the overlay produced by the GRIDOT program. If a latitude-longitude grid system is being used, the user may choose to have the grids drawn everywhere between the overall limits, or he may restrict the grids to a second set of latitude-longitude limits, falling within the overall limits, to avoid wasting both computer and plotter time generating grids for regions that will not be digitized. In this case the second set of latitude-longitude limits is called the "overall grid limits."

Another use of the term "overall grid limits" applies to a grid based on northings and eastings rather than latitudes and longitudes. In this case the gridded area inside the overall lat-lon limits is northing and easting limits on all four sides. On the input cards the user may specify (in latitude and longitude, meters, or feet) the north, south, east, and west borders of the gridded box. See Figure 12 for an example of a gridded area interior to the overall lat-lon border.

For user convenience, the specification of the borders of the grid may be omitted. If no grid limits are provided, the program will produce a grid throughout the "overall lat-lon limits."

3.5. Labeling the Rows and Columns of the Grid

If the user does not specify a row and column labeling scheme for the rows and columns in the grid, the program will number the rows from west to east by increments of one starting with the number 1, and from south to north by increments of one starting at 1. The user may specify (1) an alternate direction (east to west or north to south), (2) an increment between row labels or column labels other than one, and (3) a starting label for either the rows or the columns that is different than one. Also, the user may instruct the program to use a labeling scheme whose origin is specified by either a specific meridian and parallel or a specific northing and easting (see Figures 7 through 9). This origin can lie outside the gridded area. Given the origin, the program will calculate the proper labels for the rows and columns of the grid being drawn. If this option is chosen, the "origin meridian and parallel" (or "origin northing and easting") are defined according to the direction of the numbering (assuming the grid could be extended to the origin), as follows:

1. If the vertical numbering is from south to north, the origin parallel (or northing) is the south border of the first row of cells north of the origin.
2. If the vertical numbering is from north to south, the origin parallel (or northing) is the north border of the first row of cells south of the origin.
3. If the horizontal numbering is from west to east, the origin meridian (or easting) is the west border of the first column of cells east of the origin.
4. If the horizontal numbering is from east to west, the origin meridian (or easting) is the east border of the first column of cells west of the origin.

4. DESCRIPTION OF THE INPUT

4.1. Specification of the Map Overlay Data

The input for producing a grid overlay is determined by seven data cards. All seven cards for each overlay must be present even though no information may be punched on one or several of them. Any number of overlays may be produced in a single run by stacking cases one after the other.

Table 2 gives a complete specification of every data field of the seven data cards. The following seven sections give a detailed explanation of the parameters associated with these data fields and the use of options in meeting particular overlay requirements.

Figures 16 through 19 are layout sheets for the seven data cards of the GRIDOT program. When a series of overlays is produced, the user may want to make a copy of the layout forms, writing in those parameters that do not change in the series of overlays (e.g., map scale and cell size). This master may be copied to produce a new layout sheet that requires filling in only the parameters that change from overlay to overlay (e.g., overall latitude-longitude limits).

Most of the fields in the GRIDOT program have an associated default value for use when the field is left blank. However, no default exists for the following fields:

1. The map overlay title (data card 1),
2. The scale of the map overlay (data card 2),
3. The overall latitude and longitude limits of the map overlay border (data card 3),
4. The cell height and width of the overlay grid.

The default values for the remaining fields are given in Table 2.

4.2. Specification of the Map Projection

The map projection of the grid overlay may be any of the following standard map projections:

1. Polyconic projection: Many current USGS maps are published in Polyconic projections. The central meridian (halfway between the overall longitude limits) will be drawn as a straight vertical line. This projection is the default if a map projection is not specified.

2. Albers Equal Area projection: Most National Geographic Society maps use this projection. The standard parallels of the projection are assumed to be 27 $1/2^0$ and 45 $1/2^0$ unless otherwise specified on data card 2.

3. Universal Transverse Mercator: At present, only new, large-area Army Map Service maps use this system. Unless a specific zone is indicated, the zone of the meridian between the overall longitude limits is assumed to be the in zone of the map.

4. Lambert Conformal projection: The standard parallels of the projection are assumed to be 27 $1/2^0$ and 45 $1/2^0$ unless otherwise specified on data card 2.

5. State-plane system: The code of the state-plane system to be used must be supplied as an additional parameter. A list of the codes of the state-plane systems apppears in Appendix C.

Table 2. Specification of Input Parameters and Card Formats

	Field	Format	Columns	Default	Remarks
Card 1					
	Title	20A4	1-80	All Blanks	
Card 2					
	Scale	F10.0	1-10	(No Default)	
	Overlay Segments Flag (not currently used)	A1	11	N	Y = Overlay segments are to be plotted N = No overlay segments
	Grid Numbering Offset Flag	A1	12	N	N = Origin for grid cell labeling is the borders of the drawn grid system Y = Origin for grid cell labeling is given as data
	Additional Row/Column of Cell Numbers Flag	A1	13	N	Y = Draw an additional row (at the top) and column (at the right) of cell labels
	Map Maximum Height	I2	18-19	27	In inches
	Map Maximum Width	I2	20-21	40	In inches
	Grid Type	A2	22-23	PC	PC = "+" marks at cell corners GL = Grid lines GP = Grid lines & "+" marks at cell centers
	Angle Display Flag	A3	24-26	DMS	DEG = Degrees and fractions of degrees DMS = Degrees, minutes, seconds
	Map Projection	A4	27-30	POLY	POLY = Polyconic ALBR = Albers equal area LAMB = Lambert conformal UTMR = Universal transverse mercator STAT = State Plane

Table 2 (Continued)

	Field		Format	Columns	Default	Remarks
Card 2 (cont.)	Map Projection Zone or State Code		A3	31-33	UTMR: Central Meridian of Grid Area STAT: No Default	Zone number for UTMR maps State plane code for state plane maps (right adjusted)
	Grid Lines Coordinate System		A4	34-37	LTLN	UTMR = Universal transverse mercator (meters) STAT = State plane (feet) LTLN = Latitude/Longitude (degrees or degrees-minutes-seconds)
	Grid Lines Zone or State Code		A3	38-40	UTMR: Central Meridian STAT: No Default	Zone number for UTMR grids or state plane code for state plane grids (right adjusted)
	Projection Northern Parallel	(DEG)	F10.0	41-50	45 1/2°	
		(MIN)	F3.0	51-53		
		(SEC)	F7.4	54-60		North and south parallels are used in the Albers and Lambert projections
	Projection Southern Parallel	(DEG)	F10.0	61-70	27 1/2°	
		(MIN)	F3.0	71-73		
		(SEC)	F7.4	74-80		
Card 3	Northern Latitude Limit	(DEG)	F10.0	1-10		
		(MIN)	F3.0	11-13	(No Default)	
		(SEC)	F7.4	14-20		Degrees or degrees and fraction of a degree Minutes Seconds and fractions of seconds
	Southern Latitude Limit	(DEG)	F10.0	21-30		
		(MIN)	F3.0	31-33	(No Default)	
		(SEC)	F7.4	34-40		

Table 2 (Continued)

	Field		Format	Columns	Default	Remarks
Card 3 (cont.)	Western Longitude Limit	(DEG)	F10.0	41-50	(No Default)	Degrees or degrees and a fraction of a degree
		(MIN)	F3.0	51-53		Minutes
		(SEC)	F7.4	54-60		Seconds
	Eastern Longitude Limit	(DEG)	F10.0	61-70	(No Default)	
		(MIN)	F3.0	71-73		
		(SEC)	F7.4	74-80		
Card 4	Latitude Increment Between Edge Tic Marks	(DEG)	F10.0	1-10	No Tic Marks	Degrees or degrees and a fraction of a degree
		(MIN)	F3.0	11-13		Minutes
		(SEC)	F7.4	14-20		Seconds
	Longitude Increment Between Edge Tic Marks	(DEG)	F10.0	21-30		Latitude/Longitude Tic Marks are Inside Latitude/Longitude Box
		(MIN)	F3.0	31-33		
		(SEC)	F7.4	34-40		
	Northing Increments Between Edge Tic Marks		F10.0	41-50	No Tic Marks	Units of the northing and easting tic marks are defined by the grid system units flag on Card 1
	Easting Increment Between Edge Tic Marks		F10.0	51-60		Northing/Easting Tic Marks are Outside Latitude/Longitude Box
Card 5	Cell Height {Fractional Degrees / Degrees / Meters or Feet}		F10.0	1-10	(No Default)	If cell height in degrees, height must be within 1/10% of dividing Northern-Southern latitude difference. If cell height in

Table 2 (Continued)

	Field		Format	Columns	Default	Remarks
Card 5 (cont.)	Minutes		F3.0	11-13		meters or feet and SW, NE corners of grid are given, height must be within 1/10% of dividing Northern-Southern northing difference
	Seconds		F7.4	14-20		
	Cell Width Fractional Degrees Degrees Meters or Feet		F10.0	21-30	(No Default)	If cell width in degrees, width must be within 1/10% of dividing Western-Eastern longitude difference. If cell width in meters or feet and SW, NE corners of grid are given, width must be within 1/10% of dividing Western-Eastern easting difference.
	Minutes		F3.0	31-33		
	Seconds		F7.4	34-40		
Card 6	[Latitude/Longitude Grid System]					
	North Border of Grid	(DEG)	F10.0	1-10	North	
		(MIN)	F3.0	11-13	Latitude	
		(SEC)	F7.4	14-20	Border	
	South Border of Grid	(DEG)	F10.0	21-30	South	
		(MIN)	F3.0	31-33	Latitude	
		(SEC)	F7.4	34-40	Border	
	West Border of Grid	(DEG)	F10.0	41-50	West	
		(MIN)	F3.0	51-53	Longitude	
		(SEC)	F7.4	54-60	Border	
	East Border of Grid	(DEG)	F10.0	61-70	East	
		(MIN)	F3.0	71-73	Longitude	
		(SEC)	F7.4	74-80	Border	

Table 2 (Continued)

	Field	Format	Columns	Default	Remarks
Card 6					
	[UTM (meters) or state-plane (feet) Grid System]				
	North Border of Grid	F10.0	1-10	Gridding to the Corresponding Latitude or Longitude Limit	
	South Border of Grid	F10.0	21-30		
	West Border of Grid	F10.0	41-50		
	East Border of Grid	F10.0	61-70		
Card 7					
	Cell Labeling Direction Code	A2	1-2	WE	WE = West to East EW = East to West NS = North to South SN = South to North
	Label of the Origin Cell in this Direction	I10	3-12	1	If no offset origin is used the origin cell is at the extreme row or column of the gridding. Card 1, Column 12 specifies whether an offset origin is to be used or not.
	Label Increment in this Direction	I8	13-20	1	If direction is West to East, offset is the West border of the origin cell. If direction is East to West, offset the East border of the origin cell. If direction is South to North, offset is the the South border of the origin cell. If direction is North to South, offset is the North border of the origin cell.
	Offset Origin for Cell Labeling			0.0	
	Fractional Degrees Degrees Northing or Easting	F10.0	21-30		
	Minutes	F3.0	31-33		
	Seconds	F7.4	34-40		

Columns 41 through 80 identical field definitions for labeling in the orthogonal direction. The default Cell Labeling Direction Code for these fields is "NS."

Table 2 (Continued)

	Field	Format	Columns	Default	Remarks
Card 7 (cont.)	Second Cell Numbering Direction	A2	41-42	SN	(See Card 6)
	First Cell Number in This Direction	I10	43-52	1	
	Increment in This Direction	I8	53-60	1	
	Offset Origin for Cell Numbering in This Direction Fractional Degrees Degrees Northing or Easting	F10.0	61-70	0.0	
	Minutes	F3.0	71-73		
	Seconds	F7.4	74-80		

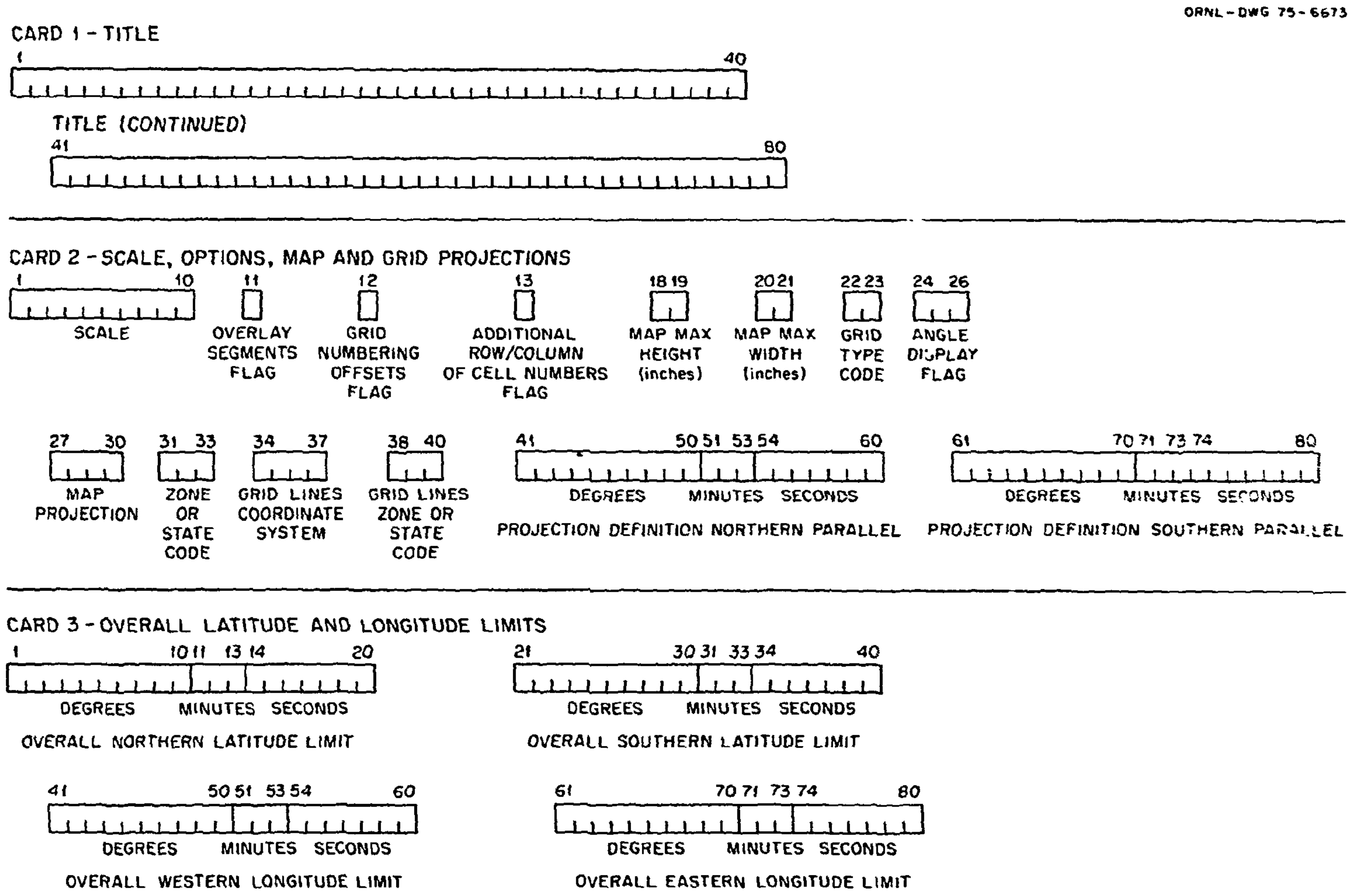

Fig. 16. Layout Sheets for GRIDOT Data Cards 1-3.

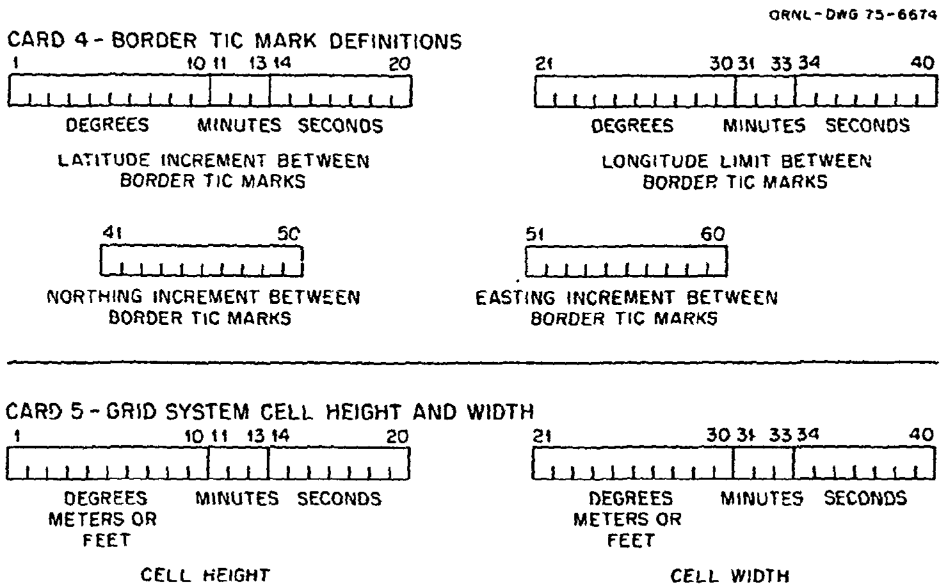

Fig. 17. Layout Sheets for GRIDOT Data Cards 4 and 5.

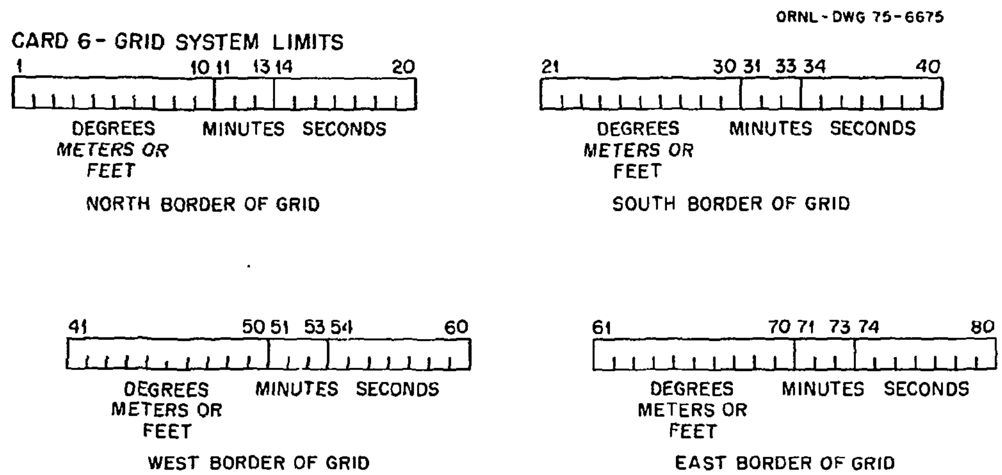

Fig. 18. Layout Sheet for Gridot Data Card 6.

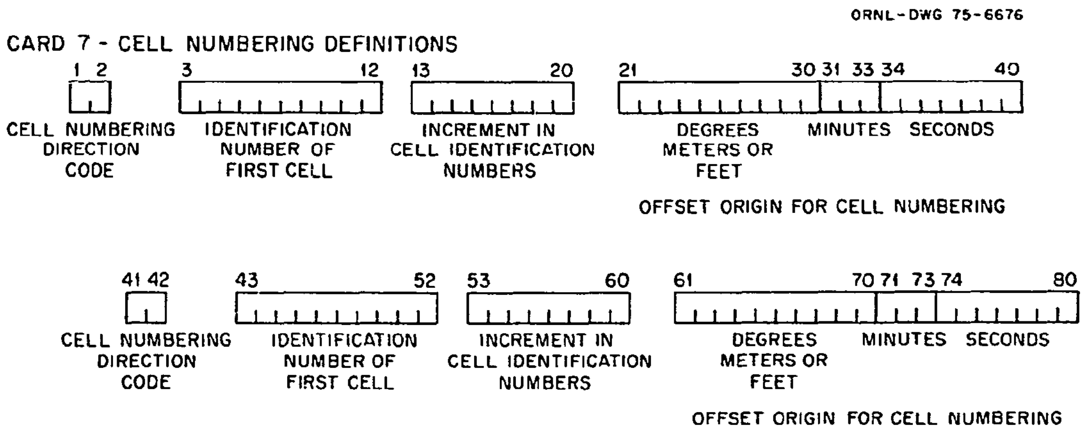

Fig. 19. Layout Sheet for GRIDOT Data Card 7.

The GRIDOT program does not provide a projection known as "Transverse Mercator." This projection is used for many current USGS and Army Map Service publications. For small areas (up to two degrees in latitude or longitude), a Polyconic projection will be virtually indistinguishable from the "Transverse Mercator" projection. Thus users of either Polyconic or "Transverse Mercator" maps may omit an entry in the map projection data field of data card 2, since a Polyconic projection is the default.

The codes used for the various projections are

1. POLY = Polyconic
2. ALBR = Albers Equal Area
3. UTMR = Universal Transverse Mercator
4. LAMB = Lambert's Conformal
5. STAT = State-plane system.

This information is given on card 2.

4.3. Specification of the Coordinate System

In addition to specifying a projection in which the map is to be plotted, the user must also specify a coordinate system for the grid itself. The three types of coordinate systems which the user may specify are:

1. UTMR = Coordinate system measured in meters based on the Universal Transverse Mercator projection. The zone number of the meridian midway between the overall longitude limits is assumed if no zone number is stated.

2. STAT = Coordinate system measured in feet based on the state-plane system. The particular state being used must be given as a state-plane code (see Appendix C).

3. LTLN = Coordinate system measured as angles of latitude and longitude which may be used with any map projection. If no coordinate system type is given, LTLN is assumed to be the default.

The Polyconic, Albers, and Lambert codes are not permitted in this field for the following reason. It is very unusual for data to be based in any of these three coordinate systems, and the inexperienced user often confuses the projection of the grid coordinate system with the projection of the map overlay. By not permitting the user to draw lines of constant Polyconic, Albers, or Lambert northing and easting, the GRIDOT program can determine a juxtaposition of the two projection concepts.

The grid consists of a rectangular raster if the grid coordinate system projection and the map projection are the same. The grid lines are curves if the two are different. The spacing of the grid lines is dependent on the cell size specified on data card 5.

4.4. Specification of the Cell Size

The distances between successive horizontal lines and between successive vertical lines of the grid are called the cell height and width, respectively. The cell size may be measured in (1) latitude and longitude angle increments, (2) Universal Transverse Mercator northing and easting increments (measured in meters), or (3) state-plane northing and easting increments (measured in feet). Card 5 is used to specify the cell height and width. The type of increments (the coordinate system) used to measure the cell size is given on data card 2. The grid is assumed to be measured in latitude-longitude increments unless otherwise specified. The grid lines are drawn at constant latitude-longitude or northing-easting of the coordinate system used to define the cell size. Section 4.5 describes the format in which latitude-longitudes or northing-eastings are punched on the input card.

4.5. The Card Format for Punching Latitude-Longitudes or Northing-Eastings

There are several different places on the input cards in which the user may (or must) enter either a latitude and longitude (or a northing and easting). The program has been set up so that a consistent format is used for all occurrences of these parameters. In specifying latitudes and longitudes the user may use either a "degrees and fractions-of-degrees" convention or a "degrees-minutes-seconds" convention interchangeably. However, the GRIDOT program will display latitudes and longitudes on the printed output and the map overlay in degrees-minutes-seconds unless the letters "DEG" are entered for the angle display flag on data card 2. All angles are read using an (F10.0, F3.0, F7.4) format. Angles specified in degrees and fractions of a degree use only the first F10.0 field, and must be stated using a decimal point. On the other hand, degrees, minutes and seconds may be written with the least significant degree digit in the 10th position (F10.0), the least significant minutes digit in the 13th position (F30), and the units digit of the seconds in the 16th position (F7.4), all three fields without a decimal point. The seconds field may contain a decimal point if it is necessary to specify a fractional number of seconds.

Northings and eastings are always entered as 10-column fields with a format of F10.0. In several cases (for example, the grid cell height and width) fields contain either a latitude-longitude angle, or a northing-easting measurement. For these parameters the first F10.0 portion of a 20-column field is the degrees part of an angle, or the northing (or easting) if the parameter is in UTM meters or state-plane feet. In other words, the F3.0 and F7.4 used for minutes and seconds are ignored when specifying northings and eastings rather than latitudes and longitudes.

4.6. Specification of the Type of Overlay Grid Marks

The grid may be drawn in one of three formats, each of which is indicated by a two-character code in data card 2.

1. PC (the default) for "plus at corners." The intersections of the horizontal and vertical grid lines are represented by a plus sign 0.06 inches high (about 1/16 inch). The grid lines themselves are not plotted. The plus signs designate the corners of each cell.

2. GL for grid lines. These lines represent the edges of each cell.

3. GP for grid lines and a plus sign at the center of the cells.

4.7. Specification of the Extent of the Overlay Grid

As was discussed in Section 3.4, the user has the option of preparing a grid for the entire bordered area lying between the overall latitude/longitude limits given on card 3, or he may choose to restrict the gridding to some smaller gridded area within these limits to save on plotter time.

Data card 6 may be used to define the grid area subset by specifying northern/southern latitude boundaries, followed by western/eastern longitude boundaries. The cell height must evenly divide the latitude limits, and the cell width must divide the longitude limits. If data card 6 is left blank, the grid will fill the entire area specified on data card 3. Alternatively, the grid area subset may be defined on data card 6 as northern and southern boundaries given as northings (meters or feet), followed by eastern and western boundaries given as eastings (meters or feet).

4.8 Defining the Labels for the Rows and Columns of the Grid

On data card 7 are two groups of fields. Either one may be used for the vertical direction labeling scheme. The other is used for the horizontal direction. If the entire data card is left blank, cells are numbered from south to north by 1 starting at 1, and from west to east by 1 starting at 1. If something other than this convention is desired, then the fields are used as follows:

Field 1: A two-character code for the sense of the numbering being defined. Use either NS, SN, WE, or EW (NS=north to south, SN=south to north, WE=west to east, EW=east to west).

Field 2: The label of the first row of cells in this direction. Assumed to be 1 if no value is provided.

Field 3: The increment between successive cell labels. Assumed to be 1 if no value is provided.

Field 4: (Used only if the flag in column 12 of data card 1 is marked "Y".) The standard parallel (latitude), or northing (for vertical numbering), or the standard meridian (longitude), or easting (for horizontal numbering), of the origin used to define the labeling scheme. The relation of the origin to the labels of the rows and columns is discussed in Section 3.5.

4.9. Specifications of Tic Marks Along the Overall Latitude-Longitude Border

Angle increments and/or northing-easting increments may be entered in data card 4 to generate tic marks along the overall latitude-longitude border. The tics are approximately 1/4 inch long drawn either inside the border (for latitude-longitude marks) or outside the border (for either UTM or state-plane tic marks). Tic marks are generated along the border for every latitude and longitude and/or for every northing and easting of the grid coordinate system that is evenly divided by the given increment. In the case of a latitude-longitude grid coordinate system, the use may generate latitude-longitude tic marks and/or UTM tic marks. These tic marks may serve as reference points to aid in positioning the overlay on top of a map.

5. DESCRIPTION OF OUTPUT

5.1. The Map Overlay (Calcomp Plotter Output)

The 80 characters of identification from data card 1 are plotted at the bottom margin of the overlay. The overall latitude and longitude limits are identified either in a "degrees and fractions of degrees" convention, or a "degrees-minutes-seconds" convention, according to the setting of the angle display flag (data card 2). Unless otherwise limited (by parameters on data card 2) the overall latitude limits must be separated by no more than 27 inches (for a 30-inch Calcomp plotter), and the longitude limits by no more than 40 inches. If an extra row and column of cell identification numbers are specified, the extra row is added at the top of the plot and the extra column at the right edge. The extra row and column numbers may be cut off the plot and used as an aid in the digitization (see Section 6.3). There is a registration mark in the lower left hand corner in the shape of a cross, 1/2 inch high and wide. This mark is drawn before the generation of the plot and then redrawn at the end of the plot. If the plotter is malfunctioning, two crosses will not fall one on top of the other, as shown in Figure 20.

5.2. The Printed Data Log

As shown in Figure 21, every input data item, whether explicitly given or assumed by default, is reported for each overlay. This enables the user to determine if an input error was made or if the expected default was not the one used. The data log corresponds to the overlay of Figure 20.

5.3. Error Messages

The GRIDOT program automatically checks for a number of errors. They are all related to invalid input specifications by the user. Appendix B lists the messages which may be produced by input errors.

ORNL-DWG 75-12963

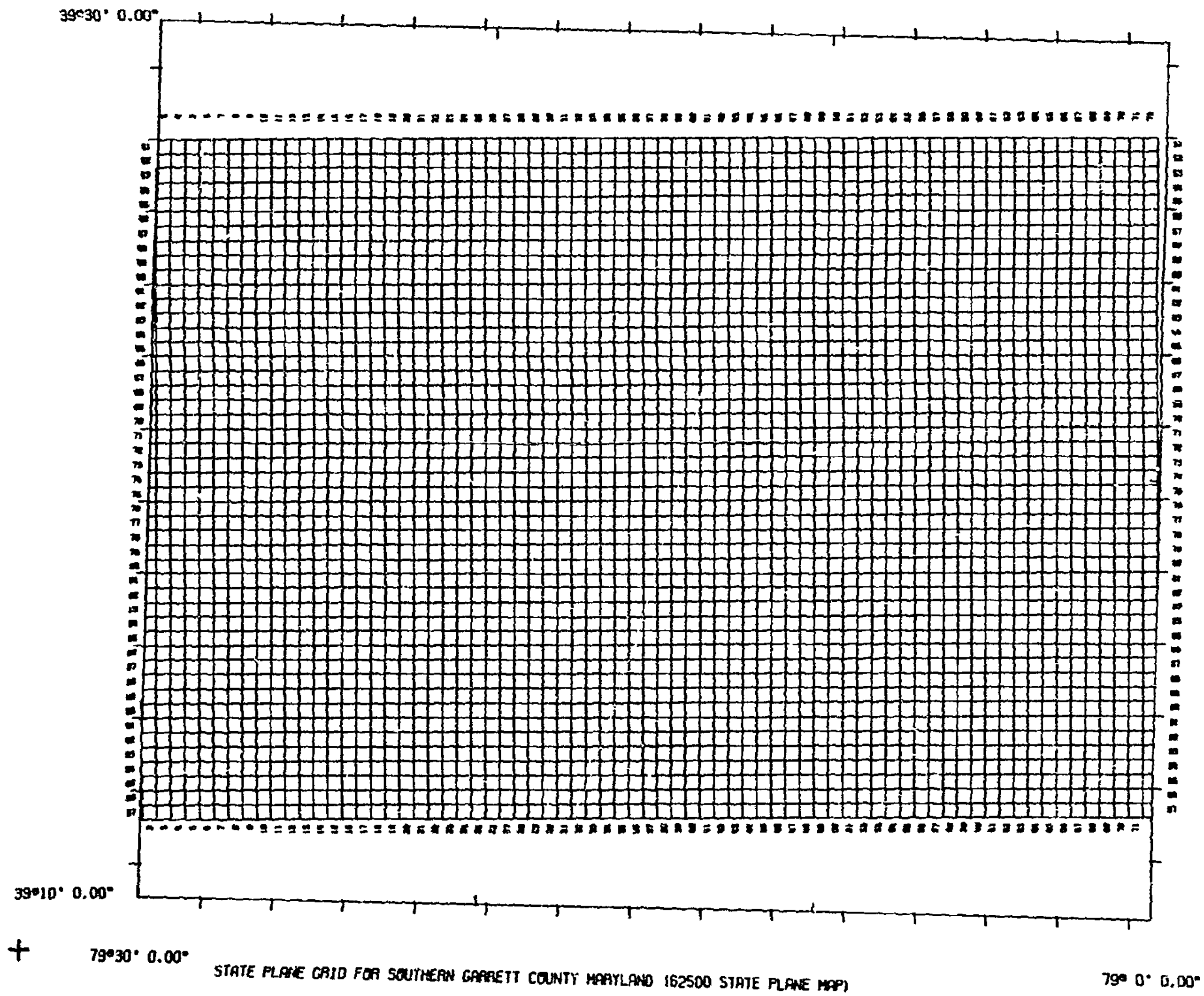

Fig. 20. Use of the Registration Mark to Assess Plotter Accuracy.

ORNL-DWG 75-15390

```
490*************************************************************************************************
   *************************************************************************************************
                        STATE PLANE GRID FOR SCUTHERN GARRETT CCUNTY MARYLAND (62500 STATE PLANE MAP)
   *************************************************************************************************
   *************************************************************************************************

        MAP SCALE                     =        (1/    62500.)
        POLYGONAL OVERLAY?            =        N (N=NO.Y=YES)
        GRID NUMBERING OFFSET?        =        Y (N=NO.Y=YES)
        ADDITIONAL CELL NUMBERS?=              N (N=NO.Y=YES)
        MAXIMUM MAP HEIGHT            =        27 INCHES
        MAXIMUM MAF WIDTH             =        40 INCHES
        GRID TYPE                     =        GL (PC=+ AT CCRNERS. GL=GRID LINES. GP=GRID AND CENTERED +)
        FRACTIONAL DEGREES/DMS        =        DMS
        MAP PROJECTION                =        STAT
        MAP STATE CODE                =         MD
        GRID PROJECTION               =        STAT
        GRID STATE CODE               =         MD
        LATITUDE BOUNDARY NORTH =              39. DEG   30. MIN    0.0    SEC
        LATITUDE BOUNDARY SOUTH =              39. DEG   10. MIN    0.0    SEC
        LONGITUDE BOUNDARY WEST =              79. DEG   30. MIN    0.0    SEC
        LONGITUDE BOUNDARY EAST =              79. DEG    0. MIN    0.0    SEC
        LATITUDE TIC INCREMENT        =         0. DEG   10. MIN    0.0    SEC
        LONGITUDE TIC INCREMENT =               0. DEG   10. MIN    0.0    SEC
        NORTHING TIC INCREMENT        =              10000.
        EASTING TIC INCREMENT         =              10000.
        NORTH/SOUTH GRID SPACING=                     2000. F
        EAST/WEST GRID SPACING        =               2000. F
        NORTH GRID BORDER             =             600000. F
        SOUTH GRID BORDER             =             506000. F
        WEST GRID BORDER              =              92000. F
        EAST GRID BORDER              =             234000. F
        GRID CELL NUMBERING           =        WE FROM         1 BY       1
        GRID NUMBERING ORIGIN         =              90000. F

        GRID CELL NUMBERING           =        NS FROM         1 BY       1
        GRID NUMBERING ORIGIN         =             700000. F

IHC002I STOP        0
```

Fig. 21.   A Typical Data Log.

6. TECHNIQUES OF GRID DIGITIZING

6.1. Introduction to Spatial Digitization

Once the proper overlay grid has been plotted by the GRIDOT program, the user must then determine the manner in which the geographical data is to be represented and stored in the grid system. Various techniques for representing gridded data are discussed in Section 6.2. It is important that the user retain the information content necessary to perform the intended spatial analyses. For example, storing the dominant land-use characteristic in each cell will not allow the user to search the data base later for all occurrences (no matter how small) of one particular land-use.

A few techniques for actually digitizing and coding the data are discussed in Section 6.3. With certain types of spatial data it is possible to use manual shortcuts that will save labor costs and time. These schemes allow for digitizing either areal data (that is, data that may be defined as an enumeration average, or representative value for any area within a given region, such as precipitation) or lineal data (data defined by a curve, such as a lake shore). Of these types of data, areal data present the greater challenge and are discussed in the following sections. Lineal data capture is specifically discussed in Section 6.2.6. The following paragraphs present a few of the techniques and problems which the user must be aware of.

As areal data is being gathered and recorded, it is possible to transform the information into variables that are suited to specific analyses. For example, an agricultural capability unit could be derived and recorded from soil information rather than the raw soil data. Similarly, slope or aspect data could be derived from elevation data; growing season, from rainfall and temperature data. This is sometimes a mistake, however, for the raw information is usually more valuable. One should remember that computer techniques can usually determine the derived variables from raw data more quickly and accurately than the human recorder. Also, the raw data may be more useful in some other analysis as compared to a more specific derived quantity.

Categorizing is an important transformation concept in dealing with data-oriented analysis. The following example shows transformation of the continuous variable, precipitation, to a 5-value (state) category variable.

0: No precipitation
1: 0 to 10 inches/year
2: 10 to 30 inches/year
3: 30 to 60 inches/year
4: Over 60 inches/year

On converting the data to such a basis, some information is lost, and the analyst must take this into account when questions of accuracy or suitability for another analysis arise.

Another useful data gathering technique is the combination of two or more quantities in a single datum. The most common use of this technique consists of superimposing a Boolean variable (presence or absence of a characteristic) on another variable. For example, if predominant land-use (as categories) is being recorded, presence of a utility easement in a cell could be indicated by using the negative of the land-use code to show this condition. Similarly, the negative of a soil type code could be used to record the presence of a sink hole in a given cell.

These examples present a few of the types of problems which must be considered by the investigator before embarking on a large data collection effort. In the next section we will present several common techniques for spatially converting areal and surface feature data to a grid cell basis, that is, to a rectangular array of numbers.

6.2. Techniques for Grid Representation of Spatial Data

6.2.1. Dominant Characteristic

Classification by dominant characteristic assigns to the cell the value of the dominant variable or the value of the dominant characteristic of the cell. If crop type is being digitized, the value of the dominant variety is the value of the cell, e.g., 35% barley. As a simpler example, a cell could be coded with just the presence of the dominant feature, such as an M (for meadow land) if the cell contains more area of meadow land than any other category. Notice that a cell consisting of 40% meadow land, 30% cultivated farm land, and 30% roads and highways would be coded as meadow land in this scheme.

The advantage of the "dominant characteristic" method is simplicity, but at the expense of lost information, as shown in the second example.

6.2.2. Set Percentage Basis

This scheme is basically a superposition of additional variables (present-not present) on a dominant characteristic variable. For example, a variable such as crop type might be zero unless the area under cultivation exceeds a user-supplied threshold (say 10%), after which the dominant crop code and percentage of cultivation in the dominant crop are recorded.

6.2.3. Cell Center Characteristic

This method assigns to the cell the value of the variable or variables at the cell center. The GRIDOT program contains an option to put tic marks at the center of each cell for this purpose. The method offers a straightforward rule for digitizing. This technique is quite useful with a continuous variable such as elevation, which can be subsequently interpolated to obtain a finer level of information. This method also eliminates the digitizing bias in trying to estimate the dominant characteristic.

6.2.4. Percent of Cell Basis

If a variable being digitized changes significantly within the cells, the digitization may consist of an estimate of the percentage of cell area occupied by one or more of the variables being digitized. Using a previous example, one might attempt to estimate the percentage of each land-use category; for example, "40M, 30CF, 30RH," for 40% meadow land, 30% cultivated farmland, and 30% roads and highways.

A simpler rule for this scheme is to estimate area percentages for the first two or first three dominant categories. Subsequent computer processing can be used to convert the percentages to a standard basis, such as acreage or square miles.

6.2.5. Use of Subcell Identification

For digitizing features in which the user wishes to maintain some idea of where the feature is located within a cell, a subcell identificaton may be used. For example, in gathering forestation data the digitizer might record not only the percent of cell area covered by hardwoods, but he might also record the corner (northeast=1, southeast=2, southwest=3, or northwest=4) of the cell in which most of the hardwoods occur. In the case of point data, such as location of public buildings (school locations, churches, libraries, etc.), this technique provides a way of pinpointing the information more accurately. This type of digitizing is especially useful when a hierarchical grid structure is used, as in the ORRMIS land-use data base.[4]

6.2.6. Length of Lineal Feature

Rather than encoding lineal features by a series of cells marked "feature present" or "feature not present" (using a variable that is, say, 1 and 0, respectively), one might consider estimating the length of the linear feature in each cell. An analysis of shoreline development might be a case where this higher order approximating scheme would be justified.

6.2.7. Sampling and Interpolation

In the case of a slowly varying continuous variable, such as average rainfall or mean temperature, one might consider digitizing a number of representative cells, being sure to choose a larger number of samples in those areas where variations occur more frequently. Computer interpolation techniques can be used to fill in the missing values within the grid. A complete digitized map may then be produced, including the calculated values, and overlaid on the original source map, if one exists. Any data values which have been grossly miscalculated can then be edited to produce a final digitized map which require much less time than digitizing every cell. These methods are not useful for density variables (that is, any variable with units of "a count of something per unit area"). Population density and housing density are examples of variables not suited to sampling and interpolation.

6.3. Techniques for Coding Digitized Data

The following discuss various methods for recording the information being digitized. The common, straightforward technique consists of writing a data value for each cell, row by row and column by column. In order to identify the row and column numbers easily and quickly, especially when using the "column-change" format described below, the user may cut out the extra strip of column numbers drawn at the top of the plot and tape them to a ruler or T-square, which is then placed below each successive row of cells as they are digitized. This configuration is shown in Figure 22. This technique eliminates the continual looking up to the top of the plot to find the appropriate column numbers. If the operator is digitizing successive columns rather than successive rows (as shown in Figure 22), then the extra strip of row numbers on the extreme right hand side of the plot may be cut out, taped on a T-square, and the plot rotated 90^0 for the column scan.

If the data changes slowly, one might use a "column-change" format in which the digitizer records the data row by row and enters the column number and value of each series of cells in each row that have the same value. Rows can be skipped if the previous row defines the succeeding row. For example, the shorthand method could be used to define a 25 by 25 grid where

Row 1:	Columns	1-4	have the value 10
		5-17	have the value 12
		18-25	have the value 11
Row 2:	Columns	1-5	have the value 10
		6-17	have the value 12
		18-25	have the value 11
Row 3:	(Same as Row 2)		
Row 4:	Columns	1-4	have the value 10
		5-16	have the value 11
		17-25	have the value 10

Table 3 shows the recorded data in a form suitable for keypunching. With certain types of data it would be more convenient if the user could digitize polygonal outlines or simple line segments and then transform them to a grid basis using computer techniques. The GRIDOT program has the option of plotting plus marks at the corners of the cells as was shown in Figure 6. This grid may then be overlaid on a map from which polygonal outlines are to be digitized representing, for example, county outlines. Horizontal and vertical straight lines are drawn from one tic mark to an adjacent tic mark to best approximate the polygonal outlines.

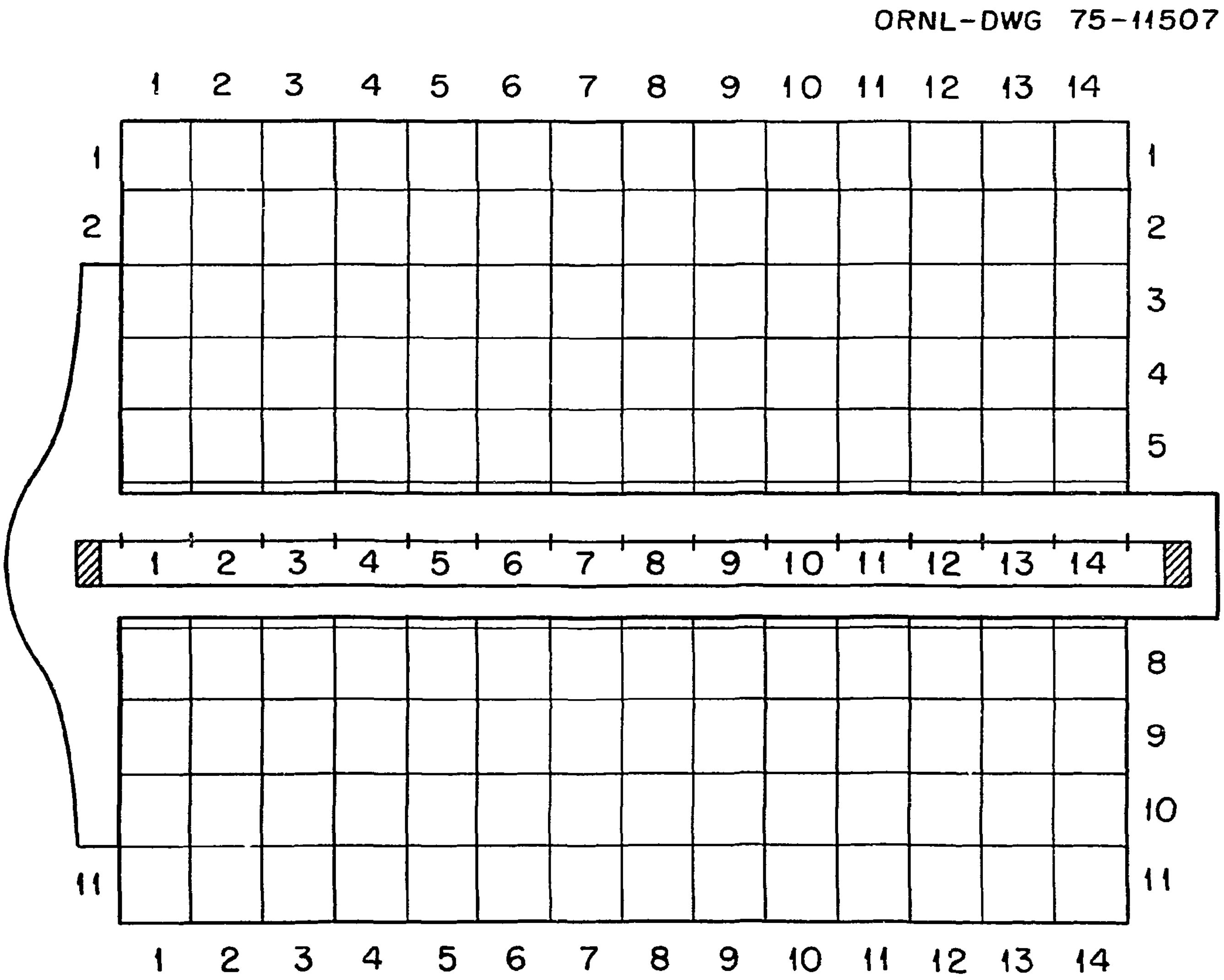

Fig. 22. Using a Registration Strip on a T-Square as an Aid in Row Coding.

Table 3. Data Captured in Column Change Format.

	Column	Value
Row 1	1	10
	5	12
	18	11
Row 2	1	10
	6	12
	18	11
Row 4	1	10
	5	11
	17	10

In Figure 23 is a grid with four regions defined by manually drawn horizontal and vertical lines. The tic marks are identified by row and column numbers as shown. Notice that the scheme depends on the outlines being drawn as a set of vertical and horizontal segments only. No diagonal segments are allowed. The outline of the polygon representing region number 1 is a set of segments from

```
 Col. Row     Col. Row     Col. Row     Col. Row     Col. Row
( 1 , 6 ) to ( 10 , 6 ) to ( 10 , 9 ) to ( 15 , 9 ) to ( 15 , 11) to

 Col. Row     Col. Row     Col. Row     Col. Row
( 11 , 11) to ( 11 , 13) to ( 1 , 13) to ( 1 , 6 ) .
```

Notice that the first and second points have the same row number. The second and third points then have the same column number, and so on, in alternating fashion. The last number written for each region should be identical to the starting row number, thus indicating that the polygon is closed. By eliminating these duplicate row and column numbers the digitizer can shorten the amount of numbers to be written down, as shown in Table 4. Notice that each region number is followed by a starting column and row number. The outline is then described by alternating column and row numbers as shown in Table 4. Computer techniques can be used to translate this shorthand notation and convert the row and column numbers into a series of x,y coordinates defining the vertices of each polygonal area. These coordinates are then used to determine the cell centers falling in each polygonal area so that the cells may be assigned to the proper polygon.

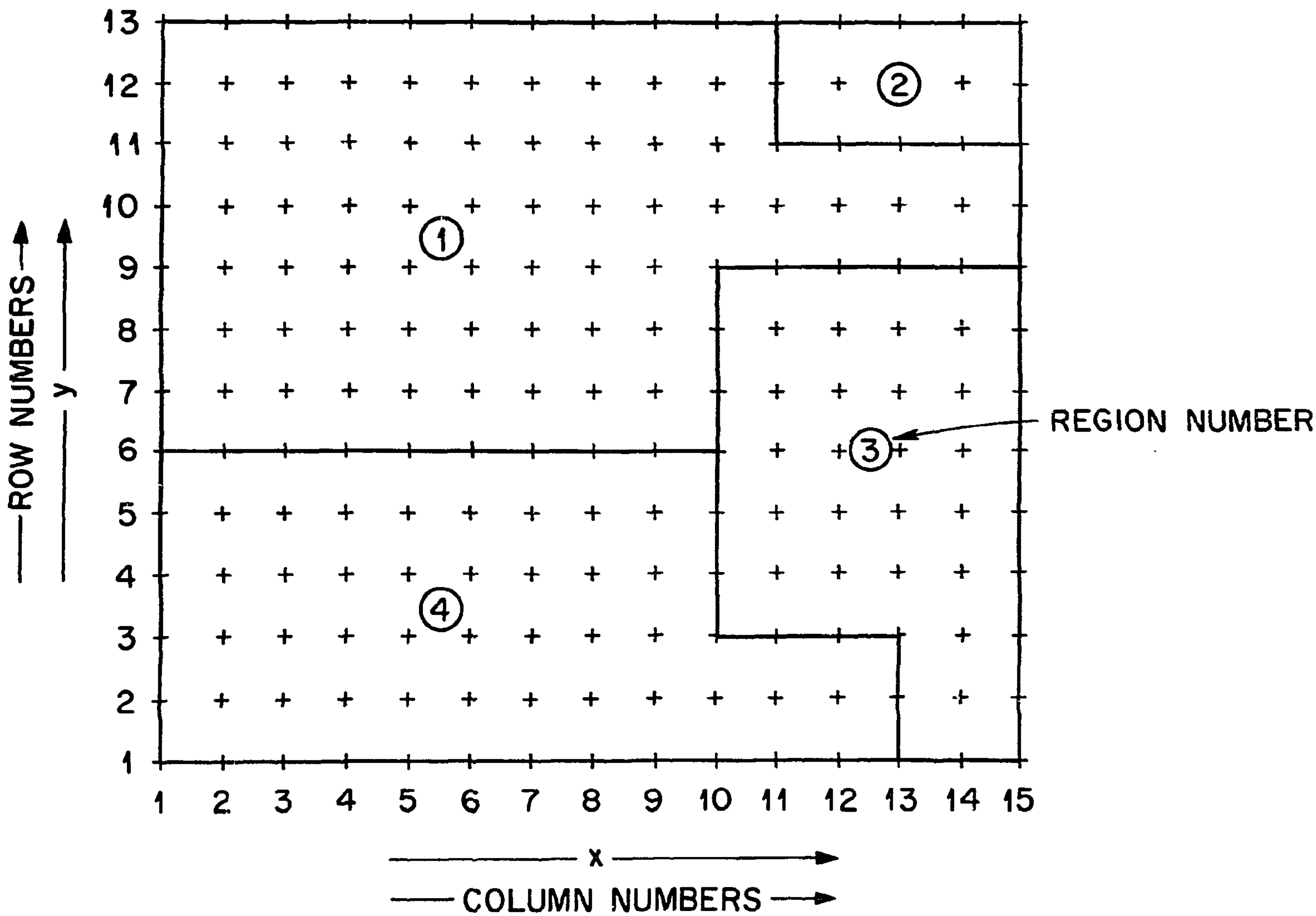

Fig. 23. Data Suitable for Alternate Index Data Capture.

Table 4. Data Captured in Alternate Index Format.

Region No.	Starting Col./Row No.	Col. No.	Row No.	Col. No.	Row No.	Col. No.	Row No.	Col. No.	Row No.
1	(1,6)	10	9	15	11	11	13	1	6
2	(11,13)	15	11	11	13				
3	(15,9)	10	3	13	1	15	9		
4	(1,6)	10	3	13	1	1	6		

7. COMPUTATIONAL TECHNIQUES

7.1. Plotting Techniques

The GRIDOT program will plot lines on the overlay using as few plotter coordinates as possible. Each lineal feature of the overlay output (for example, a southern latitude border) is drawn as a series of straight line segments. The number of segments in the approximation of the plotted curve is chosen so that the maximum error in the segmental approximation is no more than 1/100 of an inch, and the number of segments is the last number that meets this error criterion. The plotting of the curves is performed by the utility routine BILINE.

The program is also designed so that pen motion is kept to a minimum. For example, when the horizontal (or vertical) grid lines are being drawn, the pen moves in a zig-zag fashion. In other words, after drawing a line from left to right, the pen then draws the next line from right to left rather than wasting motion by moving back to the left margin and always drawing left to right. Likewise, the labeling of the rows and columns is done whenever the pen is closest to the point at which a label is to appear.

7.2. Uses of the Map Projection Routines

All the map projection routines are called using a standard argument list. There are four subroutines with identified argument lists. They are

Subroutine Name	Function
PROJ 'NE'	Calculates northing and easting from latitude and longitude
PROJ 'LL'	Calculates latitude and longitude from northing and easting
PROJ 'NL'	Calculates northing and longitude from latitude and easting
PROJ 'LE'	Calculates latitude and easting from northing and longitude

Reference 1 by T. C. Tucker should be consulted for additional information on the projection routines.

8. POSSIBLE FUTURE IMPROVEMENTS

8.1. Additional Tic Mark Capability

In the case of a latitude-longitude grid coordinate system, the present GRIDOT program permits the user to generate latitude-longitude tic marks and/or UTM tic marks around the border. In the case of a UTM or state-plane grid, the user may draw latitude-longitude tic marks and/or either UTM or one of the state-plane tic marks, according to the projection of the grid coordinate system. A useful extension would permit the user to specify tic marks for several grid coordinate systems instead of just two.

8.2. Hewlett Packard Angle Convention

The Hewlett Packard hand calculators use a convention for specifying angles that uses the format Degrees.MinutesSeconds. For example, 139° 14′ 3.75″ is entered as 139.140375. This convention allows the user to enter the angle in a single field (as opposed to remembering where three fields are defined) but still retains the convenience of a degress-minutes-seconds notation. The feature could be specified by a third angle convention code, HPD, for Hewlett-Packard Degrees.

8.3. Provision for Other Map Projections

The five projections presently provided are commonly used for small areas, that is, up to a few degrees. A possible future extension would permit overlays for global areas or extreme latitudes. Also, the user will recall the lack of a "Transverse Mercator" projection, which may be added to some future version. These additions would not result in any change to the format of the input cards but simply the addition of another map projection name.

8.4. Overlaying Segmental Outlines on the Grid

In data card 2 the program provides for a flag to allow drawing those portions of a set of line segments falling within the overall latitude-longitude limits. This feature is presently not implemented. When it is, these segments may define political or administrative subdivisions, (county outlines, census districts), or natural or man-made features (land cover, highways). Such a capability would allow the user to digitize variables for specific geographical areas only (for one county, perhaps) where these areas were not rectangular in shape. By using these segmental outlines the user would also find it easier to register his overlay on base maps or even rectified aerial photographs if roads or other factors were drawn on top of the grid. The manner in which the segmental outlines would be formatted has yet to be determined.

One new test version of GRIDOT has been run to determine the feasibility of plotting county outlines on top of the grid, as shown in Fig. 24. This new version of GRIDOT has not been generalized or completely debugged, and thus is not described here. Future documentation will be provided for this and other new features.

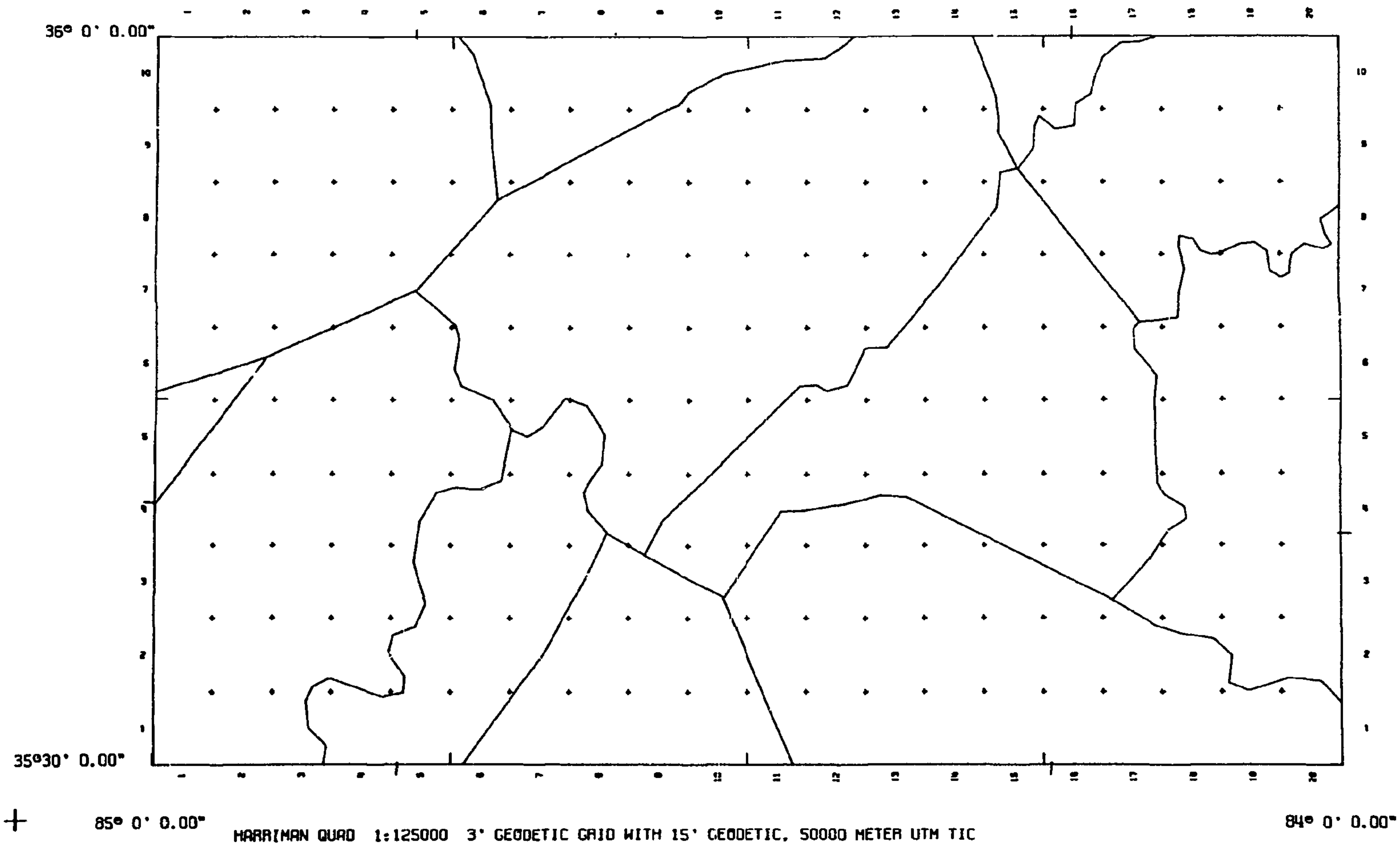

Fig. 24. A Grid Overlay for the Harriman Quadrangle ($1^0 \times 30'$) in East Tennessee with County Outlines Superimposed.

REFERENCES

1. T. C. Tucker and L. J. Campbell, *CATCH: Computer Assisted Topography, Cartography, and Hypsography. Part I: MAPROJ: A Subroutine Package for a Number of Common Map Projections*, ORNL/TM-3790 (in press).

2. R. G. Mashburn, R. C. Durfee, and R. G. Edwards, *REGRID: A Generalized Grid-to-Grid Transformation Procedure*, ORNL/RUS-18 (in press).

3. C. R. Meyers, D. L. Wilson, and R. C. Durfee, *An Application of the ORRMIS Geographical Digitizing and Information System Using Data from the CARETS Project*, ORNL/RUS-12 (in press).

4. R. C. Durfee, *ORRMIS: Oak Ridge Regional Modeling Information System (Part I)*, ORNL/NSF/EP-73 (1974).

APPENDIX A
STATE CODES USED IN SPECIFYING STATE-PLANE PROJECTIONS

State	Zone	Code
Alabama	East	ALE
	West	ALW
Arizona	East	AZE
	Central	AZC
	West	AZW
Arkansas	North	ARN
	South	ARS
California	Zone 1 (North)	CA1
	Zone 2	CA2
	Zone 3	CA3
	Zone 4	CA4
	Zone 5	CA5
	Zone 6 (South)	CA6
	Zone 7 (LA)	CA7
Colorado	North	CON
	Central	COC
	South	COS
Connecticut		CT
Delaware		DE
Florida	East	FLE
	West	FLW
	North	FLN
Georgia	East	GAE
	West	GAW
Idaho	East	IDE
	Central	IDC
	West	IDW
Illinois	East	ILE
	West	ILW
Indiana	East	INE
	West	INW
Iowa	North	IAN
	South	IAS

State	Zone	Code
Kansas	North	KSN
	South	KSS
Kentucky	North	KYN
	South	KYS
Louisiana	North	LAN
	South	LAS
Maine	East	MEE
	West	MEW
Maryland		MD
Massachusetts	Mainland	MAM
	Island (SE)	MAI
Michigan	East	MIE
	Central	MIC
	West	MIW
Minnesota	North	MNN
	Central	MNC
	South	MNS
Mississippi	East	MSE
	West	MSW
Missouri	East	MOE
	Central	MOC
	West	MOW
Montana	North	MTN
	Central	MTC
	South	MTS
Nebraska	North	NEN
	South	NES
Nevada	East	NVE
	Central	NVC
	West	NVW
New Hampshire		NH
New Jersey		NJ
New Mexico	East	NME
	Central	NMC
	West	NMW

State	Zone	Code
New York	Long Island	NYL
	East	NYE
	Central	NYC
	West	NYW
North Carolina		NC
North Dakota	North	NDN
	South	NDS
Ohio	North	OHN
	South	OHS
Oklahoma	North	OKN
	South	OKS
Oregon	North	ORN
	South	ORS
Pennsylvania	North	PAN
	South	PAS
Rhode Island		RI
South Carolina	North	SCN
	South	SCS
South Dakota	North	SDN
	South	SDS
Tennessee		TN
Texas	North	TX1
	North Central	TX2
	Central	TX3
	South Central	TX4
	South	TX5
Utah	North	UTN
	Central	UTC
	South	UTS
Vermont		VT
Virginia	North	VAN
	South	VAS
Washington	North	WAN
	South	WAS

State	Zone	Code
West Virginia	North	WVN
	South	WVS
Wisconsin	North	WIN
	Central	WIC
	South	WIS
Wyoming	Zone I (East)	WY1
	Zone II	WY2
	Zone III	WY3
	Zone IV (West)	WY4

APPENDIX B
LISTING OF ERROR MESSAGES

1. Invalid Map Projection

   The map projection must be either POLY (Polyconic), ALBR (Albers Equal Area), LAMB (Lambert Conformal), UTMR (Universal Transverse Mercator), or STATM (State-plane).

2. Invalid Grid System

   The grid coordinate system must either be LTNL (Latitude-longitude), UTMR (Universal Transverse Mercator), or STAT (State-plane). Remember, UTM systems require a zone code, and state-plane systems require a state-plane code (see Appendix C).

3. Southern Latitude Limit Greater than Northern

4. Eastern Longitude Limit Greater Than Western

   The overall overlay limits are given in northern latitude, western longitude, eastern longitude order. Remember that longitudes increase going west in the western hemisphere.

5. Lat or Long Cell Height or Width Improper

   The user probably forgot to enter a cell height and/or width.

6. Easting at Right Border Less Than Easting at Left Border

7. Northing at Top Border Less Than Northing at Bottom Border

   When the grid area limits are explicitly given, both the UTM and state-plane northings increase from south to north, and increase from west to east. The order of definition of the grid limits is northern limit, southern, western, eastern. The order is the same as the order for the overall latitude-longitude limits.

8. Cell Height Does Not Divide Latitude Limits or Cell Width Does Not Divide Longitude Limits

9. Cell Height Does Not Divide Northing Limits or Cell Width Does Not Divide Easting Limits

   The cell height must divide the north-south grid limits, and the cell width must divide the east-west grid limits, whether the grid is specified in latitude-longitude increments (degrees) UTM increments (meters), or state plane increments (feet).

10. Grid Numbering Direction Not NS, SN, EW, or WE

   Usually a result of placing the grid cell numbering direction code in the wrong columns.

APPENDIX C
FORTRAN LISTING OF SOURCE PROGRAM

GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

```
//STEP1 EXEC FORTHCLG
//FORT.SYSIN DD *
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION LAMBL,LAMCL,LAMNO,LAMEO,LAMRB,LAMN,LAMRZ
      DOUBLE PRECISION STLATS,STLATN,SINLTN,SINSQN,SINLTS,SINSQS,YS,YES
      DOUBLE PRECISION ECCSQ,SINBLT,SINPHI,COSPHI,COSSQ
      INTEGER ZONEID(4),ZONTYP,HTMR
      DOUBLE PRECISION S1,S2,OLAT,CLCN,ORIGN,ORIGE
      DOUBLE PRECISION GTMKZ,GTMRB,GTMDUM
      DOUBLE PRECISION PARM(7),FTPERM
      EQUIVALENCE (PARM(1),OLAT),(PARM(2),OLON),
     &  (PARM(3),ORIGN),(PARM(4),ORIGE),(PARM(5),LAMRB,GTMRB),
     &  (PARM(6),LAMN,GTMKZ),(PARM(7),LAMRZ,GTMDUM)
      DOUBLE PRECISION XDMS,A
      DATA SEMAJ/ 6378206.4D 00 /, SEMIN/ 6356583.8D 00 /
      DATA ECC/ 8.2271854223003000D-02 /,EPSQ/ 6.8147849459150420D-03 /
      DATA NCO/ 6.367399689169782D 06 ,-3.250286241790479D 04 ,
     &          1.384048366716706D 02 ,-7.335388130501429D-01 ,
     &          4.219413411962918D-03 ,-2.529287942342808D-05 ,
     &          1.556058285276589D-07 ,-9.738474374730020D-10 /
      DATA RPD/1.74532925199433D-2/
      DATA HTMR/'TMR'/
      DATA FTPERM/3.2808333333333333D0/
      XDMS(A)=(DMOD(A,1D2)/6D1+IDINT(DMOD(A/1D2,1D2)))/6D1+IDINT(A/1D4)
C    ****PDP-1C STATEMENTS FOR I/O****
C       OPEN(UNIT=25,ACCESS='SEQIN',FILE='INP')
C       OPEN(UNIT=26,MODE='BINARY',ACCESS='SEQOUT',FILE='OUT1')
   10 READ(25,101,END=1000)ZONEID,ZCNTYP,S1,S2,OLAT,OLON,ORIGN,ORIGE
  101 FORMAT(4A1,1X,A4,1X,-4P4F7.2,0P2F12.2)
      S1=XDMS(S1)
      S2=XDMS(S2)
      OLAT=XDMS(OLAT)
      OLON=XDMS(OLON)
      ORIGN=ORIGN/FTPERM
      ORIGE=ORIGE/FTPERM
      IF(ZONTYP .EQ. HTMR)GC TO 20
C DETERMINE THE NEW LAMBERT PROJECTION
      STLATS=DMIN1(S1,S2)
      STLATN=DMAX1(S1,S2)
      SINLTN=DSIN(RPD*STLATN)
      SINSQN=SINLTN*SINLTN
      SINLTS=DSIN(RPD*STLATS)
      SINSQS=SINLTS*SINLTS
      YS=(1D0-SINLTS)/(1D0+SINLTS)
      YES=(1D0+ECC*SINLTS)/(1D0-ECC*SINLTS)
      ECCSQ=ECC**2
      LAMN=DLOG((1D0-SINSQS)/(1D0-SINSQN)*
     &        (1D0-ECCSQ*SINSQN)/(1D0-ECCSQ*SINSQS))/
     &  (DLOG(YS*(1D0+SINLTN)/(1D0-SINLTN))+
     &  ECC*DLOG(YES*(1D0-ECC*SINLTN)/(1D0+ECC*SINLTN)))
```

GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

```
      LAMRZ=SEMAJ*(DCOS(RPD*STLATS))/((DSQRT(1D0-ECCSQ*SINSQS))*
     &  LAMN*DEXP((DLOG(YS)+ECC*DLOG(YES))*(LAMN/2D0)))
      SINBLT = DSIN(RPD*OLAT)
      LAMRB=LAMRZ*DEXP((ECC*DLOG((1D0+ECC*SINBLT)/(1D0-ECC*SINBLT))+
     &  DLOG((1D0-SINBLT)/(1D0+SINBLT)))*(LAMN/2D0)) + ORIGN
      GO TO 30
C TRANSVERSE MERCATOR PROJECTION
   20 GTMKZ=1D0-1D-2/SI
      GTMDUM=0.D0
      SINPHI=DSIN(OLAT*RPD)
      COSPHI=DCOS(OLAT*RPD)
      COSSQ=COSPHI**2
      GTMRB=-((((((((COSSQ*NCO(8)+NCO(7))*COSSQ+NCO(6))*COSSQ+NCO(5))
     &      *COSSQ+NCO(4))*COSSQ+NCO(3))*COSSQ+NCO(2))*COSPHI*SINPHI
     &      +NCO(1)*OLAT*RPD)*GTMKZ + ORIGN
   30 WRITE(26)ZONEID,ZONTYP,PARM
      GO TO 10
 1000 STOP
      END
```

```
//GO.FT26F001 DD DSN=T.RGE14872.GRIDCT.DATA,
//   UNIT=SPDA,DISP=(NEW,CATLG,DELETE),
//   SPACE=(TRK,(5,1),RLSE),DCB=(RECFM=VBS,BLKSIZE=7204)
//GO.FT25F001 DD *
ALE   TMR    250.00    0.0    30.30  85.50          0.0     500000.00
ALW   TMR    150.00    0.0    30.00  87.30          0.0     500000.00
AZE   TMR    100.00    0.0    31.00 110.10          0.0     500000.00
AZC   TMR    100.00    0.0    31.00 111.55          0.0     500000.00
AZW   TMR    150.00    0.0    31.00 113.45          0.0     500000.00
ARN   LAMB    34.56   36.14   34.20  92.00          0.0    2000000.00
ARS   LAMB    33.18   34.46   32.40  92.00          0.0    2000000.00
CA1   LAMB    40.00   41.40   39.20 122.00          0.0    2000000.00
CA2   LAMB    38.20   39.50   37.40 122.00          0.0    2000000.00
CA3   LAMB    37.04   38.26   36.30 120.30          0.0    2000000.00
CA4   LAMB    36.00   37.15   35.20 119.00          0.0    2000000.00
CA5   LAMB    34.02   35.28   33.30 118.00          0.0    2000000.00
CA6   LAMB    32.47   33.53   32.10 116.15          0.0    2000000.00
CA7   LAMB    33.52   34.25   34.08 118.20   4160926.74    4186692.58
CON   LAMB    39.43   40.47   39.20 105.30          0.0    2000000.00
COC   LAMB    38.27   39.45   37.50 105.30          0.0    2000000.00
COS   LAMB    37.14   38.26   36.40 105.30          0.0    2000000.00
CT    LAMB    41.12   41.52   40.50  72.45          0.0     600000.00
DE    TMR   2000.00    0.0    38.00  75.25          0.0     500000.00
FLE   TMR    170.00    0.0    24.20  81.00          0.0     500000.00
FLW   TMR    170.00    0.0    24.20  82.00          0.0     500000.00
FLN   LAMB    29.35   30.45   29.00  84.30          0.0    2000000.00
GAE   TMR    100.00    0.0    30.00  82.10          0.0     500000.00
GAW   TMR    100.00    0.0    30.00  84.10          0.0     500000.00
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GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

IDE	TMR	190.00	0.0	41.40	112.10	0.0	500000.00
IDC	TMR	190.00	0.0	41.40	114.00	0.0	500000.00
IDW	TMR	150.00	0.0	41.40	115.45	0.0	500000.00
ILE	TMR	400.00	0.0	36.40	88.20	0.0	500000.00
ILW	TMR	170.00	0.0	36.40	90.10	0.0	500000.00
INE	TMR	300.00	0.0	37.30	85.40	0.0	500000.00
INW	TMR	300.00	0.0	37.30	87.05	0.0	500000.00
IAN	LAMB	42.04	43.16	41.30	93.30	0.0	2000000.00
IAS	LAMB	40.37	41.47	40.00	93.30	0.0	2000000.00
KSN	LAMB	38.43	39.47	38.20	98.00	0.0	2000000.00
KSS	LAMB	37.16	38.34	36.40	98.30	0.0	2000000.00
KYN	LAMB	37.58	38.58	37.30	84.15	0.0	2000000.00
KYS	LAMB	36.44	37.56	36.20	85.45	0.0	2000000.00
LAN	LAMB	31.10	32.40	30.40	92.30	0.0	2000000.00
LAS	LAMB	29.18	30.42	28.40	91.20	0.0	2000000.00
MAI	LAMB	41.17	41.29	41.00	70.30	0.0	200000.00
MAM	LAMB	41.43	42.41	41.00	71.30	0.0	600000.00
MEE	TMR	100.00	0.0	43.50	68.30	0.0	500000.00
MEW	TMR	300.00	0.0	42.50	70.10	0.0	500000.00
MD	LAMB	38.18	39.27	37.50	77.00	0.0	800000.00
MIE	TMR	175.00	0.0	41.30	83.40	0.0	500000.00
MIC	TMR	110.00	0.0	41.30	85.45	0.0	500000.00
MIW	TMR	110.00	0.0	41.30	88.45	0.0	500000.00
MNN	LAMB	47.02	48.38	46.30	93.06	0.0	2000000.00
MNC	LAMB	45.37	47.03	45.00	94.15	0.0	2000000.00
MNS	LAMB	43.47	45.13	43.00	94.00	0.0	2000000.00
MSE	TMR	250.00	0.0	29.40	88.50	0.0	500000.00
MSW	TMR	170.00	0.0	30.30	90.20	0.0	500000.00
MOE	TMR	150.00	0.0	35.50	90.30	0.0	500000.00
MOC	TMR	150.00	0.0	35.50	92.30	0.0	500000.00
MOW	TMR	170.00	0.0	36.10	94.30	0.0	500000.00
MTN	LAMB	47.51	48.43	47.00	109.30	0.0	2000000.00
MTC	LAMB	46.27	47.53	45.50	109.30	0.0	2000000.00
MTS	LAMB	44.52	46.24	44.00	109.30	0.0	2000000.00
NEN	LAMB	41.51	42.49	41.20	100.00	0.0	2000000.00
NES	LAMB	40.17	41.43	39.40	99.30	0.0	2000000.00
NVE	TMR	100.00	0.0	34.45	115.35	0.0	500000.00
NVC	TMR	100.00	0.0	34.45	116.40	0.0	500000.00
NVW	TMR	100.00	0.0	34.45	118.35	0.0	500000.00
NH	TMR	300.00	0.0	42.30	71.40	0.0	500000.00
NJ	TMR	400.00	0.0	38.50	74.40	0.0	2000000.00
NME	TMR	110.00	0.0	31.00	104.20	0.0	500000.00
NMC	TMR	100.00	0.0	31.00	106.15	0.0	500000.00
NMW	TMR	120.00	0.0	31.00	107.50	0.0	500000.00
NYL	LAMB	40.40	41.02	40.30	74.00	100000.00	2000000.00
NYE	TMR	300.00	0.0	40.00	74.20	0.0	500000.00
NYC	TMR	160.00	0.0	40.00	76.35	0.0	500000.00
NYW	TMR	160.00	0.0	40.00	78.35	0.0	500000.00
NC	LAMB	34.20	36.10	33.45	79.00	0.0	2000000.00
NON	LAMB	47.26	48.44	47.00	100.30	0.0	2000000.00

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NDS	LAMB	46.11	47.29	45.40	100.30	0.0	2000000.00
OHN	LAMB	40.26	41.42	39.40	82.30	0.0	2000000.00
OHS	LAMB	38.44	40.02	38.00	82.30	0.0	2000000.00
OKN	LAMB	35.34	36.46	35.00	98.00	0.0	2000000.00
OKS	LAMB	33.56	35.14	33.20	98.00	0.0	2000000.00
ORN	LAMB	44.20	46.00	43.40	120.30	0.0	2000000.00
ORS	LAMB	42.20	44.00	41.40	120.30	0.0	2000000.00
PAN	LAMB	40.53	41.57	40.10	77.45	0.0	2000000.00
PAS	LAMB	39.56	40.58	39.20	77.45	0.0	2000000.00
RI	TMR	1600.00	0.0	41.05	71.30	0.0	500000.00
SCN	LAMB	33.46	34.58	33.00	81.00	0.0	2000000.00
SCS	LAMB	32.20	33.40	31.50	81.00	0.0	2000000.00
SDN	LAMB	44.25	45.41	43.50	100.00	0.0	2000000.00
SDS	LAMB	42.50	44.24	42.20	100.20	0.0	2000000.00
TN	LAMB	35.15	36.25	34.40	86.00	100000.00	2000000.00
TX1	LAMB	35.39	36.11	34.00	101.30	0.0	2000000.00
TX2	LAMB	32.08	33.58	31.40	97.30	0.0	2000000.00
TX3	LAMB	30.07	31.53	29.40	100.20	0.0	2000000.00
TX4	LAMB	28.23	30.17	27.50	99.00	0.0	2000000.00
TX5	LAMB	26.10	27.50	25.40	98.30	0.0	2000000.00
UTN	LAMB	40.43	41.47	40.20	111.30	0.0	2000000.00
UTC	LAMB	39.01	40.39	38.20	111.30	0.0	2000000.00
UTS	LAMB	37.13	38.21	36.40	111.30	0.0	2000000.00
VT	TMR	280.00	0.0	42.30	72.30	0.0	500000.00
VAN	LAMB	38.02	39.12	37.40	78.30	0.0	2000000.00
VAS	LAMB	36.46	37.58	36.20	78.30	0.0	2000000.00
WAN	LAMB	47.30	48.44	47.00	120.50	0.0	2000000.00
WAS	LAMB	45.50	47.20	45.20	120.30	0.0	2000000.00
WVN	LAMB	39.00	40.15	38.30	79.30	0.0	2000000.00
WVS	LAMB	37.29	38.53	37.00	81.00	0.0	2000000.00
WIN	LAMB	45.34	46.46	45.10	90.00	0.0	2000000.00
WIC	LAMB	44.15	45.30	43.50	90.00	0.0	2000000.00
WIS	LAMB	42.44	44.04	42.00	90.00	0.0	2000000.00
WY1	TMR	170.00	0.0	40.40	105.10	0.0	500000.00
WY2	TMR	170.00	0.0	40.40	107.20	0.0	500000.00
WY3	TMR	170.00	0.0	40.40	108.45	0.0	500000.00
WY4	TMR	170.00	0.0	40.40	110.05	0.0	500000.00

GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

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//STEP2 EXEC FORTGC,CLSIZE=170K
//FORT.SYSLIN DD DSN=T.RGE14872.GRIDOT.HEX,
//   DISP=(NEW,CATLG,DELETE),UNIT=SPCA,
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//   SPACE=(800,(400,20),RLSE)
//FORT.SYSIN DD *
C      PROGRAM GRIDOT
       IMPLICIT REAL*8(A-H,L-Z)
C           WRITTEN AT THE OAK RIDGE NATIONAL LABORATORY
C      THIS PROGRAM DRAWS A GRIDOT LATTICE OF EITHER (1) + MARKS AT THE C
C      INTERSECTIONS OF GEODETIC CELLS, OR (2) STRAIGHT LINES CONNECTING
C      THE CORNER INTERSECTIONS OF GEODETIC CELLS.
C
       DIMENSION LATN(3),LATS(3),LONW(3),LONE(3),DNS(3),DEW(3),
     1   GN(3),GS(3),GW(3),GE(3),PDEF1(3),PDEF2(3),
     2   TICLAT(3),TICLON(3),GZ(3,2),GZERO(2)
       REAL ROUND
       INTEGER KTX,KTY,INPRO,INZON,OUTPRC,OUTZON,ID(2),KZ(2),KGO(2)
       INTEGER TITLE(20),ATOI,LREAD,LWRITE,FEET,METERS,DEGDMS,HDEG,HDMS,
     1   HHPD,HLL,HBLL,HYES,HNO,HPC,HGL,HGP
       INTEGER BLANK,HSTA,HALB,HPOL,HUTM,HLAM,MAXH,MAXW
       INTEGER HNS,HSN,HWE,HEW
       INTEGER HC,HS
       REAL X,Y,SIZE,ANGLE
       LOGICAL DIR,JB,IB
       DATA LREAD/5/,LWRITE/6/,FEET/'F   '/,METERS/'M   '/
       DATA HYES/'Y   '/,HNO/'N   '/,HPC/'PC  '/,HGL/'GL  '/,HGP/'GP  '/
       DATA HDEG/'DEG '/,HDMS/'DMS '/,HHPD/'HPD '/
       DATA HLL/'LTLN'/,HBLL/' LL '/
       DATA BLANK/'    '/,HSTA/'STAT'/,HALB/'ALBR'/,
     1  HPOL/'POLY'/,HUTM/'UTMR'/,HLAM/'LAMB'/
       DATA HNS/'NS'/,HSN/'SN'/,HWE/'WE'/,HEW/'EW'/
       DATA ZERO/0.D0/,SIZE/.06/
       DATA HC/'C   '/,HS/'S   '/
       COMMON /LIMITS/ NBORD,SBORD,WBORD,EBORD,CELNS,CELEW,
     1   SWORGN,SWORGE,NELIMN,NELIME,
     2   X0,Y0,SCALER,SCALE,X,Y,
     3   KTX,KTY,INPRO,INZON,OUTPRC,OUTZON
       COMMON /DEGFLG/ DEGDMS
C
C*****BEGIN INPUT
C
C           READ CARD 1   (TITLE)
 1000 READ(LREAD,8000,END=5700)TITLE
 8000 FORMAT(20A4)
      WRITE(LWRITE,8020)TITLE
 8020 FORMAT(1H1,105(1H*)/1X,105(1H*)//26X,20A4//
     1   1X,105(1H*)/1X,105(1H*)/////)
C
C          READ CARD 2  (SCALE, OVERLAY SEGMENTS FLAG,
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C                        GRID NUMBERING OFFSET FLAG,
C                        ADDITIONAL ROW/COLUMN OF CELL NUMBERS FLAG,
C                        MAXIMUM HEIGHT, MAXIMUM WIDTH, GRID TYPE,
C                        ANGLE DISPLAY FLAG, MAP PROJECTION,
C                        MAP ZONE OR STATE CODE, GRID PROJECTION,
C                        GRID ZONE OR STATE CODE
      READ(LREAD,8040,END=5650)SCALE,ISEG,IOFF,IADDL,MAXH,MAXW,ILINE,
     1     DEGDMS,OUTPRO,OUTZON,INPRO,INZON,PDEF1,PDEF2
 8040 FORMAT(F10.0,3A1,4X,2I2,A2,A3,2(A4,A3),2(-4PF10.0,0PF3.0,0PF7.4))
      IF(DEGDMS .NE. HDEG)DEGDMS=HDMS
      IF(OUTPRO .EQ. BLANK)OUTPRO=HPOL
      IF(INPRO .EQ. HSTA)INUNIT=FEET
      IF(INPRO .EQ. HUTM)INUNIT=METERS
      IF(INPRO .EQ. BLANK .OR. INPRO .EQ. HBLL)INPRO=HLL
      IF(MAXH .EQ. 0)MAXH=27
      IF(MAXW .EQ. 0)MAXW=40
      IF(ISEG .EQ. BLANK)ISEG=HNO
      IF(IOFF .EQ. BLANK)IOFF=HNO
      IF(IADDL .EQ. BLANK)IADDL=HNO
      IF(ILINE .EQ. BLANK)ILINE=HPC
      WRITE(LWRITE,8060)SCALE,ISEG,IOFF,IADDL,MAXH,MAXW,ILINE,
     1   DEGDMS,OUTPRO
 8060 FORMAT(10X,'MAP SCALE                    =            (1/',F9.0,')'/
     1        10X,'POLYGONAL OVERLAY?          =',12X,A1,
     *        ' (N=NO,S=STATE ONLY,C=COUNTY&STATE)'/
     2        10X,'GRID NUMBERING OFFSET?      =',12X,A1,' (N=NO,Y=YES)'/
     3        10X,'ADDITIONAL CELL NUMBERS?=',12X,A1,' (N=NO,Y=YES)'/
     4        10X,'MAXIMUM MAP HEIGHT          =',12X,I2,' INCHES'/
     5        10X,'MAXIMUM MAP WIDTH           =',12X,I2,' INCHES'/
     6        10X,'GRID TYPE                   =',12X,A2,
     7 ' (PC=+ AT CORNERS, GL=GRID LINES, GP=GRID AND CENTERED +)'/
     8        10X,'FRACTIONAL DEGREES/DMS      =',12X,A4/
     9        10X,'MAP PROJECTION              =',12X,A4)
      IF(SCALE .LE. 0.D0)GO TO 5750
      IF(OUTPRO .NE. HSTA .AND. OUTPRO .NE. HALB .AND.
     1  OUTPRO .NE. HPOL .AND. OUTPRO .NE. HUTM .AND.
     2  OUTPRO .NE. HLAM) GO TO 5800
      READ(LREAD,8080,END=5650)LATN,LATS,LONW,LONE
 8080 FORMAT(4(-4PF10.0,0PF3.0,0PF7.4))
      NLAT=DMSTOD(LATN)
      SLAT=DMSTOD(LATS)
      WLON=DMSTOD(LONW)
      ELON=DMSTOD(LONE)
      IF(OUTPRO .NE. HUTM .AND. OUTPRO .NE. HSTA)GO TO 1200
      IF(OUTPRO .EQ. HSTA)GO TO 1150
      IF(OUTZON .NE. BLANK)GO TO 1050
      OUTZON=0
      CALL PROJ('NE',OUTPRO,N,E,SLAT,(WLON+ELON)*.5D0,OUTZON)
      GO TO 1100
 1050 WRITE(LWRITE,8090)OUTZON
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 8090 FORMAT(10X,'MAP UTM ZONE NUMBER     =',12X,A4)
      GO TO 1200
 1100 WRITE(LWRITE,8100)OUTZCN
 8100 FORMAT(10X,'MAP UTM ZONE NUMBER     =',I16)
      GO TO 1200
 1150 WRITE(LWRITE,8120)OUTZON
 8120 FORMAT(10X,'MAP STATE CODE          =',12X,A4)
 1200 IF( INPRO .NE. HLL .AND. INPRO .NE. HSTA .AND.
     1  INPRO .NE. HUTM)GO TO 5850
      IF( INPRO .NE. HUTM .AND. INPRO .NE. HSTA)GO TO 1400
      WRITE(LWRITE,8140)INPRO
 8140 FORMAT(10X,'GRID PROJECTION         =',12X,A4)
      IF( INPRO .EQ. HSTA)GO TO 1350
      IF( INZON .NE. BLANK)GO TO 1250
      INZON=0
      CALL PROJ( 'NE',INPRO,N,B,SLAT,(WLCN+ELON)*.5D0,INZON)
      GO TO 1300
 1250 WRITE(LWRITE,8150)INZCN
 8150 FORMAT(10X,'GRID UTM ZONE NUMBER    =',12X,A4)
      GO TO 1400
 1300 WRITE(LWRITE,8160)INZCN
 8160 FORMAT(10X,'GRID UTM ZONE NUMBER    =',I16)
      GO TO 1400
 1350 WRITE(LWRITE,8180)INZCN
 8180 FORMAT(10X,'GRID STATE CODE         =',12X,A4)

 1400 IF( OUTPRO .NE. HALB .AND. OUTPRO .NE. HLAM)GO TO 1550
      PD1=DMSTOD(PDEF1)
      PD2=DMSTOD(PDEF2)
      IF(PD1 .NE. 0.D0 .AND. PD2 .NE. 0.D0)GO TO 1500
      PD1=27.5D0
      PD2=45.5D0
      PDEF1(2)=30.D0
      PDEF2(2)=30.D0
      IF(DEGDMS .EQ. HHPD)GO TO 1450
      PDEF1(1)=27.D4
      PDEF2(1)=45.D4
      GO TO 1500
 1450 PDEF1(1)=27.3D4
      PDEF2(1)=45.3D4
 1500 IF(DEGDMS .NE. HDMS) WRITE(LWRITE,8200)PD1,PD2
 8200 FORMAT(10X,'STANDARD PARALLEL #1      =',-4PF10.6,' DEG'/
     1       10X,'STANDARD PARALLEL #2      =',-4PF10.6,' DEG')
      IF(DEGDMS .EQ. HDMS) WRITE(LWRITE,8220)PDEF1,PDEF2
 8220 FORMAT(10X,'STANDARD PARALLEL #1      =',
     1  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     2       10X,'STANDARD PARALLEL #2      =',
     3  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC')
C
C        PRINT CARD 3  (NORTH LAT LIMIT, SOUTH LAT LIMIT,
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C                      WEST LON LIMIT, EAST LON LIMIT)
 1550 IF(DEGDMS .EQ. HDMS)WRITE(LWRITE,8240)LATN,LATS,LONW,LONE
 8240 FORMAT
     1 (10X,'LATITUDE BOUNDARY NORTH =',
     2  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     3  10X,'LATITUDE BOUNDARY SOUTH =',
     4  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     5  10X,'LONGITUDE BOUNDARY WEST =',
     6  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     7  10X,'LONGITUDE BOUNDARY EAST =',
     8  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC')
      IF(DEGDMS .NE. HDMS)WRITE(LWRITE,8260)LATN(1),LATS(1),
     1   LONW(1),LONE(1)
 8260 FORMAT(10X,'LATITUDE BOUNDARY NORTH =',-4PF10.6,' DEG'/
     1        10X,'LATITUDE BOUNDARY SOUTH =',-4PF10.6,' DEG'/
     2        10X,'LONGITUDE BOUNDARY WEST =',-4PF10.6,' DEG'/
     3        10X,'LONGITUDE BOUNDARY EAST =',-4PF10.6,' DEG')
      IF(NLAT .LE. SLAT)GO TO 5900
      IF(WLON .LE. ELON)GO TO 5950
      IF(INZON .EQ. 0 .AND. INPRO .EQ. HUTM)
     1  CALL UTMR('NE',N,E,(NLAT+SLAT)*.5D0,(WLON+ELON)*.5D0,INZON)
      IF(OUTZON .EQ. 0 .AND. OUTPRO .EQ. HUTM)
     1  CALL UTMR('NE',N,E,(NLAT+SLAT)*.5D0,(WLON+ELON)*.5D0,OUTZON)
C
C          READ CARD 4  (DELTA LAT BETWEEN TICS,
C                        DELTA LON BETWEEN TICS,
C                        DELTA NORTHING BETWEEN TICS,
C                        DELTA EASTING BETWEEN TICS)
      READ(LREAD,8280,END=5640)TICLAT,TICLON,TICNOR,TICEAS
 8280 FORMAT(2(-4PF10.0,0PF3.0,0PF7.4),2F10.0)
      LATTIC=DMSTOD(TICLAT)
      LONTIC=DMSTOD(TICLON)
      IF(LATTIC .EQ. 0.D0)GO TO 1700
      IF(LONTIC .NE. 0.D0)GO TO 1650
      LONTIC=LATTIC
      DO 1600 I=1,3
 1600 TICLON(I)=TICLAT(I)
 1650 IF(DEGDMS .EQ. HDMS)WRITE(LWRITE,8300)TICLAT,TICLON
 8300 FORMAT
     1 (10X,'LATITUDE TIC INCREMENT  =',
     2  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     3  10X,'LONGITUDE TIC INCREMENT =',
     4  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC')
      IF(DEGDMS .EQ. HDEG)WRITE(LWRITE,8320)TICLAT(1),TICLON(1)
 8320 FORMAT(10X,'LATITUDE TIC INCREMENT  =',-4PF10.6,
     1        10X,'LONGITUDE TIC INCREMENT =',-4PF10.6)
 1700 IF(TICEAS .EQ. 0.D0)TICEAS=TICNOR
      IF(TICNOR .NE. 0.D0)WRITE(LWRITE,8340)TICNOR,TICEAS
 8340 FORMAT(10X,'NORTHING TIC INCREMENT  =',12X,F10.0/
     1        10X,'EASTING TIC INCREMENT   =',12X,F10.0)
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GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

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C
C          READ CARD 5  (CELL HEIGHT AS DELTA LAT OR DELTA NORTHING,
C                        CELL WIDTH AS DELTA LON OR DELTA EASTING
      READ(LREAD,8360,END=5650)DNS,DEW
 8360 FORMAT(2(-4PF10.0,0PF3.0,0PF7.4))
      DELNS=DMSTOD(DNS)
      DELEW=DMSTOD(DEW)
      IF(DELEW .NE. 0.D0)GO TO 1800
      DO 1750 I=1,3
 1750 DEW(I)=DNS(I)
      DELEW=DELNS
 1800 IF(INPRO .NE. HLL)GO TO 1850
C
C          CELL SIZE IN DEGREES
      IF(DEGDMS .EQ. HDMS)WRITE(LWRITE,8380)DNS,DEW
 8380 FORMAT
     1 (10X,'NORTH/SOUTH GRID SPACING=',
     2  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     3  10X,'EAST/WEST GRID SPACING  =',
     4  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC')
      IF(DEGDMS .NE. HDMS)WRITE(LWRITE,8400)DNS(1),DEW(1)
 8400 FORMAT(10X,'NORTH/SOUTH GRID SPACING=',12X,-4PF10.6,' DEG'/
     1        10X,'EAST/WEST GRID SPACING  =',12X,-4PF10.6,' DEG')
      IF(DEGNS .LE. 0.D0 .OR. DEGEW .LE. 0.D0)GO TO 6000
      GO TO 1900
C
C          CELL SIZE IN METERS OR FEET
 1850 WRITE(LWRITE,8420)DNS(1),INUNIT,DEW(1),INUNIT
 8420 FORMAT(10X,'NORTH/SOUTH GRID SPACING=',12X,-4PF10.0,1X,A1/
     1        10X,'EAST/WEST GRID SPACING  =',12X,-4PF10.0,1X,A1)
 1900 IF(DELNS .LE. 0.D0 .OR. DELEW .LE. 0.D0)GO TO 6050
C
C          CARD 6  (NORTHERN,SOUTHERN,WESTERN,EASTERN BORDERS OF GRID)
      READ(LREAD,8440,END=5650)GN,GS,GW,GE
 8440 FORMAT(4(-4PF10.0,0PF3.0,0PF7.4))
      NBORD=DMSTOD(GN)
      SBORD=DMSTOD(GS)
      WBORD=DMSTOD(GW)
      EBORD=DMSTOD(GE)
      SWORGN=0.D0
      SWORGE=0.D0
      NELIMN=0.D0
      NELIME=0.D0
      IF(NBORD .EQ. 0.D0)NBORD=NLAT
      IF(SBORD .EQ. 0.D0)SBORD=SLAT
      IF(WBORD .EQ. 0.D0)WBORD=WLON
      IF(EBORD .EQ. 0.D0)EBORD=ELON
      DO 1950 I=1,3
      IF(GN(I) .EQ. 0.D0)GN(I)=LATN(I)
      IF(GS(I) .EQ. 0.D0)GS(I)=LATS(I)
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      IF(GW(I) .EQ. 0.D0)GW(I)=LONW(I)
      IF(GE(I) .EQ. 0.D0)GE(I)=LONE(I)
 1950 CONTINUE
      IF(NBORD+SBORD+WBORD+EBORD .GT. 500D0)GO TO 2050
 2000 IF(DEGDMS .EQ. HDMS)WRITE(LWRITE,8460)GN,GS,GW,GE
 8460 FORMAT(10X,'GRID NORTHING BORDER    =',
     1  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     2         10X,'GRID SOUTHERN BORDER    =',
     3  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     4         10X,'GRID WESTERN BORDER     =',
     5  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'/
     6         10X,'GRID EASTERN BORDER     =',
     7  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC')
      IF(DEGDMS .EQ. HDEG)WRITE(LWRITE,8480)NBORD,SBORD,WBORD,EBORD
 8480 FORMAT(10X,'GRID NORTHING BORDER    =',-4PF10.6,' DEG'/
     1         10X,'GRID SOUTHERN BORDER    =',-4PF10.6,' DEG'/
     2         10X,'GRID WESTERN BORDER     =',-4PF10.6,' DEG'/
     3         10X,'GRID EASTERN BORDER     =',-4PF10.6,' DEG')
      IF(INPRO .NE. HLL)GO TO 2100
      ENS=DMOD((NBORD-SBORD),DELNS)/DELNS
      EEW=DMOD((WBORD-EBORD),DELEW)/DELEW
      IF(ENS .GT. .001D0 .AND. ENS .LT. .999D0 .OR.
     *  EEW .GT. .001D0 .AND. EEW .LT. .999D0)GO TO 6200
      GO TO 2200
 2050 SWORGN=GS(1)/1.D4
      SWORGE=GW(1)/1.D4
      NELIMN=GN(1)/1.D4
      NELIME=GE(1)/1.D4
 2100 CALL PROJ('NE',INPRO,SNSW,WESW,SBORD,WBORD,INZON)
      CALL PROJ('NE',INPRO,SNSE,EESE,SBORD,EBORD,INZON)
      CALL PROJ('NE',INPRO,NNNE,EENE,NBORD,EBORD,INZON)
      CALL PROJ('NE',INPRO,NNNW,WENW,NBORD,WBORD,INZON)
      IF(SWORGN .EQ. 0.D0)SWORGN=DMIN1(SNSW,SNSE)
      IF(SWORGE .EQ. 0.D0)SWORGE=DMIN1(WESW,WENW)
      IF(NELIMN .EQ. 0.D0)NELIMN=DMAX1(NNNW,NNNE)+DELNS
      IF(NELIME .EQ. 0.D0)NELIME=DMAX1(EESE,EENE)+DELEW
      SWORGN=DELNS*IDINT(SWORGN/DELNS)
      SWORGE=DELEW*IDINT(SWORGE/DELEW)
      NELIMN=DELNS*IDINT(NELIMN/DELNS)
      NELIME=DELEW*IDINT(NELIME/DELEW)
 2150 WRITE(LWRITE,8500)NELIMN,INUNIT,SWORGN,INUNIT,
     1    SWORGE,INUNIT,NELIME,INUNIT
 8500 FORMAT(10X,'NORTH GRID BORDER        =',12X,F10.0,1X,A1/
     1         10X,'SOUTH GRID BORDER        =',12X,F10.0,1X,A1/
     2         10X,'WEST GRID BORDER         =',12X,F10.0,1X,A1/
     3         10X,'EAST GRID BORDER         =',12X,F10.0,1X,A1)
      IF(SWORGN .GE. NELIMN)GO TO 6100
      IF(SWORGE .GE. NELIME)GO TO 6150
      IF(DMOD((NELIMN-SWORGN),DELSN)/DELSN .GT. .001D0 .OR.
     1   DMOD((NELIME-SWORGE),DELWE)/DELWE .GT. .001D0)GO TO 6250
```

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C
C         READ CARD 7  (CELL NUMBERING DIRECTION, FIRST CELL INDEX,
C                       CELL NUMBERING INCREMENT, CELL NUMBERING ORIGIN)
C                       (THESE FIELDS ARE REPEATED ONCE)
 2200 READ(LREAD,8520,END=5650)
     1   (ID(I),KZ(I),KGO(I),(GZ(J,I),J=1,3),I=1,2)
 8520 FORMAT(2(A2,I10,I8,-4PF10.0,0PF3.0,0PF7.4))
      DO 2250 I=1,2
      IF(KGO(I) .EQ. 0 .AND. KZ(I) .EQ. 0)KZ(I)=1
      IF(KGO(I) .EQ. 0)KGO(I)=1
 2250 CONTINUE
      IF(ID(1) .EQ. BLANK)ID(1)=HWE
      IF(ID(2) .EQ. BLANK)ID(2)=HSN
      IF(IOFF .NE. HYES)GO TO 2300
      IF(INPRO .NE. HLL)WRITE(6,8540)
     1   (ID(I),KZ(I),KGO(I),GZ(1,I),INUNIT,I=1,2)
      IF(INPRO .EQ. HLL .AND. DEGDMS .EQ. HDMS)WRITE(6,8560)
     1   (ID(I),KZ(I),KGO(I),(GZ(J,I),J=1,3),I=1,2)
      IF(INPRO .EQ. BLANK .AND. DEGDMS .NE. HDMS)WRITE(6,8580)
     1   (ID(I),KZ(I),KGO(I),GZ(1,I),I=1,2)
      GZERO(1)=DMSTOD(GZ(1,1))
      GZERO(2)=DMSTOD(GZ(1,2))
      GO TO 2350
 8540 FORMAT(10X,'GRID CELL NUMBERING      =',12X,A2,' FROM',I8,' BY',I6/
     1        10X,'GRID NUMBERING ORIGIN   =',12X,-4PF10.0,1X,A1//
     2        10X,'GRID CELL NUMBERING     =',12X,A2,' FROM',I8,' BY',I6/
     3        10X,'GRID NUMBERING ORIGIN   =',12X,-4PF10.0,1X,A1)
 8560 FORMAT(10X,'GRID CELL NUMBERING      =',12X,A2,' FROM',I8,' BY',I6/
     1        10X,'GRID NUMBERING ORIGIN   =',
     2  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC'//
     3        10X,'GRID CELL NUMBERING     =',12X,A2,' FROM',I8,' BY',I6/
     4        10X,'GRID NUMBERING ORIGIN   =',
     5  -4PF15.0,' DEG',0PF6.0,' MIN',0PF10.4,' SEC')
 8580 FORMAT(10X,'GRID CELL NUMBERING      =',12X,A2,' FROM',I8,' BY',I6/
     1        10X,'GRID NUMBERING ORIGIN   =',12X,-4PF10.6//
     2        10X,'GRID CELL NUMBERING     =',12X,A2,' FROM',I8,' BY',I6/
     3        10X,'GRID NUMBERING ORIGIN   =',12X,-4PF10.6)
 2300 WRITE(6,8600)(ID(I),KZ(I),KGO(I),I=1,2)
 8600 FORMAT(10X,'GRID CELL NUMBERING      =',12X,A2,' FROM',I8,' BY',I6/
     1        10X,'GRID CELL NUMBERING     =',12X,A2,' FROM',I8,' BY',I6)
 2350 DO 2650 J=1,2
      IF(ID(J) .NE. HNS)GO TO 2400
      JB=.TRUE.
      JGO=-KGO(J)
      GO TO 2450
 2400 IF(ID(J) .NE. HSN)GO TO 2500
      JB=.FALSE.
      JGO=KGO(J)
 2450 JZ=KZ(J)
      GO TO 2650
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 2500 IF( ID(J) .NE. HEW)GO TO 2550
      IB=.TRUE.
      IGO=-KGO(J)
      GO TO 2600
 2550 IF( ID(J) .NE. HWE)GO TO 6300
      IB=.FALSE.
      IGO=KGO(J)
 2600 IZ=KZ(J)
 2650 CONTINUE
C*****END  INPUT
C
C*****BEGIN PRELIMINARY CALCULATIONS
      SCALER=12D0/SCALE
      IF(OUTPRO .NE. HSTA)SCALER=39.37D0/SCALE
      CELEW=1.D0/DELEW
      CELNS=1.D0/DELNS
      IF( INPRO .EQ. HLL)GO TO 2700
      KTX=ROUND( (NELIME-SWORGE)*CELEW+1.D0)
      KTY=ROUND( (NELIMN-SWORGN)*CELNS+1.D0)
      GO TO 2750
 2700 KTY=ROUND( (NBORD-SBORD)*CELNS+1.D0)
      KTX=ROUND( (WBORD-EBORD)*CELEW+1.D0)
 2750 IF(OUTPRO .EQ. HPOL)
     1  CALL POLYST(SLAT,(WLON+ELON)*.5D0,0.D0,0.D0)
      IF(OUTPRO .EQ. HALB)
     1  CALL ALBRST(PD1,PD2,27.5D0,(WLON+ELON)*.5D0,0.D0,0.D0)
      IF(OUTPRO .EQ. HLAM)
     1  CALL LAMBST(PD1,PD2,27.5D0,(WLON+ELON)*.5D0,0.D0,0.D0)
      CALL PROJ('NE',OUTPRO,YSW,XSW,SLAT,WLON,OUTZON)
      CALL PROJ('NE',OUTPRO,YSE,XSE,SLAT,ELON,OUTZON)
      CALL PROJ('NE',OUTPRO,YNE,XNE,NLAT,ELON,OUTZON)
      CALL PROJ('NE',OUTPRO,YNW,XNW,NLAT,WLON,OUTZON)
      CALL PROJ('NE',OUTPRO,YMID,XMID,SLAT,(ELON+WLON)*.5D0,OUTZON)
      X0=DMIN1(XSW,XNW)
      Y0=DMIN1(YSW,YSE,YMID)
      YMAX=DMAX1(YNW,YNE)
      XMAX=DMAX1(XSE,XNE)
      IF((XMAX-X0)*SCALER .GT. MAXW .OR.
     1   (YMAX-Y0)*SCALER .GT. MAXH)GO TO 6350
      X0=X0-2.D0/SCALER
      Y0=Y0-1.D0/SCALER
      YMAX=(YMAX-Y0)*SCALER+.5D0
      XMAX=(XMAX-X0)*SCALER+1.D0
      I=KTX/2
      IF(I .EQ. 0)I=1
      J=KTY/2
      IF(J .EQ. 0)J=1
      CALL CONVRT(KTX/2.0,KTY/2.0,TN,TE)
      XM=X
      YM=Y
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      CALL CONVRT(1.0+KTX/2.0,1.0+KTY/2.0,TN,TE)
      DX=X- XM
      DY=Y-YM
      DS=DMIN1(DX,DY)
      HI=0.07
      IF(DS.LT.0.1) HI=0.035
      DX=(DX-HI)*.5
      DY=(DY+HI)*.5
      YHIGH=29.5-12.*HI
      YLABEL=YHIGH+5.*HI
      SWDISP=HI*8.
C     END PRELIMINARY CALCULATIONS
C
C     ESTABLISH CELL NUMBERING PARAMETERS
      IF(IB)IZ=IZ-IGO*(KTX-2)
      IF(JB)JZ=JZ-JGO*(KTY-2)
      IF(IOFF .NE. HYES)GO TO 3250
      IF(INPRO .NE. HLL)GO TO 3000
      DO 2950 J=1,2
      IF(ID(J) .NE. HNS)GO TO 2800
      INC=ROUND((GZERO(J)-NEORD)*CELNS*KGO(J))
      JZ=JZ+INC
      GO TO 2950
 2800 IF(ID(J) .NE. HSN)GO TO 2850
      INC=ROUND((SBORD-GZERO(J))*CELNS*KGO(J))
      JZ=JZ+INC
      GO TO 2950
 2850 IF(ID(J) .NE. HEW)GO TO 2900
      INC=ROUND((EBORD-GZERO(J))*CELEW*KGO(J))
      IZ=IZ+INC
      GO TO 2950
 2900 IF(ID(J) .NE. HWE)GO TO 2950
      INC=ROUND((GZERO(J)-WBORD)*CELEW*KGO(J))
      IZ=IZ+INC
 2950 CONTINUE
      GO TO 3250
 3000 DO 3200 J=1,2
      IF(ID(J) .NE. HNS)GO TO 3050
      INC=ROUND((GZERO(J)-NELIMN)*CELNS*KGO(J))
      JZ=JZ+INC
      GO TO 3200
 3050 IF(ID(J) .NE. HSN)GO TO 3100
      INC=ROUND((SWORGN-GZERO(J))*CELNS*KGO(J))
      JZ=JZ+INC
      GO TO 3200
 3100 IF(ID(J) .NE. HEW)GO TO 3150
      INC=ROUND((GZERO(J)-NELIME)*CELEW*KGO(J))
      IZ=IZ+INC
      GO TO 3200
 3150 IF(ID(J) .NE. HWE)GO TO 3150
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      INC=ROUND((SWORGE-GZERO(J))*CELEW*KGC(J))
      IZ=IZ+INC
 3200 CONTINUE
 3250 CONTINUE
      KMAX=MAX0(IZ,IZ+IGO*(KTX-1),JZ,JZ+JGO*(KTY-1))
C KMAX IS THE LARGEST ROW OR COLUMN NUMBER
      LMAX=KMAX
      LOGL=DLOG10(LMAX)
      KMAX=LOGL+1
C KMAX IS NOW THE NUMBER OF DIGITS IN LARGEST NUMBER
      NEDISP=(26-6*KMAX)*HI/7.0
C     END CELL NUMBERING PARAMETERS
C
C     INITALIZE PLOTTER
 3300 CALL PLINIT
      CALL CROSS
C
C
C           DRAW THE CELL NUMBERS ALONG THE BOTTOM
      ANGLE=90.
      DO 3400 I=2,KTX
      ICOL=(I-2)*IGO+IZ
      CALL CONVRT(I-.5,1.0,TLAT,TLON)
      IF(TLAT .GE. SLAT .AND. TLAT .LE. NLAT .AND.
     1  TLON .LE. WLON .AND. TLON .GE. ELON)GO TO 3350
      IF(INPRO .EQ. HLL)GO TO 3400
      E=(I-1.5)/CELEW+SWORGE
      CALL PROJ('NL',INPRO,N,E,SLAT,TLON,INZON)
      IF(TLON .GT. WLON .OR. TLON .LT. ELON)GO TO 3400
      CALL PROJ('NE',OUTPRO,N1,E1,SLAT,TLON,OUTZON)
      X=(E1-X0)*SCALER
      Y=(N1-Y0)*SCALER
 3350 CALL NUMBER(X,Y-SWDISP,HI,ICOL,ANGLE,2HI8)
 3400 CONTINUE
C
C           DRAW THE CELL NUMBERS ALONG THE EAST EDGE FROM SOUTH TO NORTH
      ANGLE=0.
      DO 3500 J=2,KTY
      JROW=(J-2)*JGO+JZ
      CALL CONVRT(FLOAT(KTX),J-.5,TLAT,TLON)
      IF(TLAT .GE. SLAT .AND. TLAT .LE. NLAT .AND.
     1  TLON .LE. WLON .AND. TLON .GE. ELON)GO TO 3450
      IF(INPRO .EQ. HLL)GO TO 3500
      N=(J-1.5)/CELNS+SWORGN
      CALL PROJ('LE',INPRO,N,E,TLAT,ELON,INZON)
      IF(TLAT .LT. SLAT .OR. TLAT .GT. NLAT)GO TO 3500
      CALL PROJ('NE',OUTPRO,N1,E1,TLAT,ELON,OUTZON)
      X=(E1-X0)*SCALER
      Y=(N1-Y0)*SCALER
 3450 CALL NUMBER(X-NEDISP,Y,HI,JROW,ANGLE,2HI8)
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```
      IF(IADDL .EQ. HYES)CALL NUMBER(XMAX+NEDISP,Y,HI,JROW,
     1  ANGLE,2HI8)
 3500 CONTINUE
C
C           DRAW CELL NUMBERS ALONG THE TOP FROM EAST TO WEST
      ANGLE=90.
      DO 3600 I=2,KTX
      ICOL=(KTX-I)*IGO+IZ
      CALL CONVRT(KTX-I+1.5,FLOAT(KTY),TLAT,TLON)
      IF(TLAT .GE. SLAT .AND. TLAT .LE. NLAT .AND.
     1  TLON .LE. WLON .AND. TLON .GE. ELON)GO TO 3550
      IF(INPRO .EQ. HLL)GO TO 3600
      E=(KTX-I+1.5)/CELEW+SWORGE
      CALL PROJ('NL',INPRO,N,E,NLAT,TLON,INZON)
      IF(TLON .GT. WLON .OR. TLON .LT. ELON)GO TO 3600
      CALL PROJ('NE',OUTPRO,N1,E1,NLAT,TLON,OUTZON)
      X=(E1-X0)*SCALER
      Y=(N1-Y0)*SCALER
 3550 CALL NUMBER(X,Y-NEDISP,HI,ICOL,ANGLE,2HI8)
      IF(IADDL .EQ. HYES)CALL NUMBER(X,YMAX+NEDISP,HI,ICOL,
     1  ANGLE,2HI8)
 3600 CONTINUE
C
C           DRAW CELL NUMBERS ALONG THE WEST EDGE FROM TOP TO BOTTOM
      ANGLE=0.
      DO 3700 J=2,KTY
      JROW=(KTY-J)*JGO+JZ
      CALL CONVRT(1.0,KTY-J+1.5,TLAT,TLON)
      IF(TLAT .GE. SLAT .AND. TLAT .LE. NLAT .AND.
     1  TLON .LE. WLON .AND. TLON .GE. ELON)GO TO 3650
      IF(INPRO .EQ. HLL)GO TO 3700
      N=(KTY-J+1.5)/CELNS+SWORGN
      CALL PROJ('LE',INPRO,N,E,TLAT,WLON,INZON)
      IF(TLAT .LT. SLAT .OR. TLAT .GT. NLAT)GO TO 3700
      CALL PROJ('NE',OUTPRO,N1,E1,TLAT,WLON,OUTZON)
      X=(E1-X0)*SCALER
      Y=(N1-Y0)*SCALER
 3650 CALL NUMBER(X-SWDISP,Y,HI,JROW,ANGLE,2HI8)
 3700 CONTINUE
C
      IF(INPRO .EQ. HLL .AND. NBORD .EQ. NLAT .AND. SBORD .EQ. SLAT
     1  .AND. WBORD .EQ. WLON .AND. EBORD .EQ. ELON
     2  .AND. ILINE .EQ. HPC)GO TO 4450
C           DRAW NORTH/SOUTH GRID LINES WORKING FROM WEST TO EAST
      DIR=.TRUE.
      DO 4000 I=1,KTX
      IF(ILINE .EQ. HPC .AND. I .NE. 1 .AND. I .NE. KTX)GO TO 4000
      DIR=.NOT.DIR
      CALL CONAUX(I,1,NLAT1,ELON1)
      CALL CONAUX(I,KTY,NLAT2,ELON2)
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      IF( INPRO .EQ. HLL)GO TO 3950
      CALL PROJ( 'NL',INPRO,NT,ELON1 ,SLAT,ALONS,INZON)
      NLAT1=DMAX1(NLAT1 ,NT,SWCRGN)
      CALL PROJ( 'NL',INPRO,NT,ELON2 ,NLAT,ALONN,INZON)
      NLAT2=DMIN1(NLAT2 ,NT,NELIMN)
      CALL PROJ( 'LL',INPRO,NLAT1,ELON1 ,ALATS,ALONS,INZON)
      CALL PROJ( 'LL',INPRO,NLAT2,ELON2,ALATN,ALONN,INZON)
      IF((ALONS .LE. ELON .AND. ALONN .LE. ELON) .OR.
     1  (ALONS .GE. WLON .AND. ALONN .GE. WLON))GO TO 4000
      T=(ALATN-ALATS)/(ALONS-ALONN)
      IF(ALONS .LE. WLON)GO TO 3750
      ALATS=ALATS+(ALONS-WLON)*T
      ALONS=WLON
      GO TO 3800
 3750 IF(ALONS .GE. ELON)GO TO 3800
      ALATS=ALATS+(ALONS-ELON)*T
      ALONS=ELON
 3800 IF(ALONN .LE. WLON)GO TO 3850
      ALATN=ALATN+(ALONN-WLON)*T
      ALONN=WLON
      GO TO 3900
 3850 IF(ALONN .GE. ELON)GO TO 3900
      ALATN=ALATN+(ALONN-ELON)*T
      ALONN=ELON
 3900 CALL PROJ( 'NE',INPRO,NLAT1,ELON1 ,ALATS,ALONS,INZON)
      CALL PROJ( 'NE',INPRO,NLAT2,ELON2,ALATN,ALONN,INZON)
 3950 IF( .NOT.DIR)CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  NLAT1,ELON1,NLAT2,ELON2,SCALE,XO,YO)
      IF(DIR)CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  NLAT2,ELON2,NLAT1 ,ELON1 ,SCALE,XO,YO)
 4000 CONTINUE
C          DRAW E/W GRID LINES
 4050 DIR=.TRUE.
      DO 4350 J=1,KTY
      IF( ILINE .EQ. HPC .AND. J .NE. 1 .AND. J .NE. KTY)GO TO 4350
      DIR=.NOT.DIR
      CALL CONAUX(1,J,NLAT1 ,ELON1)
      CALL CONAUX(KTX,J,NLAT2,ELON2)
      IF( INPRO .EQ. HLL)GO TO 4300
      CALL PROJ( 'LE',INPRO,NLAT1,ET,ALATW,WLON,INZON)
      ELON1=DMAX1(ELON1 ,ET,SWORGE)
      CALL PROJ( 'LE',INPRO,NLAT2,ET,ALATE,ELON,INZON)
      ELON2=DMIN1(ELON2,ET,NELIME)
      CALL PROJ( 'LL',INPRO,NLAT1,ELON1,ALATW,ALONW,INZON)
      CALL PROJ( 'LL',INPRO,NLAT2,ELON2,ALATE,ALONE,INZON)
      IF((ALATW .GE. NLAT .AND. ALATE .GE. NLAT) .OR.
     1  (ALATW .LE. SLAT .AND. ALATE .LE. SLAT))GO TO 4350
      T=(ALONE-ALONW)/(ALATW-ALATE)
      IF(ALATW .GE. SLAT)GO TO 4100
      ALONW=ALONW+(ALATW-SLAT)*T
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      ALATW=SLAT
      GO TO 4150
 4100 IF(ALATW .LE. NLAT)GO TO 4150
      ALONW=ALONW+(ALATW-NLAT)*T
      ALATW=NLAT
 4150 IF(ALATE .GE. SLAT)GO TO 4200
      ALONE=ALONE+(ALATE-SLAT)*T
      ALATE=SLAT
      GO TO 4250
 4200 IF(ALATE .LE. NLAT)GO TO 4250
      ALONE=ALONE+(ALATE-NLAT)*T
      ALATE=NLAT
 4250 CALL PROJ('NE',INPRO,NLAT1,ELON1,ALATW,ALONW,INZON)
      CALL PROJ('NE',INPRO,NLAT2,ELON2,ALATE,ALONE,INZON)
 4300 IF(.NOT.DIR)CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  NLAT1,ELON1,NLAT2,ELON2,SCALE,X0,Y0)
      IF(DIR)CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  NLAT2,ELON2,NLAT1,ELON1,SCALE,X0,Y0)
 4350 CONTINUE
      IF(ILINE .EQ. HPC)GO TO 4450
      IF(ILINE .NE. HGP)GO TO 4600
C
C           DRAW + MARKS STARTING FROM THE WEST
 4400 OFFSET=.5D0
      KUP=KTX-1
      JUP=KTY-1
      GO TO 4500
 4450 IF(KTX .EQ. 2 .OR. KTY .EQ. 2)GO TO 4600
      KUP=KTX-2
      JUP=KTY-2
      OFFSET=1.D0
 4500 DIR=.TRUE.
      DO 4550 I=1,KUP
      DIR=.NOT.DIR
      DO 4550 J=1,JUP
      JT=J
      IF(DIR)JT=JUP+1-J
      CALL CONVRT(I+OFFSET,JT+OFFSET,TLAT,TLON)
      IF(TLAT .GT. NLAT .OR. TLAT .LT. SLAT .OR.
     1  TLON .GT. WLON .OR. TLON .LT. ELON)GO TO 4550
      CALL SYMBOL(X,Y,SIZE,3,ANGLE,-1)
 4550 CONTINUE
C
 4600 IF(TICNOR .EQ. 0.D0)GO TO 5100
      IF(INPRO .NE. HLL)GO TO 4650
      INPRO=HUTM
      INZON=0
      CALL PROJ('NE',INPRO,N,E,(SLAT+NLAT)*.5D0,(WLON+ELON)*.5D0,INZON)
 4650 DELTA=SCALE*.125D0/12.D0
      IF(INPRO .NE. HSTA)DELTA=SCALE*.125D0/39.37D0
```

```
C              TIC MARKS ALONG THE BOTTOM
      CALL PROJ('NE',INPRO,NSW,ESW,SLAT,WLON,INZON)
      CALL PROJ('NE',INPRO,NSE,ESE,SLAT,ELON,INZON)
      ET=TICEAS*IDINT(ESW/TICEAS)
 4700 IF(ET .LT. ESW)GO TO 4750
      CALL PROJ('NL',INPRO,N1,ET,SLAT,LT,INZON)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  N1+DELTA/5D0,ET,N1-DELTA,ET,SCALE,X0,Y0)
 4750 ET=ET+TICEAS
      IF(ET .LT. ESE)GO TO 4700
C              TIC MARKS ALONG RIGHT EDGE
      CALL PROJ('NE',INPRO,NNE,ENE,NLAT,ELON,INZON)
      NT=TICNOR*IDINT(NSE/TICNOR)
 4800 IF(NT .LT. NSE)GO TO 4850
      CALL PROJ('LE',INPRO,NT,E1,LT,ELON,INZON)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  NT,E1-DELTA/5D0,NT,E1+DELTA,SCALE,X0,Y0)
 4850 NT=NT+TICNOR
      IF(NT .LT. NNE)GO TO 4800
C              TIC MARKS ALONG TOP
      CALL PROJ('NE',INPRO,NNW,ENW,NLAT,WLON,INZON)
      ET=TICEAS*(1.D0+IDINT(ENE/TICEAS))
 4900 IF(ET .GT. ENE)GO TO 4950
      CALL PROJ('NL',INPRO,N1,ET,NLAT,LT,INZON)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  N1-DELTA/5D0,ET,N1+DELTA,ET,SCALE,X0,Y0)
 4950 ET=ET-TICEAS
      IF(ET .GT. ENW)GO TO 4900
C              TIC MARKS ALONG LEFT
      NT=TICNOR*(1.D0+IDINT(NNW/TICNOR))
 5000 IF(NT .GT. NNW)GO TO 5050
      CALL PROJ('LE',INPRO,NT,E1,LT,WLON,INZON)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  NT,E1+DELTA/5D0,NT,E1-DELTA,SCALE,X0,Y0)
 5050 NT=NT-TICNOR
      IF(NT .GT. NSW)GO TO 5000
C          DRAW THE LATITUDE/LONGITUDE LIMITS IF NECESSARY
 5100 OFFSET=0.D0
      INPROT=INPRO
      INPRO=HLL
      IF(LATTIC .EQ. 0.D0)GO TO 5550
      DELLON=SCALE*.4D-7
      DELLAT=DELLON*DCOS(SLAT/57.295D0)
C              TIC MARKS ALONG BOTTOM
      LONT=LONTIC*(1.D0+IDINT(WLON/LONTIC))
 5150 IF(LONT .GT. WLON)GO TO 5200
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  SLAT,LONT,SLAT+DELLAT,LONT,SCALE,X0,Y0)
 5200 LONT=LONT-LONTIC
      IF(LONT .GT. ELON)GO TO 5150
```

```
C              LAT TIC ALONG RIGHT
      LATT=LATTIC*IDINT(SLAT/LATTIC)
 5250 IF(LATT .LT. SLAT)GO TO 5300
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  LATT,ELON,LATT,ELON+DELLON,SCALE,XO,YO)
 5300 LATT=LATT+LATTIC
      IF(LATT .LT. NLAT)GO TO 5250
C              LON TIC MARKS ALONG TOP EDGE
      LONT=LONTIC*IDINT(ELON/LONTIC)
 5350 IF(LONT .LT. ELON)GO TO 5400
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  NLAT,LONT,NLAT-DELLAT,LONT,SCALE,XO,YO)
 5400 LONT=LONT+LONTIC
      IF(LONT .LT. WLON)GO TO 5350
C              LAT TIC MARKS ALONG LEFT EDGE
      LATT=LATTIC*(1.D0+IDINT(NLAT/LATTIC))
 5450 IF(LATT .GT. NLAT)GO TO 5500
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     1  LATT,WLON,LATT,WLON-DELLON,SCALE,XO,YO)
 5500 LATT=LATT-LATTIC
      IF(LATT .GT. SLAT)GO TO 5450
 5550 CELNS=1.D0/(NLAT-SLAT)
      CELEW=1.D0/(WLON-ELON)
      KTX=2
      KTY=2
C     IF(ISEG .NE. BLANK)CALL GENDOT(SLAT,NLAT,ELON,WLON,
C    *  OUTPRO,OUTZON,SCALE,XO,YO,ISEG)
      IF( INPROT .EQ. HLL .AND. NBORD .EQ. NLAT .AND. SBORD .EQ. SLAT
     1  .AND. WBORD .EQ. WLON .AND. EBORD .EQ. ELON
     2  .AND. ILINE .NE. HPC)GO TO 5600
      NBORD=NLAT
      SBORD=SLAT
      EBORD=ELON
      WBORD=WLON
      CALL OUTLIN
C*****BEGIN DRAWING TITLE
 5600 NBORD=NLAT
      SBORD=SLAT
      EBORD=ELON
      WBORD=WLON
      CALL CONVRT(1.0,1.0,TLAT,TLON)
      CALL CROSS
      CALL SYMBOL(X+1.0,0.1,0.13,TITLE,0.0,80)
C
C*****BEGIN LABELLING BORDERS IN DEG,MIN,SEC
      H=0.13
C=====BEGIN BOT-SOUTHWEST
      KNTROL=0
      CALL DMSLAB(WLON,X,.27,H,KNTROL)
C
```

```
C=====BEGIN LEFT-SOUTHWEST
      X=X-0.15-KMAX*HI
      KNTROL=-1
      CALL DMSLAB(SLAT,X,Y,H,KNTRCL)
C
C=====BEGIN LEFT-NORTHEAST
      CALL CONVRT(1.0,FLOAT(KTY),TLAT,TLON)
      KNTROL=-1
      CALL DMSLAB(NLAT,X,Y,H,KNTROL)
C
C=====BEGIN BOT-SOUTHEAST
      CALL CONVRT(FLOAT(KTX),1.0,TLAT,TLON)
      Y=0.27
      KNTROL=0
      CALL DMSLAB(ELON,X,Y,H,KNTRCL)
C=====END BOT-SOUTHEAST
C*****END LABELLING BORDERS IN DEG,MIN,SEC
      CALL PLOT(X+12.,0.,-3)
      GO TO 1000
 5640 IF(ISEG .NE. HC .AND. ISEG .NE. HS)GO TO 5650
      CALL PLLMT
      INPROT=BLANK
      GO TO 5550
 5650 WRITE(LWRITE,8620)
 8620 FORMAT('0INSUFFICIENT DATA')
 5700 STOP
 5750 WRITE(LWRITE,8640)
 8640 FORMAT('0IMPROPER SCALE')
      GO TO 5700
 5800 WRITE(LWRITE,8660)
 8660 FORMAT('0INVALID OUTPUT PROJECTION')
      GO TO 5700
 5850 WRITE(LWRITE,8680)
 8680 FORMAT('0INVALID INPUT PROJECTION')
      GO TO 5700
 5900 WRITE(LWRITE,8700)
 8700 FORMAT('0SOUTHERN LATITUDE LIMIT GREATER THAN NORTHERN')
      GO TO 5700
 5950 WRITE(LWRITE,8720)
 8720 FORMAT('0EASTERN LONGITUDE LIMIT GREATER THEN WESTERN')
      GO TO 5700
 6000 WRITE(LWRITE,8740)
 8740 FORMAT('0LAT/LONG CELL HEIGHT/WIDTH IMPROPER')
      GO TO 5700
 6050 WRITE(LWRITE,8760)
 8760 FORMAT('0GRID CELL HEIGHT/WIDTH IMPROPER')
      GO TO 5700
 6100 WRITE(LWRITE,8780)
 8780 FORMAT('0EASTERN EASTING LESS THAN WESTERN LIMIT')
      GO TO 5700
```

```
 6150 WRITE(LWRITE,8800)
 8800 FORMAT('0NORTHERN NORTHING LESS THAN SOUTHERN LIMIT')
      GO TO 5700
 6200 WRITE(LWRITE,8820)
 8820 FORMAT('0CELL HEIGHT DOES NOT DIVIDE LATITUDE LIMITS OR'/
     1  ' CELL WIDTH DOES NOT DIVIDE LONGITUDE LIMITS')
      GO TO 5700
 6250 WRITE(LWRITE,8840)
 8840 FORMAT('0CELL HEIGHT DOES NOT DIVIDE NORTHING LIMITS OR'/
     1  ' CELL WIDTH DOES NOT DIVIDE EASTING LIMITS')
      GO TO 5700
 6300 WRITE(LWRITE,8860)
 8860 FORMAT('0GRID NUMBERING DIRECTION CODE NOT NS,SN,EW, OR WE')
      GO TO 5700
 6350 WRITE(LWRITE,8880)
 8880 FORMAT('0MAP WIDTH OR HEIGHT EXCEEDS LIMITS')
      GO TO 5700
      END


      SUBROUTINE CONAUX(I,J,NLATX,ELONX)
      IMPLICIT REAL*8(A-H,L-Z)
      COMMON /LIMITS/ NBORD,SBORD,WBORD,EBORD,CELNS,CELEW,
     $  SWORGN,SWORGE,NELIMN,NELIME,
     $  X0,Y0,SCALER,SCALE,X,Y,
     $  KTX,KTY,INPRO,INZON,OUTPRO,OUTZON
      INTEGER*4 KTX,KTY,INPRO,INZON,OUTPRO,OUTZON
      REAL*4 X,Y
      INTEGER*4 HLL/'LTLN'/
      IF(INPRO .NE. HLL)GO TO 20
      ELONX=WBORD-(I-1)/CELEW
      NLATX=(J-1)/CELNS+SBORD
      GO TO 30
   20 NLATX=(J-1)/CELNS+SWORGN
      ELONX=(I-1)/CELEW+SWORGE
   30 RETURN
      END


      SUBROUTINE CONVRT(TI,TJ,NLATX,ELONX)
      IMPLICIT REAL*8(A-H,L-Z)
      COMMON /LIMITS/ NBORD,SBORD,WBORD,EBORD,CELNS,CELEW,
     $  SWORGN,SWORGE,NELIMN,NELIME,
     $  X0,Y0,SCALER,SCALE,X,Y,
     $  KTX,KTY,INPRO,INZON,OUTPRO,OUTZON
      INTEGER*4 KTX,KTY,INPRO,INZON,OUTPRO,OUTZON
      REAL*4 X,Y,TI,TJ
      INTEGER*4 HLL/'LTLN'/
```

```
      IF(INPRO .NE. HLL)GO TO 20
      ELONX=WBORD-(TI-1.)/CELEW
      NLATX=SBORD+(TJ-1.)/CELNS
      GO TO 30
   20 NLATX=SWORGN+(TJ-1.)/CELNS
      ELONX=SWORGE+(TI-1.)/CELEW
         CALL PROJ('LL',INPRO,NLATX,ELONX,NLATX,ELONX,INZON)
   30 CALL PROJ('NE',OUTPRO,N,E,NLATX,ELONX,OUTZON)
      X=(E-X0)*SCALER
      Y=(N-Y0)*SCALER
      RETURN
      END


      SUBROUTINE OUTLIN
      IMPLICIT REAL*8(A-H,L-Z)
      INTEGER*4 INPRO,INZON,OUTPRO,OUTZON
      REAL*4 X,Y
      COMMON /LIMITS/ NBORD,SBORD,WBORD,EBORD,CELNS,CELEW,
     $  SWORGN,SWORGE,NELIMN,NELIME,
     $  X0,Y0,SCALER,SCALE,X,Y,
     $  KTX,KTY,INPRO,INZON,OUTPRO,OUTZON
C          START AT THE SW CORNER AND WORK EAST
      CALL CONAUX(1,1,NLAT1,ELON1)
      CALL CONAUX(KTX,1,NLAT2,ELON2)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     *  NLAT1,ELON1,NLAT2,ELON2,SCALE,X0,Y0)
      ELON1=ELON2
      NLAT1=NLAT2
      CALL CONAUX(KTX,KTY,NLAT2,ELON2)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     *  NLAT1,ELON1,NLAT2,ELON2,SCALE,X0,Y0)
C
C           START FROM THE NW CORNER AND WORK WEST
      NLAT1=NLAT2
      ELON1=ELON2
      CALL CONAUX(1,KTY,NLAT2,ELON2)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     *  NLAT1,ELON1,NLAT2,ELON2,SCALE,X0,Y0)
C
C          START FROM THE NW CORNER AND WORK SOUTH
      NLAT1=NLAT2
      ELON1=ELON2
      CALL CONAUX(1,1,NLAT2,ELON2)
      CALL BILINE(INPRO,INZON,OUTPRO,OUTZON,
     *  NLAT1,ELON1,NLAT2,ELON2,SCALE,X0,Y0)
      RETURN
      END
```

GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

```
      SUBROUTINE PLINIT
      REAL*8 BUFFER(3204)
      CALL PLOTS(BUFFER,3204)
      RETURN
      END


      SUBROUTINE CROSS
      CALL PLOT(.375,.5,3)
      CALL PLOT(.375,.25,2)
      CALL PLOT(.5,.375,3)
      CALL PLOT(.25,.375,2)
      RETURN
      END


      SUBROUTINE DMSLAB(DEG,X,Y,H,KNTROL)
C****
C     GIVEN THE REAL*8 VALUE 'DEG'
C     CONVERT TO INTEGER*4 VALUES 'IDEG, IMIN' AND REAL*4 'SEC'
C     AND PLOT WITH HEIGHT 'H' INCHES ALONG A HORIZONTAL LINE AT 'Y'
C     SO THAT THE FIRST CHARACTER STARTS AT 'X' WHEN KNTROL.GT.0
C             THE  LAST CHARACTER ENDS   AT 'X' WHEN KNTROL.LT.0
C             THE STRING IS CENTERED AROUND 'X' WHEN KNTROL.EQ.0
C             'SEC' IS PRINTED WITH F5.2 FORMAT
C****
      REAL*8 DEG,FMIN,DIG
      DIG=DEG+13D-7
C THIS ADDS ABOUT 0.005 SECOND FOR ROUND OFF PURPOSES
      IDEG=DIG
      FMIN=(DIG-IDEG)*6D1
      IMIN=FMIN
       SEC=(FMIN-IMIN)*6D1
      NDEGDI=2
      IF(IDEG.LT.10) NDEGDI=1
      IF(IDEG.GE.100) NDEGDI=3
      NCHAR=NDEGDI+10
      DX=H*.857143
      TWODX=DX+DX
      FOURDX=TWODX+TWODX
      DP=DX*.33334
      IF(KNTROL) 1,2,3
    1 XP=X-NCHAR*DX
      GO TO 4
    2 XP=X-NCHAR*DX*.5
      GO TO 4
    3 XP=X
    4 IF(NDEGDI-2) 5,6,7
```

GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

```
    5 CALL NUMBER(XP,Y,H,IDEG,0.,2HI1)
      XP=XP+DX
      GO TO 8
    6 CALL NUMBER(XP,Y,H,IDEG,0.,2HI2)
      XP=XP+TWODX
      GO TO 8
    7 CALL NUMBER(XP,Y,H,IDEG,0.,2HI3)
      XP=XP+DX+TWODX
    8 YP=Y+H-DP
      DH=DP+DP
      CALL SYMBOL(XP+DP,YP,DH,1,0.,-1)
      XP=XP+DX
      CALL NUMBER(XP,Y,H,IMIN,0.,2HI2)
      XP=XP+TWODX
      CALL SYMBOL(XP,Y,H,125,0.,-1)
      XP=XP+DX
      CALL NUMBER(XP,Y,H,SEC,0.,4HF5.2)
      XP=XP+DX+FOURDX
      CALL SYMBOL(XP,Y,H,127,0.,-1)
      RETURN
      END


      DOUBLE PRECISION FUNCTION DMSTOD(DMS)
      DOUBLE PRECISION DMS(3),A,XDMS
      INTEGER DEGDMS,HHPD
      DATA HHPD/'HPD '/
      COMMON /DEGFLG/ DEGDMS
      XDMS(A)=(DMOD(A,1D2)/6D1+IDINT(DMOD(A/1D2,1D2)))/6D1+IDINT(A/1D4)
      IF(DEGDMS .EQ. HHPD)DMSTOD=XDMS(DMS(1))
      IF(DEGDMS .NE. HHPD)
     *  DMSTOD=DMS(1)/1D4+DMS(2)/60D0+DMS(3)/3600D0
      RETURN
      END


      REAL FUNCTION ROUND(X)
C     ROUNDING ROUTINE FOR IBM 360/370 COMPUTERS
      REAL*8 X,Y,A/Z00000000C80C00000/
      LOGICAL*1 L1(8),L2(8)
      EQUIVALENCE (L1(1),Y),(L2(1),A)
      ROUND=0.
      IF(X .EQ. 0.D0)RETURN
      Y=X
      L2(1)=L1(1)
      ROUND=X+A
      RETURN
      END
```

GRIDOT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

```
      SUBROUTINE BILINE(INPRO,INZON,CUTPRO,CUTZON,
     *  NLAT1,ELON1,NLAT2,ELON2,SCALEP,X0,Y0)
C  BILINE WILL DETERMINE THE NUMBER OF BISECTIONS (IF ANY)
C  NECESSARY SUCH THAT THE IMAGE OF THE LINE IN THE
C  OUTPUT PROJECTION DEVIATES BY NO MORE THAN TOL (PRESENTLY .01 INCH)
      IMPLICIT REAL*8 (A-H,L-Z)
      INTEGER INPRO,INZON,OUTPRO,OUTZON
      DATA  TOL/.010D0/,LATSAV/0.0D0/,LONSAV/0.0D0/
      INTEGER LTLN/'LTLN'/,N,STAT/'STAT'/
      LAT1=NLAT1
      LON1=ELON1
      IF(INPRO .NE. LTLN)CALL PROJ('LL',INPRO,NLAT1,ELON1,
     *  LAT1,LON1,INZON)
      CALL PROJ('NE',OUTPRO,N1,E1,LAT1,LON1,OUTZON)
      LAT2=NLAT2
      LON2=ELON2
      IF(INPRO .NE. LTLN)CALL PROJ('LL',INPRO,NLAT2,ELON2,
     $  LAT2,LON2,INZON)
      CALL PROJ('NE',OUTPRO,N2,E2,LAT2,LON2,OUTZON)
      LAT3=(NLAT1+NLAT2)*.5D0
      LON3=(ELON1+ELON2)*.5D0
      IF(INPRO .NE. LTLN)CALL PROJ('LL',INPRO,LAT3,LON3,
     $  LAT3,LON3,INZON)
      CALL PROJ('NE',OUTPRO,N3,E3,LAT3,LON3,OUTZON)
      DELN=N2-N1
      DELE=E2-E1
      SCALE=12.D0/SCALEP
      IF(OUTPRO .NE. STAT) SCALE=39.37D0/SCALEP
      H=SCALE*((N3-N1)*DELE-(E3-E1)*DELN)/DSQRT(DELE**2+DELN**2)
      N=DSQRT(DABS(H)/TOL)+2.D0
      DELN=NLAT2-NLAT1
      DELE=ELON2-ELON1
        IF(NLAT1.EQ.LATSAV .AND. ELON1.EQ.LONSAV) GO TO 5
        X=(E1-X0)*SCALE
        Y=(N1-Y0)*SCALE
        CALL PLOT(X,Y,3)
5     DO 10 I=2,N
      LAT=(I-1)*DELN/(N-1)+NLAT1
      LON=(I-1)*DELE/(N-1)+ELON1
      IF(INPRO .NE. LTLN)CALL PROJ('LL',INPRO,LAT,LON,LAT,LON,INZON)
      CALL PROJ('NE',OUTPRO,NORTH,EAST,LAT,LON,OUTZON)
      X=(EAST-X0)*SCALE
      Y=(NORTH-Y0)*SCALE
      CALL PLOT(X,Y,2)
   10 CONTINUE
        LATSAV=NLAT2
        LONSAV=ELON2
      RETURN
      END
```

GRIDUT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

```
      SUBROUTINE PROJ(ID,PTYPE,N,E,LAT,LON,Z)
C     INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 ID
      DOUBLE PRECISION N,E,LAT,LON
      INTEGER PTYPE,Z,HALBR,HLAMB,HPOLY,HUTMR,HSTAT
      DATA HALBR/'ALBR'/,HLAMB/'LAMB'/,HPOLY/'POLY'/,
     &  HUTMR/'UTMR'/,HSTAT/'STAT'/
      IF(PTYPE .NE. HALBR)GO TO 10
      CALL ALBR(ID,N,E,LAT,LON)
      GO TO 90
   10 IF(PTYPE .NE. HLAMB)GO TO 20
      CALL LAMB(ID,N,E,LAT,LON)
      GO TO 90
   20 IF(PTYPE .NE. HPOLY)GO TO 30
      CALL POLY(ID,N,E,LAT,LON)
      GO TO 90
   30 IF(PTYPE .NE. HUTMR)GO TO 40
      CALL UTMR(ID,N,E,LAT,LON,Z)
      GO TO 90
   40 IF(PTYPE .NE. HSTAT)CALL ERROR
      CALL STAT(ID,N,E,LAT,LON,Z)
   90 RETURN
      END


      SUBROUTINE STAT(ID,N,E,LAT,LON,Z)
C     INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 ID
      DOUBLE PRECISION N,E,LAT,LON
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C     INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     &  IDNE,IDLL,IDNL,IDLE
      INTEGER ZAREA(2,2),ZONET(5),ZARG(4),Z,BLANK,HTMR,LAST
      DOUBLE PRECISION AREA(7,2),ZPARMS(7),TPARM(7),LPARM(7),
     &  NT,ET,FTPERM
      COMMON/GTMCOM/TPARM
      COMMON/GLBCOM/LPARM
      DATA HTMR/'TMR'/,ZAREA/4*0/,LAST/0/,FTPERM/3.2808333333333333D0/
      J=1
      IF(Z .EQ. ZAREA(1,1))GO TO 60
      J=2
      IF(Z .EQ. ZAREA(1,2))GO TO 60
      CALL UNPK(Z,ZARG,J)
      IF(ZARG(1) .EQ. BLANK)GO TO 100
      LAST=MOD(LAST,2)+1
```

```
      REWIND 26
C    ****PDP-10 STATEMENT FOR I/O****
C       OPEN(UNIT=26,MODE='BINARY',FILE='OUT1',ACCESS='SEQIN')
   30 READ(26,END=100)ZONET,ZPARMS
      DO 40 I=1,4
      IF(ZONET(I) .NE. ZARG(I))GO TO 30
   40 CONTINUE
      ZAREA(1,LAST)=Z
      ZAREA(2,LAST)=ZONET(5)
      DO 50 I=1,7
   50 AREA(I,LAST)=ZPARMS(I)
      J=LAST
   60 IF(ID .EQ. IDLL .OR. ID .EQ. IDLE)NT=N/FTPERM
      IF(ID .EQ. IDLL .OR. ID .EQ. IDNL)ET=E/FTPERM
      IF(ZAREA(2,J) .EQ. HTMR)GO TO 80
      DO 70 I=1,7
   70 LPARM(I)=AREA(I,J)
      CALL GLAM(ID,NT,ET,LAT,LCN)
      GO TO 95
   80 DO 90 I=1,7
   90 TPARM(I)=AREA(I,J)
      CALL GTMR(ID,NT,ET,LAT,LON)
   95 IF(ID .EQ. IDNE .OR. ID .EQ. IDNL)N=NT*FTPERM
      IF(ID .EQ. IDNE .OR. ID .EQ. IDLE)E=ET*FTPERM
      RETURN
  100 CALL ERROR
      STOP
      END


      SUBROUTINE UTMR(ID,N,E,LAT,LON,Z)
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 ID
      DOUBLE PRECISION N,E,LAT,LCN
      DOUBLE PRECISION UTMDAT(7)
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     &  IDNE,IDLL,IDNL,IDLE
      DOUBLE PRECISION TPARM(7)
      COMMON/GTMCOM/TPARM
      INTEGER ZL(2,2),ZARG(4),Z,LAST
      DATA UTMDAT/2*0D0,0D0,5D5,0D0,.9996D0,0D0/
      DATA ZL/4*0/,LAST/0/
      IF(Z .NE. 0)GO TO 10
      IF(ID .EQ. IDNL .OR. ID .EQ. IDLL)GO TO 100
```

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```
      IF(DMOD(LON,6D0) .EQ. 0D0)GO TO 100
      Z=(186D0-LON)/6D0
   10 J=Z
      IF(Z .GE. 10 .AND. Z .LE. 30)GO TO 40
      J=ZL(2,1)
      IF(Z .EQ. ZL(1,1))GO TO 40
      J=ZL(2,2)
      IF(Z .EQ. ZL(1,2))GO TO 40
      CALL UNPK(Z,ZARG,J)
      LAST=MOD(LAST,2)+1
      ZL(1,LAST)=Z
      ZL(2,LAST)=J
      IF( J .LT. 10 .OR. J .GT. 30)GO TO 100
   40 UTMDAT(2)=(30-IABS(J))*6+3
      DO 60 I=1,7
   60 TPARM(I)=UTMDAT(I)
      CALL GTMR(ID,N,E,LAT,LON)
      RETURN
  100 CALL ERROR
      STOP
      END


      SUBROUTINE UNPK(Z,ZARG,J)
      INTEGER Z,J,ZONE(4),ZARG(4),INTS(10),BLANK
      DATA INTS/'0','1','2','3','4','5','6','7','8','9'/,BLANK/' '/
C
C   THE STATEMENTS BETWEEN ASTERISKS ARE FOR THE IBM/360
C   ********************************
      INTEGER ZT,ZB,ZK
      LOGICAL*1 LT(4),LB(4)
      EQUIVALENCE (ZT,LT(1)),(ZB,LB(1))
      DATA ZB/'    '/,ZK/Z77404C40/
      ZT=Z
      DO 1 I=1,4
      LB(1)=LT(I)
      ZONE(I)=ZB
      IF(ZONE(I) .EQ. ZK)ZONE(I)=BLANK
    1 CONTINUE
C   ********************************
C
C   THE STATEMENTS BETWEEN AMPERSANDS ARE FOR THE PDP-10
C   &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
C       DECODE(4,5,Z) ZONE
C5      FORMAT(4A1)
C   &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
      J=1
      K=1
      DO 20 I=1,4
```

```
      IF(ZONE(I) .NE. BLANK)GO TO 10
      ZARG(5-K)=BLANK
      K=K+1
      GO TO 20
   10 ZARG(J)=ZONE(I)
      J=J+1
   20 CONTINUE
      IF(J .NE. 3)GO TO 100
      J=0
      DO 30 I=1,10
      IF(ZARG(1) .EQ. INTS(I))J=J+10*(I-1)
      IF(ZARG(2) .EQ. INTS(I))J=J+I-1
   30 CONTINUE
  100 RETURN
      END


      SUBROUTINE LAMB(ID,N,E,LAT,LON)
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 ID
      DOUBLE PRECISION N,E,LAT,LON
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IONE,IDLL,IONL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     &  IONE,IDLL,IONL,IDLE
       DOUBLE PRECISION GLBBL,GLBCL,GLBNO,GLBEO,GLBRB,GLBN,GLBRZ
      COMMON /GLBCOM/GLBBL,GLBCL,GLBNO,GLBEO,GLBRB,GLBN,GLBRZ
      DOUBLE PRECISION NLRPD,Y,ZZ,Z
      DOUBLE PRECISION PRO,SINPRO,COSPRO
      DOUBLE PRECISION LPARM(7),GLPARM(7)
      EQUIVALENCE (GLPARM(1),GLBBL)
      COMMON /LAMCOM/LPARM
    5 DO 6 I=1,7
    6 GLPARM(I)=LPARM(I)
      ENTRY GLAM(ID,N,E,LAT,LON)
      NLRPD=GLBN*RPD
      IF( ID .EQ. IONL)GO TO 10
      IF( ID .EQ. IDLL)GO TO 20
C          COMMON PROCESSING FOR NE AND LE
      PRO=(GLBCL-LON)*NLRPD
      SINPRO=DSIN(PRO)
      COSPRO=DCOS(PRO)
      IF( ID .EQ. IDLE)GO TO 30
C          COMMON PROCESSING FOR NE AND NL
   10 SINPHI=DSIN(LAT*RPD)
      K=0
```

```
      GO TO 40
   20 PRO=DATAN((E-GLBEO)/(GLBRB-N))
      LON=GLBCL-PRO/NLRPD
      COSPRO=DCOS(PRO)
   30 RHO=(GLBRB-N)/COSPRO
      Y=(RHO/GLBRZ)**(2D0/GLBN)
      SINPHI=(1D0-Y)/(1D0+Y)
      K=1
   40 ZZ=SINPHI*ECC
      Z=((1D0+ZZ)/(1D0-ZZ))**ECC
      IF(K .EQ. 0)GO TO 60
      NEWSIN=(Z-Y)/(Z+Y)
      K=K+1
      IF(K .GT. 20)GO TO 100
      IF(DABS(NEWSIN-SINPHI) .LT. 1D-14)GO TO 50
      SINPHI=NEWSIN
      GO TO 40
C          COMMON PROCESSING FOR LL AND LE
50    LAT=DATAN(NEWSIN/DSQRT(1.D0-NEWSIN**2))/RPD
      IF(ID .EQ. IDLL)GO TO 90
      IF(ID .NE. IDLE)GO TO 100
      GO TO 80
   60 RHO=GLBRZ*DSQRT((Z*(1D0-SINPHI)/(1D0+SINPHI))**GLBN)
      IF(ID .EQ. IDNE)GO TO 70
C          PROCESSING FOR NL
      SINPRO=(E-GLBEO)/RHO
      PRO=DATAN(SINPRO/DSQRT(1.D0-SINPRO**2))
      LON=GLBCL-PRO/NLRPD
      COSPRO=DCOS(PRO)
C          COMMON PROCESSING FOR NE AND NL
   70 N=GLBRB-RHO*COSPRO
      IF(ID .EQ. IDNL)GO TO 90
C          COMMON PROCESSING FOR NE AND LE
   80 E=RHO*SINPRO+GLBEO
   90 RETURN
  100 CALL ERROR
      STOP
      END


      SUBROUTINE LAMBST(STLAT1,STLAT2,LATBAS,LONCEN,NBASE,EBASE)
      DOUBLE PRECISION STLAT1,STLAT2,LATBAS,LONCEN,NBASE,EBASE
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     & PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     & IDNE,IDLL,IDNL,IDLE
```

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```
      DOUBLE PRECISION LAMBL,LAMCL,LAMNO,LAMEO,LAMRB,LAMN,LAMRZ
      COMMON /LAMCOM/LAMBL,LAMCL,LAMNO,LAMEO,LAMRB,LAMN,LAMRZ
      DOUBLE PRECISION STLATS,STLATN,SINLTN,SINSQN,SINLTS,SINSQS,YS,YES
      DOUBLE PRECISION ECCSQ,SINBLT
      STLATS=DMIN1(STLAT1,STLAT2)
      STLATN=DMAX1(STLAT1,STLAT2)
      LAMBL=LATBAS
      LAMCL=LONCEN
      LAMNO=NBASE
      LAMEO=EBASE
      SINLTN=DSIN(RPD*STLATN)
      SINSQN=SINLTN*SINLTN
      SINLTS=DSIN(RPD*STLATS)
      SINSQS=SINLTS*SINLTS
      YS=(1D0-SINLTS)/(1D0+SINLTS)
      YES=(1D0+ECC*SINLTS)/(1D0-ECC*SINLTS)
      ECCSQ=ECC**2
      LAMN=DLOG((1D0-SINSQS)/(1D0-SINSQN)*
     &         (1D0-ECCSQ*SINSQN)/(1D0-ECCSQ*SINSQS))/
     &  (DLOG(YS*(1D0+SINLTN)/(1D0-SINLTN))+
     &  ECC*DLOG(YES*(1D0-ECC*SINLTN)/(1D0+ECC*SINLTN)))
      LAMRZ=SEMAJ*(DCOS(RPD*STLATS))/((DSQRT(1D0-ECCSQ*SINSQS))*
     &  LAMN*DEXP((DLOG(YS)+ECC*DLOG(YES))*(LAMN/2D0)))
      SINBLT = DSIN(RPD*LAMBL)
      LAMRB=LAMRZ*DEXP((ECC*DLOG((1D0+ECC*SINBLT)/(1D0-ECC*SINBLT))+
     &  DLOG((1D0-SINBLT)/(1D0+SINBLT)))*(LAMN/2D0)) + LAMNO
      RETURN
      END


      BLOCK DATA
      DOUBLE PRECISION LAMBL,LAMCL,LAMNO,LAMEO,LAMRB,LAMN,LAMRZ
      COMMON /LAMCOM/LAMBL,LAMCL,LAMNO,LAMEO,LAMRB,LAMN,LAMRZ
      DATA LAMBL/23D0/,LAMCL/96D0/,LAMNO/0D0/,LAMEO/25D5/,
     &  LAMRB/9823240.64741628400/,LAMN/.6107940479934963100/,
     &  LAMRZ/12618790.30586667D0/
      END


      SUBROUTINE GTMR(ID,N,E,LAT,LON)
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 ID
      DOUBLE PRECISION N,E,LAT,LON
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
```

```
  &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
  &  IDNE,IDLL,IDNL,IDLE
   DOUBLE PRECISION GTMBL,GTMCL,GTMNO,GTMEO,GTMRB,GTMKZ,GTMDUM
   COMMON /GTMCOM/GTMBL,GTMCL,GTMNO,GTMEO,GTMRB,GTMKZ,GTMDUM
   DOUBLE PRECISION PART,SINSQ,TANSQ,ESCS,P,PSCS,FVP,B5P,FIIIP,A6P,
  &  NUPHIK,NT,ET,NEWLON,SINSEC
   DATA SINSEC/1.74532925199427D-2/
   IF(ID .EQ. IDLL .OR. ID .EQ. IDLE)PHI=(N-GTMRB)/(GTMKZ*NCO(1))
   IF(ID .EQ. IDNE .OR. ID .EQ. IDNL)PHI=LAT*RPD
   IF(ID .EQ. IDLL .OR. ID .EQ. IDNL)
  &  LON=(GTMEO-E)/(DCOS(PHI)*NCO(1)*RPD) + GTMCL
   K=1
   IF(ID .EQ. IDNE)K=0
20 COSPHI=DCOS(PHI)
   COSSQ=COSPHI**2
   SINPHI=DSIN(PHI)
   SINSQ=SINPHI**2
   TANSQ=SINSQ/COSSQ
   NUPHIK=GTMKZ*SEMAJ/DSQRT(1D0-ECC*ECC*SINSQ)
   ESCS=EPSQ*COSSQ
   P=(GTMCL-LON)*SINSEC
   PSCS=P*P*COSSQ
   FVP=(1D0-TANSQ+ESCS)*2D0
   B5P=(TANSQ-18D0)*TANSQ+72D0*ESCS-58D0*EPSQ+5D0
   ET=((B5P*PSCS+FVP)*PSCS+120D0)*COSPHI*NUPHIK/120D0
   FIIIP=((4D0*ESCS+9D0)*ESCS+5D0-TANSQ)*30D0
   A6P=(TANSQ-58D0)*TANSQ+6D2*ESCS-330D0*EPSQ+61D0
   NT=((A6P*PSCS+FIIIP)*PSCS+360D0)*P*P*SINPHI*COSPHI*NUPHIK/720D0
   PART=((((((NCO(8)*COSSQ+NCO(7))*COSSQ+NCO(6))*COSSQ+NCO(5))*COSSQ
  &      +NCO(4))*COSSQ+NCO(3))*COSSQ+NCO(2))*COSPHI*SINPHI
   IF(K .EQ. 0)GO TO 80
   K=K+1
   IF(K .GT. 20)GO TO 100
   NEWLON=LON
   NEWPHI=PHI
   IF(ID .EQ. IDLL .OR. ID .EQ. IDLE)
  &  NEWPHI=((N-GTMRB-NT)/GTMKZ-PART)/NCO(1)
   IF(ID .EQ. IDLL .OR. ID .EQ. IDNL)
  &  NEWLON=(GTMEO-E)/(ET*SINSEC)+GTMCL
   IF(DABS(NEWPHI-PHI) .LT. 1D-14 .AND.
  &  DABS(NEWLON-LON) .LT. 1D-12)K=0
   LON=NEWLON
   PHI=NEWPHI
   GO TO 20
80 IF(ID .EQ. IDNE .OR. ID .EQ. IDNL)
  &  N=NT+(PART+NCO(1)*PHI)*GTMKZ + GTMRB
   IF(ID .EQ. IDNE .OR. ID .EQ. IDLE)E=ET*P+GTMEO
   IF(ID .EQ. IDLL .OR. ID .EQ. IDLE)LAT=PHI/RPD
90 RETURN
100 CALL ERROR
```

```
      STOP
      END


      SUBROUTINE ALBR(ID,N,E,LAT,LON)
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 ID
      DOUBLE PRECISION N,E,LAT,LON
      DOUBLE PRECISION NUMER,ZZ,DENOM
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      DOUBLE PRECISION PRO,SINPRO,COSPRO
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     &  IDNE,IDLL,IDNL,IDLE
      DOUBLE PRECISION ALBBL,ALBCL,ALBNO,ALBEO,ALBRB,ALBN,ALBR2,TBBON
      COMMON /ALBCOM/ALBBL,ALBCL,ALBNO,ALBEO,ALBRB,ALBN,ALBR2,TBBON
      DOUBLE PRECISION AENRPD,Q203,Q6011,Q305,
     &  Q407,Q7013,Q509,Q8015
      DATA Q203/.66666666666666667D0/,Q6011/.54545454545454545D0/,Q305/.6D0/
      DATA Q407/.57142857142857100/,Q7013/.53846153846153800/
      DATA Q509/.55555555555555600/,Q8015/.53333333333333300/
      AENRPD=ALBN*RPD
      IF(ID .EQ. IDNL)GO TO 10
      IF(ID .EQ. IDLL)GO TO 20
C           COMMON PROCESSING FOR NE AND LE
      PRO=(ALBCL-LON)*AENRPD
      SINPRO=DSIN(PRO)
      COSPRO=DCOS(PRO)
      IF(ID .EQ. IDLE)GO TO 30
C           COMMON PROCESSING FOR NE AND NL
   10 SINPHI=DSIN(LAT*RPD)
      K=0
      GO TO 40
   20 PRO=DATAN((E-ALBEO)/(ALBRB-N))
      LON=ALBCL-PRO/AENRPD
      COSPRO=DCOS(PRO)
C           COMM PROCESSING FOR LL AND LE
   30 NUMER=ALBR2-((ALBRB-N)/COSPRO)**2
      SINPHI=NUMER/TBBON
      K=1
   40 ZZ=(SINPHI*ECC)**2
      DENOM=((((((Q8015*ZZ+Q7013)*ZZ+Q6011)*ZZ+Q509)*ZZ+Q407)*ZZ
     &        +Q305)*ZZ+Q203)*ZZ+1.D0)*TBBON
      IF(K .EQ. 0)GO TO 60
      NEWSIN=NUMER/DENOM
      K=K+1
```

```
      IF(K.GT.20) GO TO 100
      IF(DABS(SINPHI-NEWSIN).LE.1D-14) GO TO 50
      SINPHI=NEWSIN
      GO TO 40
50    LAT=DATAN(NEWSIN/DSQRT(1.D0-NEWSIN**2))/RPD
      IF(ID.EQ.IDLL) GO TO 90
      IF(ID .NE. IDLE)GO TO 100
      GO TO 80
C         COMMON PROCESSING FOR NE AND NL
   60 RHO=DSQRT(ALBR2-DENOM*SINPHI)
      IF(ID .EQ. IDNE)GO TO 70
      SINPRO=(E-ALBEO)/RHO
      PRO=DATAN(SINPRO/DSQRT(1.D0-SINPRO**2))
      LON=ALBCL-PRO/AENRPD
      COSPRO=DCOS(PRO)
C         COMMON PROCESSING FOR NE AND NL
   70 N=ALBRB-RHO*COSPRO
      IF(ID .EQ. IDNL)GO TO 90
C         COMMON PROCESSING FOR NE AND LE
   80 E=RHO*SINPRO+ALBEO
   90 RETURN
  100 CALL ERROR
      STOP
      END


      SUBROUTINE ALBRST(STLAT1,STLAT2,LATBAS,LONCEN,NBASE,EBASE)
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     &  IDNE,IDLL,IDNL,IDLE
      DOUBLE PRECISION ALBBL,ALBCL,ALBNO,ALBEO,ALBRB,ALBN,ALBR2,TBBON
      COMMON /ALBCOM/ALBBL,ALBCL,ALBNO,ALBEO,ALBRB,ALBN,ALBR2,TBBON
      DOUBLE PRECISION STLAT1,STLAT2,LATBAS,LONCEN,NBASE,EBASE
      DOUBLE PRECISION ES,ESP,ESM,RESSQ,ENFAC,ENFACN,EN
      DOUBLE PRECISION STLATS,STLATN,CONERS,CONERN,RHOFCS,RHOFCN
      DOUBLE PRECISION STLAT(2),CONER(2),RHOFC(2)
      EQUIVALENCE(STLAT(1),STLATS),(STLAT(2),STLATN),(CONER(1),CONERS),
     &  (CONER(2),CONERN),(RHOFC(1),RHOFCS),(RHOFC(2),RHOFCN)
      STLATS=DMIN1(STLAT1,STLAT2)
      STLATN=DMAX1(STLAT1,STLAT2)
      ALBBL=LATBAS
      ALBCL=LONCEN
      ALBEO=EBASE
      ALBNO=NBASE
      DO 1 I=1,2
```

```
      SINPHI=DSIN(RPD*STLAT(I))
      ES=SINPHI*ECC
      ESP=ES+1D0
      ESM=1D0-ES
      RESSQ=1D0/(ESP*ESM)
      CONER(I)=RESSQ*SINPHI*.5D0+.25D0*DLOG(ESP/ESM)/ECC
    1 RHOFC(I)=(DCOS(RPD*STLAT(I))*SEMAJ)**2 * RESSQ
      ENFACN=(RHOFCN-RHOFCS)/(CONERS-CONERN)
      TBBON=2D0*SEMIN**2
      ALBN=ENFACN/TBBON
      TBBON=TBBON/ALBN
      ALBR2=(RHOFCS+ENFACN*CONERS)/ALBN**2
      SINPHI=DSIN(RPD*ALBBL)
      ESP=SINPHI*ECC+1D0
      ESM=2D0-ESP
      ALBRB=DSQRT(ALBR2-TBBON*(.5D0*SINPHI/(ESP*ESM)+
     &   .25D0*DLOG(ESP/ESM)/ECC))+ALBNO
      RETURN
      END


      BLOCK DATA
      DOUBLE PRECISION ALBBL,ALBCL,ALBNO,ALBEO,ALBRB,ALBN,ALBR2,TBBON
      COMMON /ALBCOM/ALBBL,ALBCL,ALBNO,ALBEO,ALBRB,ALBN,ALBR2,TBBON
      DATA ALBBL/23D0/,ALBCL/96D0/,ALBNO/0D0/,ALBEO/25D5/,
     &  ALBRB/9929079.557994417D0/,ALBN/.6029035006279521D0/,
     &  ALBR2/150995771793488.5D0/,TBBON/134038556964215.8D0/
      END


      SUBROUTINE POLY(ID,N,E,LAT,LON)
C     INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 ID
      DOUBLE PRECISION N,E,LAT,LON
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C     INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     &  IDNE,IDLL,IDNL,IDLE
      DOUBLE PRECISION POLBL,POLCL,POLNO,POLEO,POLRB
      COMMON /POLCOM/POLBL,POLCL,POLNO,POLEO,POLRB
      DOUBLE PRECISION NA,DLON,PART,SINTH,SINTSQ,FCOSTH
      IF(ID .EQ. IDNE .OR. ID .EQ. IDNL)GO TO 10
      NA=N+POLRB
      PHI=NA/NCO(1)
      K=1
```

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```
      IF(ID .NE. IDLL .AND. ID .NE. IDLE)GO TO 100
      GO TO 20
   10 PHI=LAT*RPD
      K=0
   20 IF(ID .EQ. IDNE .OR. ID .EQ. IDLE)DLON=(POLCL-LON)*RPD
   30 COSPHI=DCOS(PHI)
      COSSQ=COSPHI**2
      SINPHI=DSIN(PHI)
      RHO=SEMAJ*COSPHI/(DSQRT(1D0-(ECC*SINPHI)**2)*SINPHI)
      PART=(((((COSSQ*NCO(8)+NCO(7))*COSSQ+NCO(6))*COSSQ+NCO(5))*COSSQ
     &        +NCO(4))*COSSQ+NCO(3))*COSSQ+NCO(2))*COSPHI*SINPHI
      IF(ID .EQ. IDNL .OR. ID .EQ. IDLL)GO TO 35
      SINTH=DSIN(SINPHI*DLON)
      GO TO 37
   35 SINTH=(E-POLEO)/RHO
   37 SINTSQ=SINTH*SINTH
      FCOSTH=SINTSQ/(1D0+DSQRT(1D0-SINTSQ))
      IF(K .EQ. 0)GO TO 50
   40 NEWPHI=(NA-PART-RHO*FCOSTH)/NCO(1)
      K=K+1
      IF(K .GT. 20)GO TO 100
      IF(DABS(NEWPHI-PHI) .LT. 1D-14)K=0
      PHI=NEWPHI
      GO TO 30
   50 IF(ID .EQ. IDNE .OR. ID .EQ. IDNL)
     &  N=PART+NCO(1)*PHI-POLRB+RHO*FCOSTH
      IF(ID .EQ. IDNE .OR. ID .EQ. IDLE)E=RHO*SINTH+POLEO
      IF(ID .EQ. IDLL .OR. ID .EQ. IDLE)LAT=PHI/RPD
      IF(ID .EQ. IDLL .OR. ID .EQ. IDNL)
     &  LON=POLCL-DATAN(SINTH/DSQRT(1.D0-SINTH**2))/(SINPHI*RPD)
   90 RETURN
  100 CALL ERROR
      STOP
      END


      SUBROUTINE POLYST(LATBAS.LONCEN.NBASE.EBASE)
      DOUBLE PRECISION LATBAS.LONCEN.NBASE.EBASE
      DOUBLE PRECISION SEMAJ.SEMIN.ECC.EPSQ.NCO(8).RPD
      DOUBLE PRECISION PHI.SINPHI.COSPHI.COSSQ.RHO.NEWSIN.NEWPHI
C     INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE.IDLL.IDNL.IDLE
      COMMON /EARTHK/SEMAJ.SEMIN.ECC.EPSQ.NCO.RPD.
     &  PHI.SINPHI.COSPHI.COSSQ.RHO.NEWSIN.NEWPHI.
     &  IDNE.IDLL.IDNL.IDLE
      DOUBLE PRECISION POLBL.POLCL.POLNO.POLEO.POLRB
      COMMON /POLCOM/POLBL.POLCL.POLNO.POLEO.POLRB
      POLBL=LATBAS
      POLCL=LONCEN
```

```
      POLNO=NBASE
      POLEO=EBASE
      PHI=POLBL*RPD
      COSPHI=DCOS(PHI)
      COSSQ=COSPHI*COSPHI
      SINPHI=DSIN(PHI)
      POLRB=((((((NCO(8)*COSSQ+NCO(7))*COSSQ+NCO(6))*COSSQ+NCO(5))*COSSQ
     &     +NCO(4))*COSSQ+NCO(3))*COSSQ+NCO(2))*COSPHI*SINPHI+NCO(1)*PHI
     &       -POLNO
      RETURN
      END


      BLOCK DATA
      DOUBLE PRECISION POLBL,POLCL,POLNO,POLEO,POLRB
      COMMON /POLCOM/ POLBL,POLCL,POLNO,POLEO,POLRB
      DATA POLBL/23D0/,POLCL/96D0/,POLNO/0D0/,POLEO/25D5/,
     &  POLRB/2544389.7457363940D0/
      END


      BLOCK DATA
      DOUBLE PRECISION SEMAJ,SEMIN,ECC,EPSQ,NCO(8),RPD
      DOUBLE PRECISION PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI
C    INTEGER*2 MUST BE USED FOR 360.
      INTEGER*2 IDNE,IDLL,IDNL,IDLE
      COMMON /EARTHK/SEMAJ,SEMIN,ECC,EPSQ,NCO,RPD,
     &  PHI,SINPHI,COSPHI,COSSQ,RHO,NEWSIN,NEWPHI,
     &   IDNE,IDLL,IDNL,IDLE
      DATA SEMAJ/ 6378206.4D 00 /, SEMIN/ 6356583.8D 00 /
      DATA ECC/ 8.2271854223003000D-02 /,EPSQ/ 6.8147849459150420D-03 /
      DATA NCO/ 6.3673996891697820 06 ,-3.2502862417904790 04 ,
     &          1.3840483667167060 02 ,-7.3353881305014290-01 ,
     &          4.2194134115825180D-03 ,-2.5292879423428080D-05 ,
     &          1.5560582852765890D-07 ,-9.7384743747300200D-10 /
      DATA RPD/1.7453292519943300-2/
      DATA IDNE/'NE'/,IDLL/'LL'/,IDLE/'LE'/,IDNL/'NL'/
      END
```

GRIDOUT PROGRAM - R. EDWARDS AND R. DURFEE (OAK RIDGE NATIONAL LAB)

```
//STEP3 EXEC FORTHLG,REGION.GO=170K
//LKED.SYSLIN DD DSN=*.STEP2.FORT.SYSLIN,DISP=SHR
//  DD  DDNAME=SYSIN
//LKED.PLOTSUBS DD DISP=SHR,DSN=JGSPLOTH
//LKED.SYSIN DD *
  INCLUDE PLOTSUBS
//GO.FT49F001 DD UNIT=IN2OU2,DCB=(RECFM=VS,LRECL=3204,BLKSIZE=3208),
//  DISP=(NEW,KEEP),SPACE=(3208,(99),RLSE),DSN=PLOT300.RGE1
//GO.FT26F001 DD DSN=*.STEP1.GO.FT26F001,DISP=SHR
//GO.FT05F001 DD *
HARRIMAN QUAD 1:125000  20000 FOOT STATE PLANE GRID WITH 15' GEODETIC TIC MARKS
    250000  Y         GP             STATTN
        36                 35 30              85                  84
           15                 15
     20000              20000
                                              84 45
NS          1       1                  WE          1       1
```